REVIEW ARTICLE

Management of newborns exposed to mothers with confirmed or suspected COVID-19

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Abstract

There is limited information about newborns with confirmed or suspected COVID-19. Particularly in the hospital after delivery, clinicians have refined practices in order to prevent secondary infection. While guidance from international associations is continuously being updated, all facets of care of neonates born to women with confirmed or suspected COVID-19 are center-specific, given local customs, building infrastructure constraints, and availability of protective equipment. Based on anecdotal reports from institutions in the epicenter of the COVID-19 pandemic close to our hospital, together with our limited experience, in anticipation of increasing numbers of exposed newborns, we have developed a triage algorithm at the Penn State Hospital at Milton S. Hershey Medical Center that may be useful for other centers anticipating a similar surge. We discuss several care practices that have changed in the COVID-19 era including the use of antenatal steroids, delayed cord clamping (DCC), mother–newborn separation, and breastfeeding. Moreover, this paper provides comprehensive guidance on the most suitable respiratory support for newborns during the COVID-19 pandemic. We also present detailed recommendations about the discharge process and beyond, including providing scales and home phototherapy to families, parental teaching via telehealth and in-person education at the doors of the hospital, and telehealth newborn follow-up.

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Introduction

SARS-CoV-2, a novel β-coronavirus, was first reported in December 2019 in Wuhan, China, as "pneumonia of unknown etiology" [1] prior to its isolation and identification by Chinese authorities in January 2020 [2, 3]. Coronavirus disease 2019 (COVID-19) is primarily a respiratory disease of varying severity [4], which presents more commonly as asymptomatic or mild disease in newborns when compared with adults [5–7]. SARS-CoV-2 is transmitted through respiratory droplets, infected fomites [8–10], and from airborne transmission during aerosolization procedures [11]. The American Academy of Pediatrics (AAP) published initial guidance on the management of neonates born to mothers with COVID-19 [12]. Another group recently published a practical resource for perinatal-neonatal specialists, providing the most up-to-date information about COVID-19 during pregnancy [13]. Since the epidemiological data for this pandemic are rapidly evolving, neonatologists need to continuously update management

strategies for neonates born to mothers with confirmed or suspected COVID-19 [13, 14].

Transmission of SARS-CoV-2 to newborns

Since the first reported case of neonatal COVID-19 in February 2020 [15], concerns about possible vertical transmission of SARS-CoV-2 have been raised [16–19]. Early Chinese reports suggested that vertical transmission of SARS-CoV-2 does not occur, as amniotic fluid, vaginal mucus, placenta, umbilical cord, cord blood, and neonatal stool specimens tested negative for the virus [20–27]. In addition, nasopharyngeal swabs from these newborns immediately after delivery were negative. Moreover, there were no reports of vertical transmission during the Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) outbreaks due to genetically similar coronaviruses [3, 28, 29].

Possible vertical transmission was raised by a case series describing three newborns with early-onset mild COVID-19 with positive results from reverse transcriptase-polymerase chain reaction (RT-PCR) tests performed on the second day after birth [16]. The authors argued that since strict infection prevention procedures were used during the deliveries, the early-onset infections resulted from vertical transmission. It is unclear, however, if strict isolation and infection control measures continued beyond the deliveries. The earliest reported neonatal positive test occurred in a 16 h old neonate born to a mechanically ventilated mother with COVID-19 after cesarean delivery with immediate isolation, at 33 weeks' gestation [30]. While the early positive test was concerning for a vertical infection, amniotic fluid, cord blood, and placenta were not tested for virus, and therefore secondary transmission could not be excluded [30].

In other case series, serological testing of seven newborns with limited postnatal exposure (mothers delivered by cesarean section wore masks and newborns were quickly separated from their mothers) demonstrated the presence of virus-specific antibodies, including three with high IgM levels, despite negative virology testing [17, 18]. This may suggest transplacental passage of SARS-CoV-2 since IgM does not cross the placenta, although IgM assays are difficult to interpret due to frequent false positive results [19]. While postnatal transmission to newborns is most likely, current evidence is inconclusive regarding in utero transmission.

