

# Neonatal Resuscitation Where the Mother Has a Suspected or Confirmed Novel Coronavirus (SARS-CoV-2) Infection: Suggestion for a Pragmatic Action Plan

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## Keywords

Neonatal resuscitation · Novel coronavirus · SARS-CoV-2 · Newborn · Mother · Transmission

## Abstract

Coronavirus disease 2019 (COVID-19), caused by the novel SARS-CoV-2 virus, is rapidly spreading across the world. As the number of infections increases, those of infected pregnant women and children will rise as well. Controversy exists whether COVID-19 can be transmitted in utero and lead to disease in the newborn. As this chance cannot be ruled out, strict instructions for the management of mothers and newborn infants are mandatory. This perspective aims to be a practical support tool for the planning of delivery and neonatal resuscitation of infants born by mothers with suspected or confirmed COVID-19 infection. © 2020 S. Karger AG, Basel

## Background

The novel coronavirus-related infection has rapidly spread from Wuhan (China) since December 2019 [1] and was declared a pandemic on March 11, 2020 [2]. Initially defined as the 2019-novel coronavirus (2019-nCoV) [3], on February 11, 2020 the pathogen has been officially named SARS-CoV-2, and COVID-19 (coronavirus disease 2019) its related disease [4].

The main routes of transmission are via respiratory droplets or through direct contact (0–2 m) [5, 6]. Viral copies can be found in stools of positive patients, but the fecal-oral route transmission has not been confirmed [7, 8]. In adults, the most frequent presentation at illness onset is characterized by fever, cough, myalgia, fatigue, and respiratory distress, but gastrointestinal symptoms may be present [9]. Of the entire population of confirmed COVID-19 patients, children <10 years make up just 0.9%, with about 18% of these being <1 year [10, 11], with rare deaths related to the disease in this population.

Urgent questions that need to be addressed promptly include whether pregnant women who have confirmed COVID-19 infection are more likely to experience life-threatening events, and whether SARS-CoV-2 could spread vertically and pose risks to the fetus and neonate [12, 13]. Perinatal transmission of the SARS-associated coronavirus was excluded in a previous case series, where serial reverse transcriptase-polymerase chain reaction (RT-PCR) assays, viral cultures, and paired serologic titers were performed [14].

Based on current evidence based on relatively small studies, compared with SARS and MERS infections, SARS-CoV-2 appears to be less severe in pregnant women [15], and, similarly, not causing intrauterine transmission to the fetus [16, 17]. This has been confirmed by two retrospective analyses of pregnant women with COVID-19, whose neonatal throat swabs tested negative [18, 19]. Among other samples collected in several retrospective studies (amniotic fluid, cord blood, placenta, breastmilk), none showed positive result for SARS-CoV-2 [18–20]. As a consequence, SARS-CoV-2 seems to undergo transmission by droplets rather than intrauterine or transplacental transmission, but a word of caution is required due to the very limited available evidence [21, 22].

Neonatal cases appear to be milder and with better outcomes compared to adult ones [9, 21–24]. Although it is unlikely that neonates born from SARS-CoV-2-infected mothers require an intensive care management related to the maternal infection [18, 19], coronaviruses may result in adverse outcomes for the fetus and infant (intrauterine growth restriction, preterm delivery, admission to the neonatal intensive care unit (NICU), spontaneous abortion and perinatal death) [16, 17, 25].

International guidelines on resuscitation do not have the breadth to cover scenarios like the current COVID-19 pandemic [26]. In recent weeks, several recommendations on the care of pregnant women with suspected or confirmed COVID-19 [27], management of delivery, admission and discharge of newborns to and from the nursery [28–33], and breastfeeding [34–37] have been released. However, none of these has focused on the appropriate planning of neonatal resuscitation during delivery.

Some information on vertical transmission and infection control measures in neonatal units have been reported during the outbreak SARS in Southeast Asia in 2003 [14, 38].

