TJR Turkish Journal of RESUSCITATION

REVIEW
TJR 2022;1(1):1-18

CARDIOPULMONARY RESUSCITATION PRACTICES IN PEDIATRIC AND NEONATAL PATIENTS WITH DIAGNOSED OR SUSPECTED COVID-19

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ABSTRACT

Cardiopulmonary resuscitation (CPR) includes all treatment procedures during cardiac arrest. Resuscitation of pediatric and neonatal patients with a diagnosis or suspicious of COVID-19 is particularly special in terms of protection and reducing the risk of transmission. In this review, basic and advanced life support recommendations of Turkish Resuscitation Council for pediatric and new-born patients with a definite or probable diagnosis of COVID-19 are explained within the algorithm framework.

Keywords: Cardiopulmonary Resuscitation, COVID-19, Pediatric, Newborn

INTRODUCTION

All of the procedures to be performed in the treatment of cardiac arrest are called cardiopulmonary resuscitation (CPR). COVID-19 infection, declared as a pandemic by the World Health Organisation, is a highly contagious disease that causes "severe acute respiratory syndrome - Coronavirus 2 (SARS-CoV-2)", and CPR may be required in patients with a COVID infection or a possible diagnosis. In addition, there may be patients who are asymptomatic but have a positive COVID-19 test result and develop cardiac arrest for other reasons (such as myocardial infarction, arrhythmia, trauma, pulmonary embolism, intoxication) and require CPR [(1)]. The European Resuscitation Council (ERC) and the International Liaison Committee on Resuscitation (ILCOR) have identified their recommendations for the risks associated with CPR in COVID-19 patients. Turkish Resuscitation Society, in cooperation with the ERC, has adapted neonatal life support and pediatric CPR for patients with or possible COVID infection by adapting it to the conditions of our country [(4,5)]. Children who are susceptible to COVID-19 disease usually have a mild illness, but very young children and children with concomitant diseases may be prone to severe clinical disease [(10-15,16)]. However, since many other pathogens and/or underlying etiologies may cause respiratory failure in children, it may be difficult to confirm the diagnosis [(17-20)].

Protection of rescuers and health professionals

a. Health systems should have the necessary procedures and equipment to protect practitioners (health professionals, first aid teams, etc.) [(21)]
b. Healthcare professionals should use Personal Protective Equipment (PPE) when treating a child with a definite or suspected COVID-19 diagnosis [(22)], only relevant healthcare professionals should be present at the scene/room to limit the risk of transmission and conserve resources.
c. Non-medical rescuers should protect themselves as much as possible and avoid actions with a high risk of transmission. Rescuers, who are the child's caregivers or family members, will likely be more willing to provide support regardless of the potential increased risk from exposure to the virus.

In out-of-hospital pediatric cardiac arrests, approximately 70% of the rescuers are family members, and if the child is infected, they are individuals who have been exposed to SARS-CoV-2 before and who think that the personal risks are much less important than the benefit to the child. This is unlikely to be true for random rescuers. Healthcare professionals may also feel that they may result in a greater benefit than their personal risk when intervening with a child patient, but they should act responsibly towards their relatives, colleagues and society at large [(23)].

Recognition of the critically ill child

Current recommendations for the recognition of the critically ill child are also valid for the child with a definite or suspected diagnosis of COVID-19 [(4,24)]. European Resuscitation Council (ERC) guidelines emphasise the importance of early recognition of severe disease through rapid observation of behaviour, respiration and body skin colour, initially and then, if necessary, comprehensively ABCDE (A:Airway, B:Respiratory, C:Circulatory, D:Neurological assessment, E:Full body examination) approach [(25)].

There are no clinical findings or biochemical parameters showing

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high sensitivity or specifications for COVID-19 [26]. Practitioners should keep in mind the possibility of hypoxia or myocarditis before other clinical manifestations become evident. Teamwork is important in the management of a child with a severe illness, but the number of teams should be optimised at each stage.

