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Case Report
Emergent cesarean section in a preterm pregnant woman with severe COVID-19 pneumonia in Taiwan: A case report

Chien-Hui Lau a, Chih-Lin Mao a, Yin-Kuang Chang a, Sheng-Kang Chiu b, Chou-Chin Lan c, Lu-Lu Zhao d, Han-Yu Lin e, Su-Cheng Huang a, Hsiao-Chen Chiu a,*

a Department of Obstetrics and Gynecology, Taipei Tzu-Chi Hospital, The Buddhist Tzu-Chi Medical Foundation, Taipei, Taiwan
b Department of Infectious Diseases, Taipei Tzu-Chi Hospital, The Buddhist Tzu-Chi Medical Foundation, Taipei, Taiwan
c Department of Chest Medicine, Taipei Tzu-Chi Hospital, The Buddhist Tzu-Chi Medical Foundation, Taipei, Taiwan
d Department of Pediatrics, Taipei Tzu-Chi Hospital, The Buddhist Tzu-Chi Medical Foundation, Taipei, Taiwan
e Department of Anesthesiology, Taipei Tzu-Chi Hospital, The Buddhist Tzu-Chi Medical Foundation, Taipei, Taiwan

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ABSTRACT
Objective: The pandemic Coronavirus Disease 2019 (COVID-19) is a global public health crisis. Many maternity units worldwide are currently establishing the management protocols for these patients.

Case report: We report the first critically ill pregnant woman with COVID-19-induced respiratory failure undergoing emergent caesarean delivery at 32 weeks of gestation, in the setting of a positive pressure operating room (OR) with negative pressure anteroom in Taiwan.

Conclusion: Multidisciplinary planning and collaboration are necessary to achieve satisfactory clinical outcomes in pregnancies with critical COVID-19 pneumonia. The combinations of comprehensive evaluation, timely treatment as well as establishment of rigorous protocol and safe environment for the emergent delivery are important.

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Introduction
Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), spreads rapidly throughout the world and continues to cause heavy public health burden and economic destruction. In addition, recent reports demonstrated that COVID-19 infection in pregnancy is associated with maternal complication risks and adverse fetal outcomes [1]. On the other hand, healthcare works are at increased risk of SARS-CoV-2 exposure during medical procedures for COVID-19 patients, such as applying respiratory devices and performing surgical operations [2]. Infection prevention measures should be made to minimize the environmental contamination and staff risk of infection.

Currently, limited studies exist for pregnancies with COVID-19 in Taiwan. There have been two case reports in the Taiwanese Journal of Obstetrics and Gynecology, including a totally asymptomatic woman at term pregnancy [3], and the other near-term with complete recovery after COVID-19 [4]. We share our experience of the first documented case of a critically ill woman with COVID-19-related acute respiratory distress syndrome (ARDS) in Taiwan who gave birth by emergent cesarean section at 32 weeks of gestation in the positive and negative pressure rooms based on the multidisciplinary collaboration. The patient provided written informed consent for publication of this report and the associated images.

Case report
On 24 May 2021, a 32-year-old Taiwanese pregnant woman without systemic disease, gravida 1 para 0, was transferred to our hospital at 32 weeks of gestation due to a positive result of nasopharyngeal swab for COVID-19 on quantitative real time polymerase chain reaction (qRT-PCR). 10 days before admission, she experienced fever, cough, loss of smell and progressive dyspnea. Her husband, tested positive for SARS-CoV-2, was asymptomatic and isolated. During this gestation, she had regular prenatal visits and there was no remarkable abnormality.