Susceptibility of newborns and children to SARS-CoV-2

Compared with adults, children are less susceptible to SARS-CoV-2 infection and experience less severe disease with significantly lower death rates [7, 31–34]. The physiological mechanisms underlying these differences are as yet unknown, but several possibilities exist that should be explored in future studies. The immature developing immune system of children may respond to SARS-CoV-2 differently than adults, possibly resulting in a less damaging cytokine reaction. SARS-CoV-2 binds to angiotensin converting enzyme-II (ACE-2) receptors on type II alveolar epithelial cells in the lower respiratory tract to gain entry into the lungs [35, 36], and ACE-2 receptors may be functionally immature in children making them less susceptible to SARS-CoV-2 infection [37].

Fetal, neonatal, and infant characteristics

Although the reasons are unclear, and causation cannot be implied, about half of mothers with COVID-19 delivered preterm infants [25]. Fetal growth during the third trimester does not appear to be affected in infected mothers [15, 22, 24, 25, 38]. Perinatal complications such as fetal distress and premature rupture of the membranes and postnatally, respiratory distress, tachycardia, shock, thrombocytopenia, and even death have been reported in some neonates (SARS-CoV-2 negative) born to mothers with COVID-19 [22, 24, 39]. Two stillbirths have been reported [40, 41], one from a pregnant woman who had acute respiratory distress syndrome and multi-organ failure leading to extracorporeal membrane oxygenation (ECMO), and another from a mother who eventually died [40, 41]. Maternal morbidity due to the disease may lead to morbidity and mortality in fetuses/newborns who test negative for SARS-CoV-2.

A few newborns who tested positive soon after birth had dyspnea, fever, pneumonia, respiratory distress syndrome, and feeding intolerance, with overall mild disease and no deaths [20, 30].

A large epidemiologic study from China of 2143 children with laboratory-confirmed or suspected COVID-19 reported that 17.7% of cases were in infants < 1 year of age [31]. Another report from Wuhan Children's Hospital reported similar results [33]. A similar percentage (15.5%) of pediatric cases in the United States occurred in infants < 1 year of age [34]. In China, a larger proportion of infants < 1 year of age had severe/critical disease compared with older children (10.6% vs 4.8%) [31]. Similarly, in the United States, infants < 1 year of age had the highest rates of hospitalization among pediatric patients [34].

Delivery room management and resuscitation

At Penn State, universal COVID-19 testing was implemented on April 10, 2020 for all patients admitted for

delivery (Fig. 1). The unexpectedly high asymptomatic carrier rates reported from other institutions as well as prolonged face-to-face patient care required during labor and delivery drove this decision, allowing for judicious personal protective equipment (PPE) use and decreased potential exposure for both healthcare workers and newborns. When patients refuse testing, a protocol of contact and droplet isolation for both mother and newborn is used, and during the delivery, healthcare workers wear N95 respirators. Our obstetricians have cared for term COVID-19 positive patients who delivered healthy newborns (viral testing negative), and one women who convalesced and was discharged, still pregnant, at 29 weeks' gestation.

Pregnant women with confirmed or suspected COVID-19 requiring hospitalization are admitted to negative-pressure rooms, preferentially with an adjoining patient room for newborn resuscitation. Mode of delivery is based on the progression of labor and routine obstetric indications. Operative vaginal deliveries are considered for women who require a shortened second stage of labor due to maternal exhaustion or respiratory distress.

At Penn State, cesarean deliveries occur in negative-pressure operating rooms. The negative-pressure unit dedicated to COVID-19 positive pregnant patients is the surgical anesthesia intensive care unit (SAICU). Although in close proximity to the operating rooms, we learned during the labor of one patient that transporting patients with COVID-19 present many logistical challenges (need for multiple cleanings of patient equipment and for Security to clear hallways) that would delay an emergency cesarean delivery. Although this patient ultimately delivered vaginally, this scenario raised many questions about lowering the threshold for cesarean delivery for patients with COVID-19 in the future. Moreover, transport of the newborn, considered a person under investigation (PUI) [42], out of the SAICU was also delayed by the institution's COVID-19 transport policy. This has since been remedied with updated policies that allow newborn PUIs to be transferred to their rooms in a transport isolette.

