Review Article

Breathing at Birth: Neonatal Resuscitation in the Golden Minute of Life

Mossad Abdelhak Shaban Mohamed[1], Abdelbaset Taher Abdelhalim[2], Khaled Algantri[3], Md Wasek Salam[4], Salaheldin Taher[5], Abdus Salam[6].

Abstract:

At the time of delivery, the process of transition of the baby from the mother's womb to the extra uterine environment is among the most complex adaptations that a human faces in different phases of life. This transition involves both physiological and anatomical changes in the baby that occurs in a relatively short span of time. While most babies can smoothly undergo this transition without much difficulty, there are indeed many who face difficulties in this complex phase resulting in perinatal asphyxia evident by delayed or absent crying, cyanosis, generalized hypotonia, and so on. An astute assessment is needed to identify these babies at birth who are at risk of death or severe complications in the future. After identification, prompt management and resuscitation should be started immediately after birth to ensure the survival of these babies. The first moments after birth are vital, and the first 60 seconds after delivery is known as the golden minute of life. In case a baby does need resuscitation, it is imperative that the baby gets identified and effective resuscitation starts in the golden minute of life. The longer resuscitation is delayed, the more the chance of death or future complications. This paper attempts to describe the steps of neonatal resuscitation of newborn babies suffering from perinatal asphyxia to help them establish effective breathing after birth.

Keywords: neonatal resuscitation; golden minute; neonatal assessment; perinatal asphyxia; cord clamping; chest compressions.

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Introduction:

Initiation of breathing is a life-saving measure during physiological shift from the intrauterine to extra-uterine life, and 5-10% of all new-borns need support to initiate breathing at birth.[1-3] Early neonatal death within the first 24 hours contributes significantly to overall neonatal mortality rates.[4] Over one million stillbirths and around 814,000 neonatal deaths occur in term infants yearly due to intrapartum hypoxic events or birth asphyxia.[1,5] During gestational life, foetal lung alveolar spaces are filled with fluid secreted from the lung epithelium. At that time, gas exchange between the maternal and foetal circulation takes place through the placenta rather than the

1. Mossad Abdelhak Shaban Mohamed, Department of Paediatrics, Kulliyyah of Medicine, International Islamic University, Malaysia,
2. Abdelbaset Taher Abdelhalim, Paediatrics and Pharmacology Unit, Faculty of Medicine, Widad University College, Malaysia,
3. Khaled Algantri, Anatomy and Embryology Unit, Faculty of Medicine, Widad University College, Malaysia,
4. Md Wasek Salam, Resident in Phase-A, MD Paediatrics, Department of Paediatrics, Mymensingh Medical College Hospital, Mymensingh, Bangladesh.,
5. SalaheldinTaher,Junior Clinical Fellow in Paediatrics, Prince Charles Hospital, UK.
6. Abdus Salam,Medical Education Unit, Faculty of Medicine, Widad University College, Malaysia.

Correspondence: Dr Abdus Salam, Consultant Medical Educationalist and Public Health Specialist, Associate Professor and Head of Medical Education Unit, Faculty of Medicine, Widad University College, Kuantan, Pahang, Malaysia. Email: abdussalam.dr@gmail.com.ORCID iD: https://orcid. org/0000-0003-0266-9747

lungs. Moreover, there is less oxygen consumption in the foetus compared to a neonate. During foetal breathing movement, although not involved in foetal oxygenation, lung alveolar fluid is actively propelled out of the lung to the amniotic fluid, and this process of respiration strengthens the diaphragm and intercostal muscles and neural regulations.[6] During delivery, the maternal labour contraction causes constriction of umbilical blood vessels, and thereby baby experiences asphyxia, which is further intensified with the umbilical cord clamp and ending the placental circulation. After delivery, several important physiological changes occur in the neonate. Spontaneous crying of the baby at the time of delivery inflates the lung and causes air to enter the alveoli, and this air replaces the fluid that was previously present in the foetal alveoli. The establishment of pulmonary blood flow instantly capture the task of the placenta and effective gas exchange between the alveoli and outer air occurs instantaneously through respiration. Before spontaneous vaginal delivery, foetal lung fluid production also decreases and spontaneous labour contraction causes chest squeeze that expels some foetal lung fluid through the trachea. Also, fluid present in alveolar spaces is actively transported into the lung interstitium and drained through the pulmonary circulation within 6-24 hours of life.[7] Although it is reported that 83% of neonates start spontaneous breathing immediately after birth, this number increases to 87% with physical stimulation, and still, 10% of neonates at birth need respiratory assistance and around <1% require extensive resuscitation.[8]