Airway and respiratory management of critically ill child with or suspected COVID-19 infection

a. If necessary, open the airway and ensure its patency with the "head-tilt-chin-lift" or "jaw-thrust" manoeuvres. Regardless of the child's COVID-19 status, establishing and maintaining the airway is an important part of respiratory management for any critically ill child.

b. Give early oxygen support to ensure oxygenation (avoid unnecessary hyperoxia) [27,28]. Oxygen can be delivered by a nasal cannula, a simple oxygen mask, or a non-rebreathing mask. Have the patient wear a surgical mask while using any of this equipment. In those who initially fail low-flow oxygen therapy, high-flow oxygen administration with a nasal cannula should be considered in combination with a surgical mask. COVID-19 patients may respond well to CPAP avoiding intubation.

c. Timely endotracheal intubation should be considered to support oxygenation and ventilation in patients with severe respiratory distress and decompensated respiratory failure or cardiac arrest who have failed non-invasive mechanical ventilation (NIMV) administration. If balloon-mask ventilation (BMV) is temporarily required, aim for no leakage during ventilation and insert a viral filter (HME or HEPA) between the balloon and mask. If a single rescuer is unable to fully place the mask on the patient's face, switch to the two-applicator method (the chest compressor can squeeze the balloon while standing still). Airway interventions should be performed by the most experienced practitioners. Ideally, teams should be identified in advance, with special intubation trolleys (with adequate PPE including face shields for relevant personnel) prepared in advance [22]. It is recommended that a cuffed tracheal tube be used and that practitioners take care to inflate the cuff of the tube to an adequate pressure (before the patient is first ventilated). Experienced practitioners should prefer the use of videoryngoscopy. In children, chest compressions should be stopped at the time of attempting intubation while CPR is ongoing.

The risk of virus transmission is high during all airway procedures such as endotracheal intubation, SGA (Supraglottic Airway) placement, BMV, non-invasive ventilation, tracheostomy, ventilator circuit disconnection, in-tube aspiration. All practitioners in the room during these procedures should wear anti-airborne PPE [22]. Limit aerosol spread by placing a viral filter (HME, HEPA) between the patient's airway and the breathing circuit and on the ventilator's expiratory arm; clamp the tube and stop ventilation before disconnecting it; use a neuromuscular blocking drug to prevent coughing and prefer closed aspiration systems.

Recognition of Cardiac Arrest and BLS Algorithm in Pediatric Cases with Suspect or Definitive Diagnosis of COVID-19

In an unresponsive child, assess breathing visually (chest rise) and optionally by placing one hand on the abdomen [29]. Do not come close to the patient's mouth or nose at this stage. A child who does not respond and does not breathe normally is considered 'cardiac arrest'. Untrained lay rescuers will likely initially call the emergency number 112; trained rescuers should do this before starting chest compressions. In cases where two or more rescuers are present, a second rescuer should immediately call 112 [4].

When cardiac arrest is detected, rescuers should at least provide compression-only CPR. In this case, place a surgical mask over the child's mouth and nose before starting chest compressions. Routine use of a cloth dressing as an alternative is not recommended because of airway obstruction and/or restriction of passive air movement (due to compressions). However, the cloth can be gently draped over the mouth and nose when a surgical mask is not available and rescuers are not able to do it otherwise.

In the absence of a condition of primary cardiac origin ('sudden witnessed collapse'), rescuers who are willing and able to open the airway and deliver rescue breaths according to the 2015 guidelines, should only do it with the knowledge that it will increase the risk of infection (if the child has COVID-19), and that they should perform artificial ventilation with the awareness that it can significantly improve the outcome [28].

Once an automated external defibrillator (AED) is available, trained practitioners should use it as soon as possible. An AED should be offered primarily as part of ED-directed CPR where the likelihood of a shockable rhythm is high. It can be used in cases of sudden witness collapse, in children with a specific 'cardiac' history, or in children older than 1 year with no identifiable non-cardiac cause of arrest, provided that there are always at least two witnesses and an AED nearby.

Pre-hospital EMS or in-hospital CPR teams should wear airborne preventive PPEs, even if this delays the initiation or continuation of CPR before approaching the patient, unless COVID-19 has been excluded. Personnel wearing anti-droplet PPE may consider performing initial defibrillation only in children with a defined shockable rhythm before wearing PPE against airborne particles. Apply chest compressions and ventilation after wearing PPE against airborne particles. Do not delay CPR to maintain an invasive airway. Provide initial ventilation with a balloon mask [4].

Foreign Body Airway Obstruction (FBAO)

Current guidelines for the management of FBAO apply regardless

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of the putative COVID-19 status [4,24]. The risk of transmission is limited, as rescuers will largely be the child's caregivers or household members. Where coughing is considered to be effective, practitioners and bystanders should encourage the victim to cough, while maintaining appropriate distance. At this stage, the child should not wear a surgical mask, and witnesses should call 112 immediately, especially if the cough is considered ineffective.