Due to frequent exposure to aerosolizing procedures during the second stage of labor, the possible use of general endotracheal anesthesia during emergency cesarean sections, and the possible need for neonatal intubation, labor, and delivery staff are at frequent risk of exposure [43]. Delivery providers and nurses wear full PPE ("full PPE" = isolation gown, N95 respirator or powered, air purifying respirator, face shield or goggles, and gloves) [44] during the entire labor and delivery process of mothers with confirmed or suspected COVID-19, and mothers wear surgical masks.

Antenatal corticosteroids

Data are limited on how corticosteroids affect pregnant patients with COVID-19. Steroids given to MERS and SARS patients offered no clinical benefit and prolonged
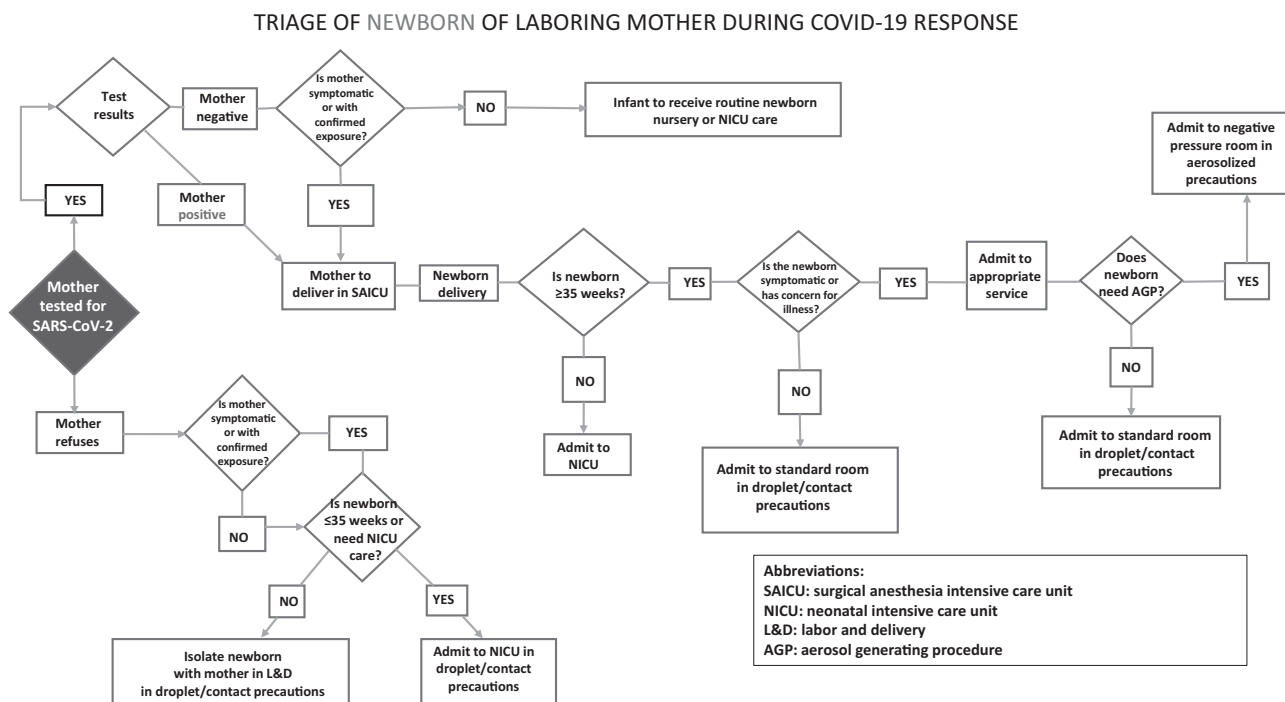
Fig. 1 Penn State algorithm for the triage of newborns of laboring mothers during COVID-19. The triage begins with the laboring mother undergoing testing for SARS-CoV-2 to determine delivery location and disposition of the newborn to the appropriate location and care service.

viral shedding [45, 46]. The American College of Obstetricians and Gynecologists (ACOG) recommends the continued use of antenatal corticosteroids for asymptomatic women or those with mild COVID-19 who are at risk of preterm birth within the next 7 days at <33 6/7 weeks' gestation [43]. If the mother is ill [47], however, the risks to the mother and the potential benefits to the fetus must be weighed and discussed with the mother and family.