This perspective aims to provide practical indications for the management of mothers and neonates before, during, and after delivery. In Padua, we have implement-

ed the described approach with positive feedback from healthcare professionals and parents, and with no newborns tested positive for SARS-CoV-2. In Padua, we have implemented an approach with positive feedback from healthcare professionals and parents, with no newborns testing positive for SARS-CoV-2.

## Before Delivery

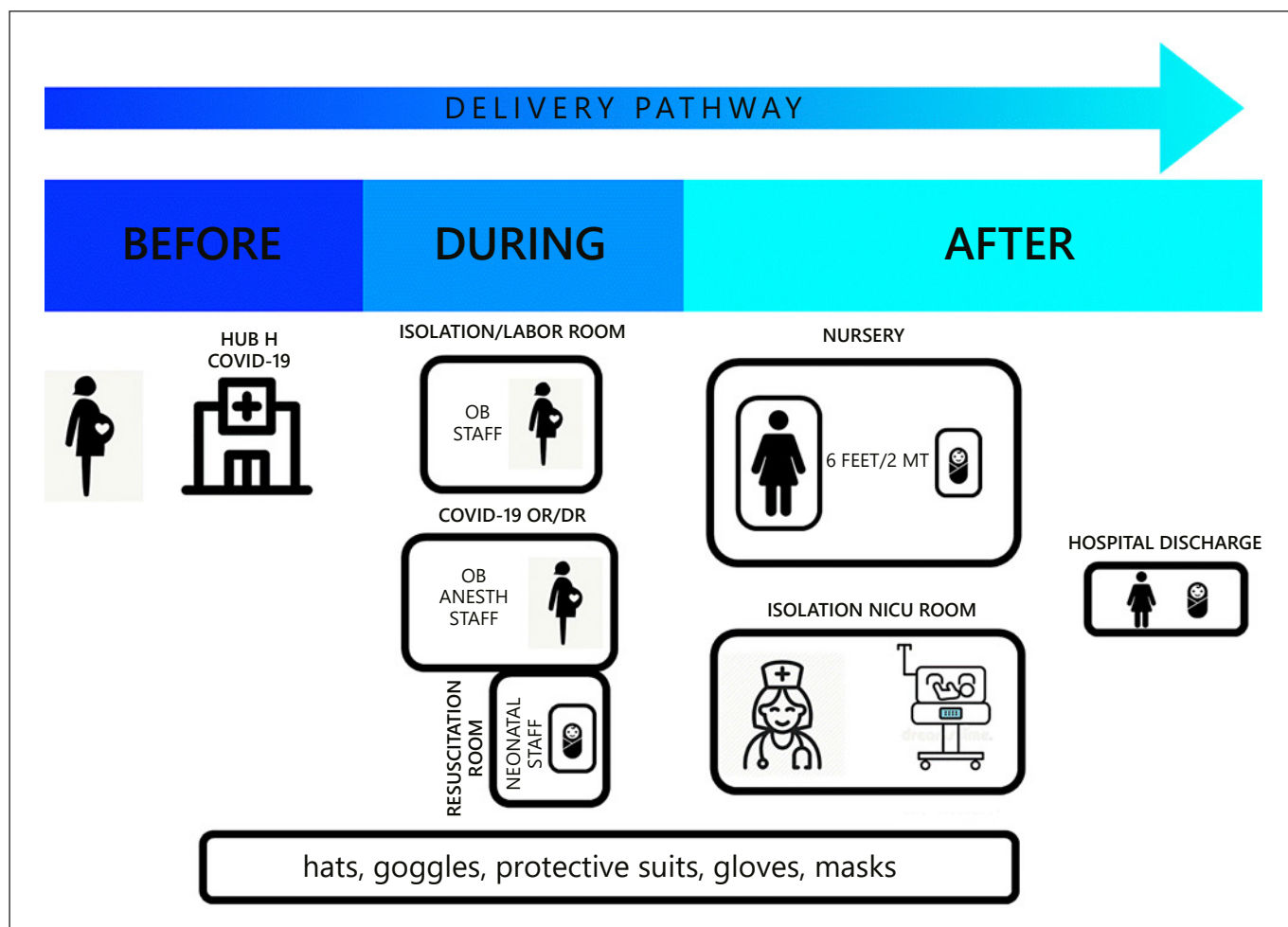
### *Where?*

From our experience, we suggest that regional plans aim at creating designated hub hospitals for pregnant COVID-19 cases (Fig. 1) These can be organized for all the multidisciplinary needs.