Advanced Life Support (ALS) in Pediatric Cases with Suspect or Definitive Diagnosis of COVID-19

Recommendations for in-hospital cardiac arrest in children diagnosed or suspected of COVID-19 are listed below **(Figure 1)**:

a. For children diagnosed or suspected of COVID-19, cardiac arrest teams should put on appropriate PPE before approaching the patient. Teams should be kept as small as possible, but efficiency should not be compromised.
b. If a defibrillator is present, turn it on immediately, insert defibrillator paddles and deliver shock if the rhythm is ventricular fibrillation/pulseless ventricular tachycardia (VF/pVT). If the child remains in VF/pVT and is wearing airborne PPE, begin chest compressions. If no airborne PPE is worn, while other HCWs are wearing airborne PPE, if necessary, give two additional shocks [17].
c. Early diagnosis and appropriate treatment of reversible causes are important during CPR. Some of the reversible causes require 'advanced' resuscitation techniques: therefore, consider immediate transport of the child to an advanced centre. There is insufficient evidence to justify the use or non-use of extracorporeal life support (ECMO) for children with COVID-19.

Life Support in New-born with Suspect or Definitive Diagnosis of COVID-19

Very few babies need resuscitation at birth. Some experience problems during this perinatal transition period and the need for resuscitation arises in the absence of support. In the vast majority of those who need support, only ventilation of the lungs is sufficient. A smaller proportion may require short-term chest compressions with lung ventilation. Specially trained personnel should be present in deliveries that are known to have a high probability of developing problems, and at least one of them should be experienced in endotracheal intubation of the newborn (NB) [1]. At birth, respiration begins spontaneously in 85% of the time, within 10-30 seconds. Drying and stimulation in 10% neonates, positive pressure ventilation in 3% help to initiate spontaneous breathing. Intubation may be required in 2% of newborns, and chest compressions and/or adrenaline administration in 0.1%. In all institutions where deliveries take place, protocols must be available in order to quickly reach an experienced resuscitation team for each birth [1].

Case series show that "Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)" has a low risk of vertical transmission at birth, and infants are at low risk of being infected at birth, even in a confirmed coronavirus (COVID-19) positive mother [2].

Maternal infection with COVID-19 may increase the risk of premature birth, and it seems to be an indication that will cause more deliveries by caesarean section [3]. Concerns about maternal health may also be effective in the birth decision [4,5].

Necessary obstetric measures against viral exposure may increase the time it takes to have babies at risk for caesarean section. However, new-borns with mothers infected with COVID-19 do not seem to be more endangered at birth [3].

Regardless of the mother's COVID-19 status, the indications for advance participation in the neonatal team and the clinical factors that may lead to resuscitation remain unchanged. Similarly, the resuscitation/stabilisation procedures during and after the evaluation are the same and follow the standard Neonatal Life Support (NLS) principles [6].

Changes have been made to the standard approach to reduce the risk of COVID-19 cross-infection for staff and infants. Turkish Resuscitation Council adapted the NLS to the conditions of our country for new-borns with or suspected COVID infection and reported the following recommendations [4,5] **(Figure 2)**:

- When maternal COVID-19 is not clinically suspected, staff should use droplet prevention PPE (fluid resistant surgical mask/safety glasses/short sleeve gown and gloves) for any approach.
- Where maternal COVID-19 is suspected/confirmed, personnel should attend resuscitation with full air shielded PPE (FFP3 mask or FFP2 (if FFP3 mask not available) / safety glasses / long sleeved gown and gloves).

Delivery Room

- A significant number of asymptomatic mothers may be infected with COVID-19 at birth [7]. Although it is recommended to define a designated area for the birth of mothers with symptoms suggestive of infection or with confirmed COVID-19 positive status, it may not be possible to distinguish all mothers in this way. Therefore, take appropriate precautions and wear PPE when attending all births.
- Ideally, the delivery of a baby from a COVID-19 suspected/positive mother should take place in a negative pressure room. However, this equipment may not be available in all delivery rooms or operating rooms. The infant should be resuscitated at least 2 meters away from the mother to minimise the risk of droplet spread (the risk of airborne spread still exists) [8]. Providing a mask for the mother can reduce droplet spread

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and, if possible, a partition or resuscitation area in the adjacent room, separate from the delivery chamber, may be considered [5].
- Operating rooms should be considered as areas with a higher risk of droplet or airborne spread due to the nature of the procedures performed on the mother (airway management, diathermy, etc.)