Delayed cord clamping (DCC)

The benefits of DCC for preterm and term neonates are well known [48]. Several reports, based on expert opinion, have recommended that DCC not be performed in neonates born to mothers with confirmed or suspected COVID-19 in order to reduce the risk of secondary transmission [15, 47, 49]. In contrast, the ACOG and the Royal College of Obstetricians and Gynecologists, based on a lack of evidence that brief exposure to the mother causes neonatal infection, still recommends performing DCC [43, 50]. Another group recommends performing DCC with the newborn held by the obstetrician [51].

At Penn State, we now perform DCC with the obstetrician holding spontaneously breathing newborns rather than placing them skin-to-skin on the mother.

Newborn resuscitation and routine care

At Penn State, a COVID-19 resuscitation team (neonatal delivery nurse, a respiratory therapist, and a neonatologist) is available for all deliveries of mothers with confirmed or suspected COVID-19. A pediatric infectious diseases consult is obtained on all neonates born to mothers with confirmed COVID-19 (or symptomatic mothers who initially test negative) so that appropriate testing and discharge follow-up is established.

Newborns ≥ 35 weeks' gestation

For newborns not predicted to need extensive resuscitation, a neonatal delivery nurse (fully donned) enters the room immediately after delivery and evaluates gestational age, tone, color, and respiratory effort. If there is good tone with spontaneous breathing, the nurse wraps the newborn with warm blankets and places her/him into a prewarmed transport isolette.

Hospital staff caring for these newborns don a gown, surgical mask, face shield, and gloves. In order to minimize PPE use and potential exposures, routine newborn tests such as screening for congenital heart disease, obtaining the newborn screen, and hearing testing are performed together.

Newborns < 35 weeks' gestation

For resuscitation of premature, high-risk, and newborns with anomalies born to mothers with cinfirmed or suspected COVID-19, a fully donned neonatal resuscitation team enters the room upon delivery. The newborn is quickly assessed, and if spontaneously breathing, is placed into the transport incubator. If resuscitation is required, necessary respiratory support is provided, and the newborn is transported to the neonatal intensive care unit (NICU) and admitted into a negative-pressure room with an antechamber. Mechanical ventilation, ECMO, and surgeries can be performed in this room. Care is provided by a neonatal nurse trained in donning and doffing PPE. A second nurse monitors donning and doffing to ensure that contamination of the primary nurse or medical provider does not occur. The minimum number of persons needed to provide care to these newborns are allowed to enter the room. Healthcare workers who are pregnant or ≥60 years of age do not care for these patients [52].

At Penn State, the initial SARS-CoV-2 test is performed within 24–48 h after birth. For newborns who initially test positive and remain in the NICU for extended periods, additional testing occurs on a case-by-case basis, likely every 48 h, and based on signs and severity of COVID-19.

Mother and newborn separation and visitation

The AAP, ACOG, and Chinese consensus experts recommend separating newborns from mothers with confirmed or suspected COVID-19 into separate isolation rooms until the mother's transmission-based precautions are discontinued [12, 15, 43, 49]. The presumed benefits of temporary separation, i.e., decreased risk of neonatal infection, should be discussed with families prior to delivery [12, 42]. The Centers for Disease Control (CDC) recently (April 4, 2020) changed their guidance regarding separating newborns from mothers with confirmed or suspected COVID-19 [42]. They now recommend that the decision to separate newborns should be made on a case-by-case basis, using shared decision-making between mothers and families and the healthcare team about the risks and benefits of cohabitating [42]. If rooming in does occur according to the families' wishes, or because of facility constraints, care should be taken to practice social distancing, hand hygiene, and infection control, and the mother should wear a facemask during contact with her newborn [42].

At Penn State, due to facility infrastructure constraints, mothers with confirmed or suspected COVID-19 and newborns are admitted to different hospital units; thus they are separated. While hospitalized, mothers with COVID-19

remain in the hospital's COVID unit. Mothers who are discharged home prior to the infant's discharge may visit their newborns after they have been afebrile for 3 days, symptoms have abated or are improving, and >7 days have passed since their symptoms first began. Alternatively, they can visit if they have two negative tests (>24 h apart), are afebrile without antipyretics, and respiratory symptoms have improved [12, 42]. Other family support persons who are PUIs may not visit the baby until their own SARS-CoV-2 molecular testing is negative and any symptoms have abated [12]. Visitors are instructed on proper techniques for donning and doffing masks, gowns, and gloves. Various technology platforms are used to video conference with families who are unable to visit.