However, every hospital should be in the position to assist non-transferable pregnant women. A pre-triage area is mandatory, followed by separate paths for suspected and diagnosed cases, or non-COVID-19 mothers. This approach requires two different delivery areas to be designated in all hospitals. At Padua University Hospital, triaging of patients is done in a tent mounted in front of the emergency department. In the obstetrical ward, we have identified one operating room (OR) and 2 labor/delivery rooms (DRs) exclusively dedicated to the care of women with suspected or confirmed COVID-19; a dedicated path and a lift have also been dedicated to these patients. In the NICU, neonates with suspected infection are cared for in isolated areas (two single, negative-pressure rooms and one room equipped with six beds). Examples of structural re-organization of a NICU have been previously described during an epidemic outbreak, but the model needs to be adapted to the local situation [38, 39].

At least a dedicated DR and an OR (possibly negative-pressure rooms) should be arranged to manage mothers with suspected or confirmed COVID-19 in every obstetric department. Next to the DR, a room or area equipped with an infant warmer should be available. As an alternative, the infant warmer could be arranged in the DR, however >6 feet (2 m) from the mother [5, 6, 40].

Preferably, screening of suspected or confirmed mothers should be done in a dedicated area before arrival to a labor and delivery unit. At Padua University Hospital, we have recently started to check all women admitted to the labor ward for SARS-CoV-2 infection because the lack of clinical symptoms does not rule out infection and transmission.



**Fig. 1.** Management of mothers with suspected or confirmed SARS-CoV-2 infection and their infants in the perinatal period.

### How?

#### Team

Multidisciplinary management is mandatory, involving midwives, obstetricians, anesthesiologists, and neonatologists. Simulation training, specific to managing suspected COVID-19 cases, should be in place in every delivery suite. It is an important exercise during the acute phase, but ideally simulation training should be conducted on regular basis (for example, at least once a year) in all hospitals for preparing healthcare caregivers to provide care for patients infected with high-consequence pathogens [41].

The contents of training include the Centers for Disease Control and Prevention (CDC) infection prevention and control procedures for healthcare providers, together with local requirements [5].

A protocol focused on equipment and the correct use of personal protective equipment (PPE) including correct donning, doffing, and disposal of PPE should be provided [42].

To minimize the need for PPE, the WHO recommends that respirators (i.e., N95, FFP2 or equivalent standard) should be used for aerosol-generating procedures (e.g., tracheal intubation, noninvasive ventilation, tracheostomy, cardiopulmonary resuscitation, manual ventilation before intubation, bronchoscopy), while medical masks should be indicated for the other situations [43]. However, the rational use for masks is still not codified and depends on country guidelines also at community level [44].

The minimum number of health caregivers and minimum "contact time" between staff and patients for each

specific scenario (i.e., vaginal delivery or cesarean section) should be planned.

Medical staff taking care of COVID-19-suspected or -positive women should wear protective clothing, N95 masks, goggles, and gloves before contact with the patients.

#### Mother

At hospital admission, all women should wear a medical mask and should undergo a triage procedure that includes (i) history of TOCC = Travel, Occupation, Contact and Clustering, (ii) clinical features e.g., fever, respiratory and/or gastrointestinal signs and symptoms, etc., and (iii) if possible, COVID-19 RT-PCR test results. Pregnant women with “influenza-like illness” (fever, cough, myalgia, sore throat, malaise) or history of contacts with persons suspected or confirmed COVID-19 should be tested for SARS-CoV-2 infection at hospital admission. These patients and those with known COVID-19 should wear a facemask and wait in a separate, well-ventilated waiting area at least 6 feet from other people and should be isolated as soon as possible in an airborne infection isolation room, where possible.