Prenatal discussions with suspected or COVID-19 parents

Depending on hospital policy, the mother may be required to be unaccompanied. Options for prenatal management discussion can be limited. For face-to-face meetings PPE is required as a precaution for droplets. Video conferencing can be used as an alternative to reduce communication. The obstetrics/midwifery team may need to undertake such discussions if the neonatal team is unable to counsel the family.

Prior involvement of the neonatal team (for suspected or COVID-19 positive mother)

Check and prepare the resuscitation area before the mother is admitted to the room. When a neonatal team is called in advance, careful planning is required to minimise the number of people entering the room and should include individuals experienced in neonatal resuscitation and interventional procedures. Additional team members may be required for assistance with the PPE. There should be a separate section within the area for putting on and removing personal protective equipment safely. This should be considered during the preparation of the team, as using PPE may cause delays, especially when there is an urgent need for extra help. If the resuscitation area is the mother's room and the need for intervention is unclear, the neonatal team should wait outside and enter only if needed. Full PPE precaution will be required for anyone entering the room. Teams wearing PPE beforehand can remove their masks/visors while they wait outside until it is clear that they are going to interfere with the baby.

Delivery

In the presence of suspected/confirmed COVID-19 infection, there is no change in the emergency management of the newborn after delivery. Delayed cord clamping is still recommended. The first evaluation of the baby can be done on the perineum, provided that extra attention is paid [5,9,10]. The baby should be given to the neonatal team only if intervention is needed. If the baby is well, it stays with the mother so that exposure to the neonatal team can be avoided.

Neonatal team called after delivery (delivery of suspected or confirmed COVID-19 positive mother)

Staff involved in any delivery should be able to successfully initiate resuscitation of the infant at risk before the neonatal team arrives. Help should be called immediately, as the neonatal team wearing PPE to prevent airborne particles may delay the intervention of the baby.

Approach to resuscitation/stabilisation

Turkish Resuscitation Council recommendations for standard NLS in the resuscitation/stabilisation approach are listed below [6].

a. Precautions should be taken to minimise potential COVID-19 exposure, wet towels should be considered contaminated and removed with care.
b. Although evidence of respiratory infection at birth and viral spread from aerosols generated through subsequent devices or procedures has not yet been identified, the use of a high-impact particulate air (HEPA) filter between the T-piece/self-inflating balloon and mask is recommended [11].
c. Two-handed airway support reduces mask leakage and is preferred when adequate Staff with appropriate PPE is present.
d. Potentially aerosol generating procedures, such as aspiration, should be minimised and the team member performing any advanced airway manoeuvre should be the most experienced [5].

Post-resuscitation care

The recommendations of the Turkish Resuscitation Council to separate the COVID-19 positive mother and new-born are as follows:

a. In general, if the mother is well, the new-born should stay with the mother. If there is a need for observation, it should be followed up by the delivery room team. Skin-to-skin care and breastfeeding may be possible if appropriate precautions are taken, including strict hand hygiene and the use of liquid-resistant surgical masks to reduce the mother's risk of droplet spread [12,13].
b. If the new-born needs to be monitored while lying down, it would be appropriate for the transfer to be via a closed incubator. Minimise exposure of the incubator to the contaminated area; if the resuscitation area is in the same room, the incubator should be kept outside the delivery area/operating room and the baby should be moved to it.
c. Staff accompanying the baby to the neonatal unit should wear PPE against all airborne particles, as there may be a need for intervention during the transfer outside of controlled areas such as the neonatal unit. If the team that transfers the new-born is the team that attended the delivery, changing the PPE should be considered before transfer, as those used in the delivery area may have been contaminated.
d. After resuscitation, the new-born should be isolated until the COVID-19 status is confirmed.

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Postpartum deterioration and resuscitation

If the cause of worsening condition or collapse is unknown, the possibility of COVID-19 infection should be considered. If the incidence of local disease is high and the mother has a definite diagnosis of COVID-19 infection, the suspicion should be much higher. Resuscitation should be done in a designated area to minimise the risk of cross-infection. Evaluation and resuscitation should follow standard NLS principles, regardless of circumstances.

Initial assessment and support team should use minimal droplet-proof PPE. Persons performing an aerosol-generating procedure should wear the full PPE. If intubation is required, the use of videoryngoscopy should be considered.