In the NICU, newborns who tests negative for SARS-CoV-2 and have no signs can be moved to a regular room [42].

Breastfeeding and breast milk

Breast milk has innumerable benefits for newborns, including passive transmission of antibodies against various infections [53]. Antibodies to a similar virus, SARS-CoV, were detected in breast milk [54]. To date, SARS-CoV-2 has not been detected in the breast milk of mothers with COVID-19 [22], and it is possible that breast milk from these mothers will provide some degree of immunity. Thus, most international associations highly recommend using breast milk from mothers with confirmed or suspected COVID-19 [42, 55–57].

Careful collection techniques should be used for pumped breast milk [42], including providing mothers with a dedicated breast pump. Mothers should wash their hands before and after pumping, and the breast pump should be properly disinfected per the manufacturer's instructions. If possible, expressed breast milk should be fed to newborns by a healthy caregiver. If a mother with confirmed or suspected COVID-19 chooses to directly breastfeed, she should wear a surgical mask and perform hand and breast hygiene prior to feeding. When the mother is not breastfeeding, the newborn should remain >2 m (~6 ft) away, be separated by a barrier, and/or be placed in an isolette. The World Health Organization and United Nations Children's Fund recommend standard breastfeeding guidelines within an hour of birth using appropriate infection prevention precautions [55, 56]. This advice may be most pertinent to areas where limited resources make breastfeeding the only viable option.

Since SARS-CoV-2 has been detected on plastic for up to 72 h [58], staff receiving bottles of expressed milk from mothers with COVID-19 should wear gloves. After securing the cap, bottles should be wiped with viricidal wipes or diluted bleach solutions and placed on a clean surface to air dry. After drying, bottles may be placed in hospital refrigerators in individual patient bins [59].

For long-term NICU stays, donor human milk is an option if maternal breast milk is not available. Human Milk Banking Association of North America milk banks uniformly use heat treatment during Holder pasteurization [60], which totally inactivates genetically similar viruses (SARS-CoV and MERS-CoV) [61, 62]. While there is currently no evidence regarding SARS-CoV-2, it is likely inactivated during heating.

At Penn State, during hospitalization, infected mothers are encouraged to provide expressed breast milk. Unfortunately, due to being in separate units, direct breastfeeding is not currently possible. At other institutions, where there is an opportunity for cohabitation, the decision to directly breastfeed can be made using shared decision-making between mothers and healthcare teams about the risks and benefits of direct breastfeeding.

Airway management and respiratory support of newborns with confirmed or suspected COVID-19

Aerosolization procedures increase the risk of airborne transmission, particularly to healthcare workers, since SARS-CoV-2 can remain in the air for >3 h and travel > 2 m (~6 ft) [58, 63]. Droplet transmission occurs when larger respiratory droplets are generated by infected individuals through coughing, sneezing, and talking. These larger droplets drop quickly and only travel a short distance, usually ≤1 m (~3 ft) [63].

Fortunately, there are very few reports of respiratory support needs in neonates with confirmed or suspected COVID-19 [16, 64]. Most exposed neonates who received mechanical ventilation also had comorbidities such as prematurity, asphyxia, and non-COVID-19 sepsis [16].

Protection of healthcare workers during respiratory care

Guidance of respiratory care of patients with confirmed or suspected COVID-19 remain fluid [44, 65, 66]. Since up to 29% cases in Wuhan, China, occurred in healthcare workers [67], aerosolization properties and stability of SARS-CoV-2 in the environment cannot be overemphasized [58]. Therefore, common aerosolizing procedures in the NICU, such as intubation, extubation, open suctioning, non-invasive ventilation, and placement of naso- and oro-gastric tubes need to be conducted with a high degree of caution, using appropriate PPE in negative-pressure rooms [11, 44]. Institutional variation of what is considered an aerosol generating procedure and how that will affect professionals

caring for COVID-19 patients adds another layer of complexity [68, 69]. A single center study showed that the team members who directly performed these procedures were at highest risk of becoming infected [70]. Institutions should critically assess the literature in light of their specific patient population and resources in order to determine what they consider aerosol generating procedures.