Neonatal resuscitation aims to prevent the mortality caused by ischaemic injury to the vital organs such as brain, heart, and kidneys and thereby prevent neonatal death and other long-term complications associated with birth asphyxia and subsequent neuro-developmental sequelae.[9] It is difficult to differentiate a stillborn and a severely depressed newborn, specifically in under-resourced places. Report showed that, out of 136 million babies born yearly, about 10 million needed breathing support at birth.[1]In developing countries, neonatal mortality is a major challenge in enhancing the survival rate of children <5 years.[10] Lack of adequate skilled birth attendance is one of the major obstacles in neonatal resuscitation, particularly in developing countries.[2] Although there are many developments in neonatal management with the accessibility to NICU care, still breathing difficulty is a major cause of neonatal death.[11]

A guideline for neonatal resuscitation has been prepared by the American Academy of Paediatrics to promote neonatal resuscitation. Assistance by drying, warming, stimulation and resuscitation at birth reduces neonatal mortality and morbidity.[12] The Neonatal Resuscitation Program (NRP) regulations have changed over time as the latest evidence emerged. Additional steps that have been added in the latest NRP regulations include the Resuscitation Quality Improvement (RQI) program, which focuses on the skill of PPV.[12] By following the latest NRP guidelines, all Institutions will get help and updated in regards to neonatal resuscitation. This paper describes about neonatal assessment and resuscitation procedures at birth aimed to reduce neonatal mortality and morbidity.

Neonatal assessment and preparing for resuscitation

Anticipating and preparing for resuscitation is an important step for the neonatal resuscitation team. Therefore, the team should do antenatal counselling and have prior knowledge regarding the gestational age, the status of the amniotic fluid, the presence of any additional risk factors and the plan of umbilical cord management from the obstetric care provider.[12] Evaluation of these factors will help them to take proper steps. However, some newborns may also require resuscitation without having any obvious risk factors. There should be at least one qualified individual for every birth with the responsibility to manage the newly born baby and be able to accomplish resuscitation at the initial stage including giving positive pressure ventilation. However, patients having risk factors, at least two qualified persons are needed. The neonatal resuscitation team having full resuscitation skills should be identified beforehand and present during birth[12]. A proper checking and monitoring allows early diagnosis, appropriate counselling and motivation to the parents and appropriate intervention.[13] The team briefing by the team leader and equipment check is the next important steps. All the necessary equipment should be available and functional to proceed to the resuscitation procedure.[12,14] Skills and competencies of the health care facility staff on provision of neonatal care is an important part of neonatal management.[15].

Initial Steps of Newborn Care

The first 60 seconds after delivery is considered the 'Golden Minute' for the evaluation and management of neonates.[3] Immediately after delivery, a rapid initial

assessment of the neonate needs to be done based on the important aspects of delivery, namely term gestation, the establishment of spontaneous crying and breathing, clear amniotic fluid and presence of good muscle tone. Based on these observations, the level of post-natal care to be given to the neonate is decided.[16]

These steps are taken immediately after birth till umbilical cord clamping and to be completed within 30 minutes of birth. There are two levels of post-natal care: routine care and post-resuscitation care. Routine care is given for term neonates with no risk factors, in whom all the above-mentioned criteria are met such as term baby, having spontaneous crying and breathing, no meconium-stained fluid, and with the presence of upright muscle tone. Usually, resuscitation do not require for these babies. Also, those required stimulation and responded to initial steps are also given routine care. The baby needs to be dried with a clean towel and gently stimulated by rubbing on the back with a dry cloth, the feet should be gently flicked, and the mouth and nose should be wiped with a thin piece of cloth. The baby should then be kept with the mother. To maintain warmth, it is necessary to keep the baby in skin-to-skin direct contact with the mother and cover the baby with a warm blanket or towel. The baby's positioning should be such that the airway remains open, and the breathing activity, skin colour, muscle tone, and other vital signs should be cautiously observed. After these are done, the baby can be transferred to the post-natal ward along with the mother.[16] The recommended temperature to be maintained in case of newborns who are non-asphyxiated is between 36.5°C and 37.5°C.[14,17]

Subsequent steps

However, if the above-mentioned criteria are not met, meaning that the baby has depressed breathing or poor muscle tone, not crying, needs supplemental oxygen and/or ongoing nursing care, and has high-risk factors, then following steps should be followed: (1)Initial steps in stabilization, (2) Ventilation and oxygenation, (3) Initiate chest compressions and (4) Administer epinephrine.[14]The first Golden Minute (60-second) is marked for completing the initial assessment, initial steps, re-evaluation, and beginning ventilation if essential. There should not be any unnecessary delay in the commencement of ventilation. This is an important step for successfully resuscitating a newborn who failed to respond in the initial steps.[3]

The baby should be kept warm by moving to a radiant heat source, dried and adequately stimulated; if necessary, with evidence of meconium or obstruction, the infant needs to be suctioned.[16,18] The head position should be the 'sniffing' or neutral position where the neck is kept slightly extended to keep the airway open. For vigorous newborns, the mouth and nose of the infant need to be suctioned with a bulb syringe and perform the initial steps of newborn care keeping baby with the mother.[14,17,18] The baby must be assessed simultaneously using the vital signs of respiration, heart rate and colour at interval of every 30-second. Heart rate is to be assessed using a 3-lead cardiac monitor; and oxygen saturation is to be monitored using pulse oximetry with a preductal probe on the right wrist, hand, or finger.