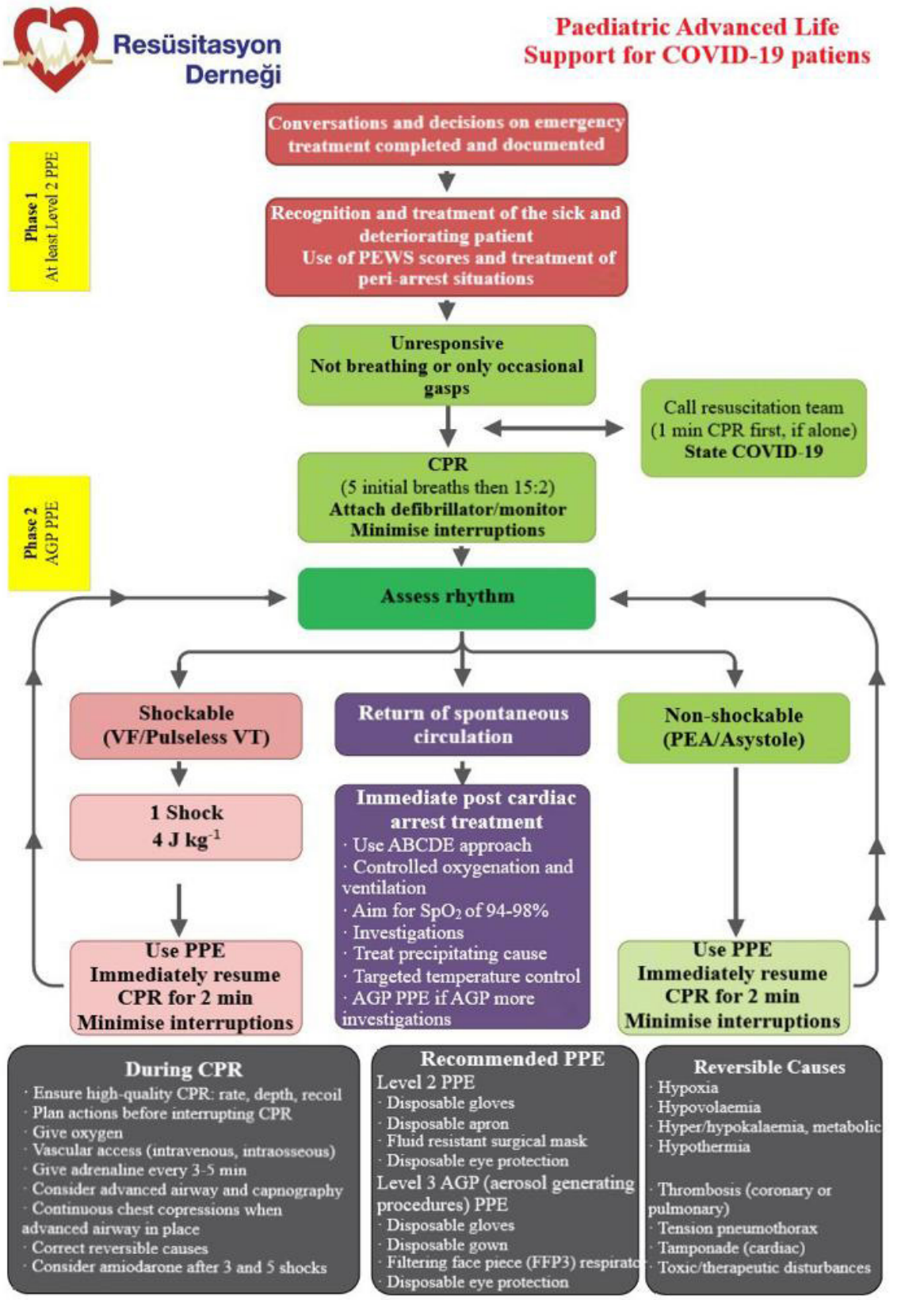
PPE level and respiratory support measure for postpartum collapse Ideally, respiratory support should not be delayed. Mask ventilation and cardiac compressions are considered aerosol-spreading procedures for all age groups, except for the neonatal period immediately after birth [14,15]. There is no published evidence yet that resuscitative measures increase the risk of infection during postpartum collapse. However, due to increased cross-infection concerns, under these circumstances, if handling a baby with postpartum collapse, all PPE should be worn as soon as possible as precaution for airborne particles. In the absence of PPE, which is a precautionary measure for airborne particles, decisions to provide respiratory support should be made with the awareness that there may be a small but as yet unidentified risk for exposure to COVID-19.