#### Equipment

Every DR should be arranged with all necessary equipment. A complete kit including the necessary PPE (mask with goggles/face-shield, gown, and gloves) for each team member should be available in dedicated envelopes in the delivery suite, as there is a potential need for aerosol-generating procedures (continuous positive airway pressure, intubation/extubation, deep suctioning, etc.) (Table 1).

#### Documentation

Immediately, inform hospital infection office or authorities, as per local requirements.

### **During Delivery**

#### *Where?*

The laboring mother should be managed in an airborne infection isolation room until the delivery. Preferably, the vaginal delivery would be assisted in the isolation room. In case of cesarean section, the woman with a face mask should be transferred to the OR immediately before surgery, possibly through dedicated paths (i.e., possible dedicated corridors or passages, lifts, etc.) accompanied by staff wearing appropriate PPE [39].

#### *How?*

#### Team

A multidisciplinary approach including midwives, obstetricians, anesthesiologists, and neonatologists is recommended. COVID-19 infection itself is not an indication for delivery, unless there is a need to improve maternal oxygenation. Time and mode of delivery must be established on routine obstetrical indications. Before the laboring woman’s arrival in the DR or OR, health caregivers should wear PPE (with N95 masks), because it is unknown if the neonate will need resuscitation maneuvers. The minimum number of providers should attend each procedure to reduce exposure and also to minimize the use of PPE, as materials would be in very short supply during an outbreak. For example, if neonatal resuscitation is expected, two team members should be considered. Rescue personnel should be available for emergency and unattended situations in a room next to the delivery suite. Also the “contact time” between staff and patients should be kept to a minimum.

As person-to-person transmission of SARS-CoV-2 is thought to be due to respiratory droplets, skin-to-skin contact is not recommended, and maternal contacts should be avoided. Vertical transmission from mother to fetus is currently uncertain, but available data suggest no evidence of this transmission mode [19, 21, 22]. Delayed cord clamping could still be performed as a standard of care, however by avoiding maternal skin contact [40].

Routine neonatal protocols will guide management of healthy newborns or of those in need of resuscitation. Despite COVID-19 infection alone not being an indication for changing established guidelines on neonatal resuscitation/stabilization [26], all aerosol-generating procedures (i.e., face-mask ventilation, tracheal intubation, non-invasive ventilation, continuous positive airway pressure) should be performed by using respirators, PAPR or N95 masks, eye protection, gloves, and gowns. Disposable laryngoscopes should be preferred, and intubation by using a videolaryngoscope can be also considered in order to increase the distance between the provider and the neonate. Despite limited evidence on their efficacy, viral filters on the expiratory limb of the ventilator circuit and closed suctioning systems could be also used, as reported in previous experiences [38, 45].

The procedure should be performed by an expert provider.

#### Mother and Neonate

The laboring woman should wear her face mask and should be managed based on routine obstetrical proto-

**Table 1.** Checklist on management of mothers with suspected or confirmed SARS-CoV-2 infection and their infants in the perinatal period