Upon admission, the temperature was 36.6 °C, blood pressure 143/76 mm Hg, pulse 98 beats/minute, respiratory rate 36 breaths/min, and oxygen saturation of 83% on ambient air. Obstetric
examination including cardio-tocography (CTG) revealed a reactive non-stress testing and there was no obvious uterine contraction. The laboratory data disclosed elevated level of C-reactive protein 12.28 mg/L and decreased PaO2/FiO2 ratio (198/1) from the arterial blood gas (Table 1). The chest film revealed bilateral multifocal ground-glass lung opacities which were compatible with COVID-19 pneumonia (Fig. 1). Endotracheal intubation with mechanical ventilation was suggested but the patient hesitated. After discussion, a non-breathing mask (NRM) with 15 L/min oxygen was used temporarily to maintain the oxygen saturation above 95%. Considering the risk of preterm birth, the patient received 4 doses of dexamethasone 6 mg in every 12 h to facilitate fetal lung maturity. Periodic fetal monitoring using CTG showed no signs of fetal distress. Progressively deteriorating oxygenation (PaO2/FiO2 ratio: 168) of the patient developed on the second day of hospitalization. The chest X-ray showed progressively diffuse bilateral infiltrates (Fig. 1). The multidisciplinary team, composed of obstetricians, pediatricians, anesthesiologists, physicians of infectious disease and chest medicine, comprehensively evaluated the overall maternal and fetal conditions as well as the feasibility of emergent operation. Given the maternal acuity and fetal gestational age, the patient received endotracheal intubation followed by cesarean section after completing dexamethasone therapy in the positive pressure OR with negative pressure anteroom (Fig. 2) with general anesthesia on 27 May 2021. The procedure of endotracheal intubation was performed by the well-experienced anesthesiologist with video-assisted equipment. All medical staff members in the specialized OR wore enhanced personal protective equipment (PPE). A viable female infant weighing 1565 gm was delivered from a breech presentation, 6 min after incision, with Apgar scores at 1 and 5 min of 6 and 8 respectively. Delayed cord clamping and skin-to-skin contact were not performed to reduce neonatal exposure to anesthesia and SARS-CoV-2. The estimated blood loss including amniotic fluid was 550 mL. The operation time was approximately 50 min in total.

The intubated patient was transferred to the surgical ICU for postoperative care and further management of COVID-19 pneumonia. Remdesivir 100 mg per day, Dexamethasone 6 mg per day and prophylactic antibiotics were administered according to the current guidelines. Venous thromboembolism was prevented by an intermittent pneumatic compression. The patient’s PaO2/FiO2 ratio improved gradually and extubation was done on postoperative day 4. She was discharged on postoperative day 12 without evident sequelae (Fig. 3).

The newborn was resuscitated by the neonatal team due to nasal flaring and respiratory distress at birth. Within minutes after birth, she was transferred to a single negative pressure room at neonatal ICU. The samples from the oral and nasopharyngeal swabs (at 24 h, 48 h) were all negative for SARS-CoV-2. At the 10th day of life, the neonate was clinically stable on high-flow nasal cannula at 3 L/min with full nasogastric tube feeding, and had normal findings on neurologic examinations.

Discussion

The COVID-19 leads to rapid progression of viral pneumonia requiring hospitalization and oxygen support. The management of pregnant women with complicated COVID-19 is challenging. The medical decision in this case was based on the latest guidelines from Taiwan Association of Obstetrics and Gynecology [5].

In brief, the general principles of COVID-19 in pregnancy include timely isolation, early mechanical ventilation for respiratory failure, close fetal and uterine contraction monitoring, individualized delivery planning, adequate OR setting, as well as multidisciplinary collaboration [6].

Timing and route of delivery

The optimal timing of delivery and the route of delivery in COVID-19 are determined by the maternal and fetal status, gestational age, comorbidities, and shared decision-making with the

| Variables                          | Reference range | Day 1 (Admission) | Day 5 (The day after operation) | Day 9 (The day of extubation) |
|------------------------------------|-----------------|-------------------|--------------------------------|--------------------------------|
| Hemoglobin (g/dL)                  | 12.0–16.0       | 10.3              | 8.3                            | 9.4                            |
| Hematocrit (%)                    | 36.0–46.0       | 30.3              | 24.7                           | 28.1                           |
| Platelet count (*10^3/μL)         | 150–400         | 258               | 338                            | 528                            |
| White-cell count (per μL)         | 3.5–11.0        | 6.87              | 6.70                           | 7.26                           |
| Differential count (per μL)       |                 |                   |                                |                                |
| Neutrophils (%)                   | 40–75           | 85.3              | 74.0                           | 64.0                           |
| Lymphocytes (%)                   | 20–45           | 10.8              | 16.0                           | 24.0                           |
| Monocytes (%)                     | 2–10            | 3.8               | 8.0                            | 6.0                            |
| C-reactive protein (mg/dL)        | <1.0            | 12.8              | 2.24                           | 3.01                           |
| AST (U/L)                         | 13–39           | 40                | –                              | 18                             |
| ALT (U/L)                         | 7–52            | 34                | –                              | 24                             |
| BUN (mg/dL)                       | 7–25            | 5                 | 11                             | 9                              |
| Creatinine (mg/dL)                | 0.60–1.20       | 0.41              | 0.45                           | 0.43                           |
| Sodium (mmol/L)                   | 135–145         | 136               | 139                            | 139                            |
| Potassium (mmol/L)                | 3.5–5.1         | 3.6               | –                              | 3.7                            |
| D-dimer (ng/mL (FEU))             | <500            | 907.88            | 1909.59                        | 1338.31                        |
| Prothrombin time (s)              | 8–12            | 9.5               | –                              | –                              |
| hs-Troponin I (pg/mL)             | <17.5           | 6.9               | –                              | –                              |
| Ferritin (ng/mL)                  | 11–306.8        | 58.5              | –                              | –                              |