Noninvasive respiratory support

Noninvasive support such as nasal intermittent positive pressure ventilation, nasal continuous positive airway pressure (CPAP), high flow nasal cannula, and nasal cannula oxygen therapy can be generated by several devices in the NICU. Since they are open systems at the patient interface, there is a large risk for droplet and airborne transmission [71]. Masks covering both the nose and mouth, as well as using the lowest possible pressure, may minimize some of the risk. Further, if noninvasive ventilation is generated by mechanical ventilators with high-efficiency particulate air (HEPA) filters, the risk of aerosolization is likely lower. Interestingly, during the SARS epidemic, nurses caring for patients receiving noninvasive ventilation did not contract more disease than those who cared for patients on ventilators [72].

Invasive respiratory support

Rapid sequence intubation is recommended for those in respiratory failure with COVID-19 [73]. If bag-mask ventilation is needed, providers should place a HEPA filter between the mask and the end tidal CO_2 device and oxygen source [65, 74], and wear full PPE [44]. If PPE is likely to inhibit the ability to visualize the vocal cords, video laryngoscopy should be performed [66]. Pulmonary hygiene should be minimized [75]. Suctioning of endotracheal tubes should be performed using in-line suctioning catheters [11, 65]. If a patient needs to be disconnected from the ventilator, the endotracheal tube should be clamped and the circuit disconnected with the heat moisture exchanger still attached to the patient [11, 65].

Conventional ventilators with dual limb circuits with expiratory HEPA filters connected to cuffed endotracheal tubes [76] are nearly closed systems that significantly decrease the risk of aerosolization. The high-frequency oscillator ventilator (HFOV, Sensormedics, Yorba Linda, CA), without specialized experimental circuits, is not able to filter the exhaled air, making its use especially worrisome to healthcare workers during a viral epidemic [77]. During the SARS outbreak, however, healthcare workers caring for patients on HFOV did not become infected more than those caring for patients receiving conventional ventilation [72]. The high-frequency jet ventilator (HFJV, Bunnell, Salt Lake City, UT) has an expulsion set with a filter that prevents aerosol generation [77].

At Penn State, noninvasive ventilation (using a ventilator) for newborns with confirmed or suspected COVID-19 is the preferred mode. If mechanical ventilation is needed, conventional ventilation is failing, or high-frequency ventilation is desired, neonates are placed on the HFJV. Newborns ≥ 1500 g with confirmed or suspected COVID-19 are placed on ventilators with capabilities to do both invasive and noninvasive ventilation, Thus, respiratory care can be adjusted without contaminating multiple devices. In surge situations with inadequate number of ventilators, bubble or variable flow CPAP may be used.

Laboratory and radiologic evaluation

The diagnosis of COVID-19 in newborns includes physical examination, laboratory, and radiologic testing [4, 24, 31].

Laboratory evaluation

A SARS-CoV-2 RT-PCR is done for asymptomatic PUIs [15]. For symptomatic PUIs and COVID-19 infected newborns, additional tests such as CBC and CRP should be performed, as well as other tests that are clinically indicated [15]. While the diagnostic role of serologic testing is currently unclear, it may be useful for future epidemiological purposes [78].

Sample collection and virus identification

The CDC recommends obtaining a nasopharyngeal swab (or a bronchoalveolar lavage sample if receiving invasive ventilation) for initial diagnostic testing [79]. RT-PCR is currently recommended for the qualitative detection of SARS-CoV-2 nucleic acid in respiratory tract specimens [80]. The Emergency Use Authorization FDA approved test used at Penn State is the Simplexa® COVID-19 Direct Kit (DiaSorin Molecular, Cypress, CA). It has excellent specificity. For newborns, the AAP recommends obtaining throat and nasopharynx swabs at about 24 and 48 h after birth, although the optimal time of testing is unknown [12]. The testing regimen should also take into account the risk of infection and limitations of resources. Additional testing in symptomatic neonates should be considered because early test results may be negative due to the incubation period of the virus. A respiratory viral panel, to rule out other infections, should also be considered in symptomatic neonates [15].