Time	Actions*
Before delivery	<ul style="list-style-type: none"> <li>- A specific simulation training on management of mother and infant with COVID-19 should be put in place in every delivery setting</li> <li>- Plan the delivery in a hub hospital; if not possible, organize a separate path for suspected or diagnosed COVID-19 cases</li> <li>- Assure screening procedures in a dedicated area before arrival in the delivery unit</li> <li>- Inform hospital infection office or authorities of new cases</li> <li>- Suspected or diagnosed mother managed in airborne infection isolation room until delivery</li> <li>- Define a dedicated delivery room/operating theater (possibly negative pressure rooms)</li> <li>- Designate a room equipped with an infant warmer next to the delivery room or, if not available, put a neonatal resuscitation bed &gt;6 feet (2 m) from the mother's bed</li> <li>- Clearly define a multidisciplinary team (midwives, obstetricians, anesthesiologists, and neonatologists) with a minimum number of health caregivers for scenario (ideally, 2 members for neonatal resuscitation)</li> <li>- Prepare separate packages with protective personal equipment (PPE, including hats, goggles, protective suits, gloves, N95 masks, etc.) for each team member in the delivery ward</li> <li>- Clearly define function and roles of team members for neonatal resuscitation</li> <li>- Equipment check (based on NRP or ERC guidelines):               <ul style="list-style-type: none"> <li>- Infant warmer temperature set, dry linen, plastic wrap</li> <li>- Suctioning (pressure 80–100 mm Hg); prefer closed systems</li> <li>- T-piece (PEEP 6 cm H<sub>2</sub>O, PIP 20–25 cm H<sub>2</sub>O, FiO<sub>2</sub> according to gestational age, flow 8–10 L/min), oxygen source, appropriate-sized masks, endotracheal tubes and laryngoscope of appropriate size, laryngeal mask, antibacterial filter, self-inflating bag</li> <li>- Videolaryngoscope</li> <li>- Drugs according to risk factors</li> <li>- Stethoscope, pulse oximeter, ECG, electrodes</li> <li>- Medications and kit for advanced resuscitation</li> </ul> </li> <li>- Rescue personnel for neonatal resuscitation available for emergency</li> <li>- Transport incubator for postnatal transfer</li> </ul>
During delivery	<ul style="list-style-type: none"> <li>- The multidisciplinary team must wear protective clothing, N95 masks, goggles, and gloves before contact with the patients and before mother's arrival in the delivery suite/operating theatre</li> <li>- Vaginal delivery assisted in the airborne isolation room or in the designated operating theatre if caesarean section</li> <li>- Consider general anesthesia for CS if mother with incipient respiratory insufficiency</li> <li>- Delayed cord clamping below the introitus or abdominal incision if no other contraindications</li> <li>- Skin-to-skin contact not recommended</li> <li>- Neonatal stabilization/resuscitation steps as usually indicated</li> </ul>
After delivery	<ul style="list-style-type: none"> <li>- All PPE should be removed and put in plastic bags</li> <li>- Cleaning and disinfection of delivery room/operating theatre and equipment</li> <li>- Manage mother in an isolated room in the post-partum period</li> <li>- Care for the baby in an incubator possibly &gt;6 feet (2 m) from mother or in a different room or, if intensive care needed, put the infant in an incubator in an isolated room in the unit</li> <li>- Staff managing mother and baby should always wear PPE and be tested for SARS-CoV-2 (nasal and oropharyngeal swabs) every 2–3 weeks</li> <li>- Send maternal specimens for SARS-CoV-2 testing (placenta, amniotic fluid)</li> <li>- Test the baby for SARS-CoV-2 (nasal and oropharyngeal swabs) 24 h after delivery</li> <li>- Consider expressed breast milk</li> <li>- Healthy neonates with two negative SARS-CoV-2 tests 24 h apart should be discharged to their mother with contact and droplet precautions until mother has two negative SARS-CoV-2</li> <li>- Monitor mother, baby, and family with a strict follow-up</li> </ul>

\* Woman and parents of the baby should be involved in decisions at all stages.

cols. For cesarean sections, general anesthesia should be considered in women developing severe respiratory insufficiency [46, 47].

#### Equipment

Mask with goggles/face-shield, gown, and gloves must be worn by all the providers in the room where mother and baby are cared for.

#### Documentation

Documentation is based on local maternal and neonatal charts.

### After Delivery

#### Where?

After birth, the DR or the OR should be immediately cleaned and disinfected and made available for further patients. The procedure should be done according to local protocols. All the equipment (i.e., tubing, masks, laryngoscope) should be disposed or sterilized.

The mother should be managed in an isolated room during the post-partum period. The baby can be cared for in the mother's room in a closed incubator at possibly >6 feet (2 m) from the mother or in a closed incubator in a different room [5, 6, 40].

Benefits and risks of this decision will depend on logistical situations and medical decisions and will be discussed with parents. In the NICU, the baby should be cared for in an incubator in a single room.