ALT, alanine aminotransferase; AST, aspartate aminotransferase; BUN, blood urea nitrogen.
patients [5]. Of note, the rate of preterm birth was reported up to 17–47% in pregnant women with COVID-19 [1,7] which need careful evaluation and prompt management to prevent adverse maternal and fetal outcomes, especially for those with ARDS [8]. Considering the PaO2/FiO2 ratio less than 300 mm Hg which indicated advanced severity, early delivery was reasonable in order to decrease maternal oxygen consumption, improve lung mechanics and prevent fetal hypoxia [5].

The role of corticosteroid in preterm pregnant women and COVID-19 infection

Administration of antenatal corticosteroid is a mainstay of therapy to improve preterm neonatal survival and reduces major short-term morbidity [9]. The potent anti-inflammatory effects of corticosteroids might also prevent or mitigate hyper-inflammatory response that can lead to lung injury and multisystem organ dysfunction in patients with severe COVID-19 [10]. For patients with severe COVID-19 at risk of preterm birth from 24 to 34 weeks of gestation and meet criteria for use of corticosteroids for maternal treatment of COVID-19, the Panel suggests intravenous/intramuscular dexamethasone 6 mg every 12 h for four doses for fetal lung maturation, then continue maternal treatment with dexamethasone at a dose of 6 mg daily to complete a total of 10 days or until discharge [10,11].

Anesthesia concerns

The anesthetic management for patients with suspected or confirmed COVID-19 infection presents a major challenge for the anesthesia professionals. Generally, neuraxial anesthesia is recommended for cesarean section because the general anesthesia may cause unnecessary aerosol generation from those with COVID-19 [12]. However, because of the presence of ARDS in this patient,
general anesthesia and endotracheal intubation were performed according to the protocol based on the practice guideline from Taiwan Society of Anesthesiologists [13], which includes designating the most experienced anesthesiologist, placing the patients in Bed up Head elevation position, preoxygenation with 100% oxygen via NRM for more than 5 min rather than mask ventilation, using the Aerosol Box (TaiwanBox) and a disposable video laryngoscope (such as McGrath MAC), putting the high-efficiency particulate air (HEPA) filter between the patient mask and the breathing circuit, and minimizing personnel in the OR during intubation.

Infection prevention strategies and the operating room settings

Inadvertent exposures may result in nosocomial transmission and health-care acquired infection. Proper infection-control strategies are effective in protecting both the healthcare workers and the patients. The Taiwan Centers of Disease Control (CDC) recommends a positive pressure OR with negative pressure anteroom for the conduction of operation [14]. As shown in Fig. 2, the anteroom and OR supplied HEPA-filtered air with 25 air changes per hour (ACH). The positive pressure in the OR relative to the areas outside prevents the entry of common pathogens (such as Staphylococcus aureus) that contaminate the open wounds, while the negative pressure anteroom at −10 Pa relative to the exterior avoids dissemination of aerosolized viral particles to the green zone. Currently, the variable pressure rooms (i.e. rooms in which the ventilation can be manually switched between positive and negative pressure) are no longer recommended in the guidelines, while investigators found that these units were not delivering air according to the set parameters [15]. An evaluation of 115 negative-pressure ventilation isolation rooms in the USA found that 52 (40%) of these rooms had positive air flow to the corridor with the doors closed [16]. The positive pressure OR with a negative pressure anteroom is the optimal setting for the prevention of airborne pathogens outside the OR. Particularly, the anteroom is not to be used for donning and doffing of PPE; instead, this area should be considered contaminated once the patients enter the OR.

Perinatal care

In the recent systematic review and meta-analysis, the risk of vertical transmission of COVID-19 during the third trimester was found to be 3.2% [17] and it is not related to delayed cord clamping and skin-to-skin contact with the baby, therefore RCOG recommended if the condition of the woman and infant allows [11].

In summary, we report the first case of a critically ill pregnant woman with COVID-19-related ARDS in Taiwan who gave birth to a premature newborn by emergent cesarean section with favorable maternal and fetal outcomes. We highlight multidisciplinary planning and collaboration, for whom decision making required balancing maternal and fetal well-being, as well as minimizing undue risk to health care professionals.

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Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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Fig. 3. Timeline of disease course according to days from the initial presentation of illness and hospital admission (May 14 to June 8, 2021). Abbreviations: PAPR, positive air pressure respiratory; PPE, personal protective equipment; ACH, air exchanges per hour; HCW: health care worker; MV, mechanical ventilator.