Radiologic evaluation

Chest x-ray findings are variable and nonspecific including unilateral or bilateral ground-glass opacity, lobar or

subsegmental areas of lung consolidation, pneumothorax, and are sometimes normal [15, 16, 24, 81–83]. CT scans do not appear to provide additional diagnostic information [4, 16, 23, 84]. Given the limited sensitivity, specificity, and radiation exposure, imaging should only be performed if clinically indicated.

Discharge and outpatient follow-up

Healthy newborns ≥ 35 weeks' gestation

Routine newborn criteria, including stable physical exam, ability to maintain body temperature, and feeding well with adequate hydration, are used to establish timing of discharge. All families, courtesy of the Children's Miracle Network, are given a baby scale (Baby/Toddler Electronic Scale, model #914, Salter). If serum bilirubin (which may be done concurrently with the newborn screen) is in the high intermediate or high-risk zone [85], they are also loaned home phototherapy (Bilibed®, model 1544976, Medela, Baar, Switzerland).

Parental education

Advice regarding home isolation precautions follow the AAP guidelines [12]. Neonates are ideally discharged into the care of an unaffected caregiver. COVID-19 positive family members are instructed to limit exposure to the newborn, generally maintaining a 2 m (~6 ft) distance. If the mother is breastfeeding or provides newborn care, she is instructed on hand hygiene and use of a mask until afebrile for 72 h without the use of antipyretics, and >7 days have passed since symptoms began [12].

Predischarge education is completed using video conferencing during the mother's hospital stay or at home following maternal discharge. On the day of discharge, the neonate is brought to a less trafficked entrance of the hospital by the discharging nurse (with a scale and home phototherapy, if needed) and is met by the family (likely still being quarantined) who are wearing gloves and a mask, for a complete in-person teaching session. During this interaction, parents and staff maintain 2 m (~6 ft) social distancing, and take turns moving in and out of the teaching space without exposing other staff or patients to the family and newborn. Lastly, parents are instructed on the use of the scale and phototherapy, about monitoring for signs of neonatal illness, and details about medical follow-up and additional testing.

Medical follow-up

Infants are followed up 1–2 days after discharge via telehealth. An informal poll of local primary care providers indicated that only 2% had a plan in place to care for these newborns as outpatients. The focus of the video visit is to evaluate for developing signs of infection, review home isolation precautions, and discuss routine concerns such as feeding, hydration, and jaundice. Neonates are weighed on the home scale during the encounter, allowing the pediatrician to visualize the neonate's tone, color, demeanor, and respiratory status. If the pediatrician is concerned about jaundice, or if the infant was discharged with home phototherapy, arrangements are made for a laboratory technician in full PPE to obtain a serum bilirubin sample in the home. Alternatively, a Chinese group developed an online bilirubin follow-up program for parents, with video education for using an online app to check transcutaneous bilirubin levels [86]. If the pediatrician is concerned that the neonate appears ill, the family is directed to the Emergency Department.

The timing of subsequent telehealth visits is determined by the initial visit and the neonate's prior history. At 14 days after birth, a repeat test for SARS-CoV-2 is performed, although this is not recommended by the AAP. This is done to identify neonates who may be at risk of infecting others. If the 14 day test result is negative, routine baby care is transitioned back to the community primary care provider.

If readmission for a neonate born to a mother with confirmed or suspected COVID-19 is necessary for any reason, the neonate will undergo testing for COVID-19, regardless of the timing of previous tests, to ensure proper use of isolation rooms and PPE.

Conclusion

This paper reports Penn State's current guidelines, based on the most up-to-date literature, about managing mothers and newborns with confirmed or suspected COVID-19. While COVID-19 generally has a mild course in newborns and children, the disease continues to evolve and has caused major morbidity and mortality worldwide. Although vertical transmission is unlikely, monitoring of neonates born to mothers with confirmed or suspected COVID-19 is imperative. While many facets of care remain the same, other practices such as antenatal corticosteroids, DCC, separation and visitation, breastfeeding, airway management and respiratory support, and neonatal follow-up have been impacted by COVID-19. While we hope our policies and procedures may be helpful to other institutions, each center must develop and revise their guidelines to provide optimal care for patients while conserving vital PPE and ventilators and protecting healthcare workers. Given the low rate of disease in newborns to date, our policies may change in the near future to allow cohabitation, direct

breastfeeding, and routine newborn care for newborn PUIs without signs of disease.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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