#### How?

##### Team

At the end of the procedure, healthcare providers should remove the PPE that should be put in plastic bags and disposed of. Staff managing the mother and the baby should wear PPE and should be tested for SARS-CoV-2 infection by nasal and oropharyngeal swabs every week for 2–3 weeks. As asymptomatic subjects are potentially contagious, in our NICU, nasal and oropharyngeal swabs are collected every week in all parents and medical staff. This “universal” approach has been adopted mainly for an epidemiological purpose and cannot be considered as standard of care.

##### Mother and Neonate

The mother should wear the face mask and should be managed based on routine local protocols. Sick preterm and full-term infants should be admitted to the NICU and

possibly managed by a limited number of healthcare providers exclusively dedicated to the care of these patients. At University Hospital of Padua, sick preterm and term infants born to mothers testing positive for SARS-CoV-2 are kept isolated in a dedicated area of the NICU (“quarantine zone”), where parents are not allowed, and physicians and nurses have to wear PPE according to CDC guidelines [5]. In addition, nasal and oropharyngeal swabs are collected at 24 h of life from those infants born from suspected or confirmed mothers whose swab result for SARS-CoV-2 is still pending. To reduce footfall within the unit and to relieve parental anxiety, video visits are strongly supported during hospital stay and after discharge [40].

#### Infant Feeding

Since it is not yet known whether SARS-CoV-2 can be transmitted through breast milk, only pasteurized human breast milk (donor or maternal) or formula milk is used for feeding preterm infants admitted to our NICU. Considering that certain viruses (like CMV and HSV) can be transmitted through this route [48], we opted for a cautious approach. However, Italian guidelines recommend using fresh expressed breast milk with no need to pasteurize it [49]. Healthy neonates with two negative nasal swabs 24 h apart should be discharged to be with their mother. Families need to receive clear information on specific precautions regarding contact and droplets, to be strictly followed until the mother has two negative SARS-CoV-2 tests. All test for SARS-CoV-2 in breast-milk were negative in 6 mothers reported by Chen et al. [18]; however, there is currently insufficient evidence regarding the safety of breastfeeding and the need for mother-baby separation. Although many scientific institutions and societies support breastfeeding [34–37], caution may still be required. The optimal mode of infant feeding (breastfeeding, expressed breast milk given by the mother or healthcare giver, formula) should be considered by the mother in coordination with the healthcare team.

#### Equipment

A mask with goggles/face-shield, gown, and gloves must be worn by all the providers in the room where mother and baby are cared for.

#### Documentation

Specimens for SARS-CoV-2 testing (placenta, amniotic fluid, umbilical cord blood) should be collected from suspected or confirmed mothers, analyzed, and stored

[50]. Mother, neonate, and family should be monitored with a strict follow-up. National and international perinatal registers for infants exposed to or suffering from COVID-19 are currently being implemented.

## Conclusions

Current recommendations on the management of suspected or confirmed COVID-19 mothers and their infants are based on limited and incomplete data, requiring continuous and comprehensive updates. Although evidence is still very limited, every effort should be done to ensure healthcare providers' safety that is of paramount importance to continue offering the best care possible to mother and child. Our designated approach for the management of women with suspected or confirmed COVID-19 and their infants before, during, and after delivery provides cues to reduce the chance of neonatal infection and therefore potential negative outcomes in the newborn.

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## Disclosure Statement

The authors have no potential conflicts of interest to disclose.

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## Author Contributions

Prof. Trevisanuto contributed to the study concept, study design, and writing of the manuscript and critically reviewed the manuscript. Dr. Moschino wrote the initial draft, revised the literature, and approved the final manuscript as submitted. Dr. Doglioni contributed to writing the draft, revised the literature, and approved the final manuscript as submitted. Prof. Roehr contributed to literature revision, provided relevant expertise, and critically reviewed the manuscript. Dr. Gervasi contributed to designing the study, collection of information, and critically reviewed the manuscript. Prof. Baraldi contributed to literature revision, provided relevant expertise, and critically reviewed the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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