CONCLUSION

Cardiopulmonary Resuscitation is an emergency treatment that includes chest compression, ventilation and defibrillation in patients who have had cardiac arrest. For patients requiring CPR during the COVID-19 pandemic, the most important thing to do for rescuers and healthcare workers should be careful CPR practice with the correct use of “Personal Protective Equipment” that reduces the risk of transmission, adhering to the confirmed guidelines. In this sense, we think that basic and advanced life support recommendations for pediatric and new-born patients with a definite or suspected diagnosis of COVID-19, organised by the Turkish Resuscitation Council in cooperation with the ERC, will be useful.

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Figure 1. Pediatric Advanced Life Support Algorithm for COVID -19 Patients [29]

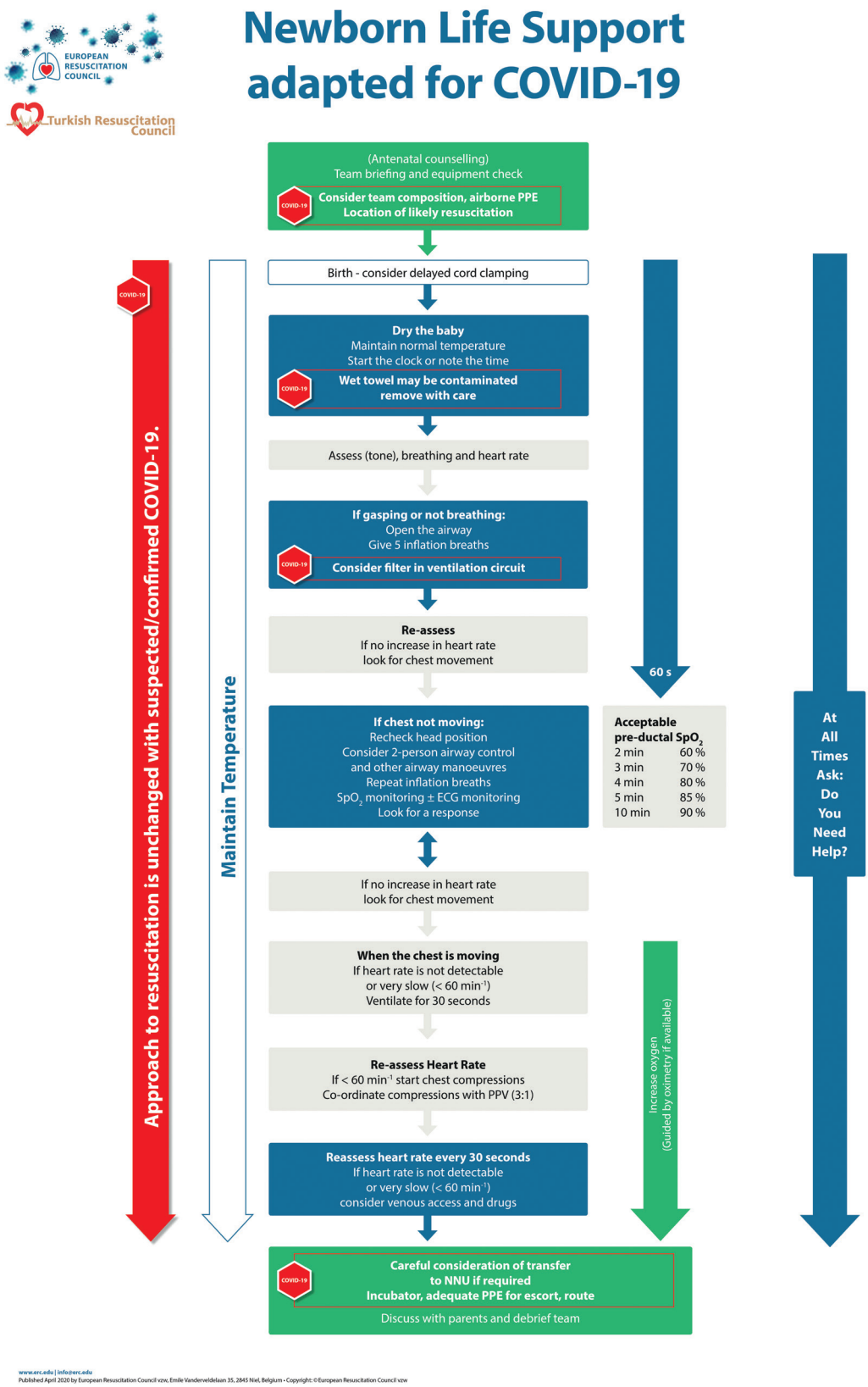


*In Courtesy of the UK Resuscitation Society

**PEWS Pediatric Early Warning Score

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Figure 2. Neonatal Life Support Algorithm for COVID -19 Patients [30]



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