Ventilation and oxygenation

The newly born babies whose heart rate is ≥ 100 beats/minute, showing respiratory distress, with or without persistent cyanosis, it is necessary to give supplemental oxygen and/or continuous positive airway pressure (CPAP). After 30-seconds, if the neonate develops apnoea, gasping, or bradycardia with a heart rate <100 beats/min, and oxygen saturation cannot be maintained even though oxygen or CPAP were given, then immediately positive pressure ventilation (PPV) should be started to assist the baby in its breathing.[12,16,18] The WHO guideline also recommends similar criteria based on the assessment of breathing. The WHO mentions that for babies who do not breathe despite thorough drying and additional stimulation, PPV should be initiated within one minute after birth.[19]

Thus, in babies with no breathing, tracheal suctioning should be continued until the trachea is cleared of any secretions or meconium or if the baby's heart ratefalls below 60/per minute. In such cases, the baby needs to be ventilated. Tracheal suctioning must be done by a specifically trained person to avoid the hazards associated with the procedure.[2,16] If there are still severe bradycardia persists despite assisted ventilation, then chest compressions coordinated with PPV, and intubation/ laryngeal mask airway need to be performed. Chest compressions should not be initiated without ensuring effective ventilations defined by bilateral breath sounds and

chest movement.

After performing assisted ventilation and coordinated chest compressions, still if the baby showed severe bradycardia, then epinephrine should be given together with simultaneous coordinated PPV, and chest compressions.[14] Hypovolaemia also needs to be corrected. If the team suspects pneumothorax, appropriate measures must be undertaken to diagnose and manage it. If the heart rate is >100b/pm, but there is respiratory distress despite 100% free-flow oxygen, the baby may be kept on CPAP rather than routine intubation for administering PPV, regardless of the gestational age of the baby. Oxygen concentration in PPV should start at 21% for full-term and 21%-30% for pre-term <35 weeks and the oxygen should be titrated to achieve a preductal oxygen saturation approximating the range achieved in healthy term infants. If blended oxygen is unavailable, then resuscitation should be commenced with room air. If baby started breathing but oxygen saturation (SpO_2) is not up to the normal range, then free-flow oxygen to be given at 30%. It is not recommended, to initiate resuscitation of preterm new borns with high oxygen (60% or more). If cardiac compression is started, the O_2 level should be increased to 100% and adjusted accordingly.[12,14] Assisted ventilations should be delivered at a rate of 40 to 60 breaths per minute to achieve or maintain a heart rate >100 per minute. While performing PP, an electronic cardiac monitor is required to accurately assess the heart rate.[12.14]

Positive pressure ventilation (PPV) and endotracheal intubation

The indicator for correct bagging is a rise in heart rate, which should be evident within the first 15 seconds of PPV. If the heart rate is not rising, chest movement needs to be assessed, and bilateral breath sounds with ventilation should be ensured. If there is still no improvement, the 'MR SOPA' ventilation corrective actions have to be taken. Here, (1) M-Mask adjustment in the face (2) R- Repositioning the head and neck, i.e., placing the head neutrally (neck slightly extended) to open the airway or Re-attempt to ventilate if not effective. At this stage, after giving five breaths, chest movement should be assessed. If no chest movement, then the next step should be (3) S- Suctioning of the mouth and nose using a bulb syringe or suction catheter, (4) O- Opening of the mouth gently by using the finger. Here, five breaths are given again and assessed for chest movement. If no chest movement, the next step should be started, which is (5) P- gradually increasing the pressure. The maximum pressure increment is 30cm H_2O for pre-term babies and 40cm H_2O for full-term babies. Five breaths are given again, and the baby is assessed for chest movement. If still not effective, then the final option should be commenced, which is (6) A-Alternative airway by inserting a laryngeal mask. or endotracheal tube (ETT). Despite the PPV, if the baby still showed no improvement and the chest is not moving in spite of performing each corrective ventilation step (MR. SOPA), including intubation, the trachea may be obstructed by thick meconium. In such cases, the trachea should be suctioned using a suction catheter inserted through the ETT, or the ETT should be directly suctioned using a meconium aspirator.[12]

In neonatal resuscitation, the highest priority is given to effective ventilation, it may take longer than 30sec, and corrective actions may be necessary (MR SOPA). Chest compressions should not be started without ensuring effective ventilations defined by bilateral breath sounds and chest movements.

Chest Compressions

Chest compressions must be started immediately if the heart rate is <60bpm despite effective ventilation. The chest compressions should be coordinated with the ventilations and performed for at least 60 seconds before assessing the heart rate. The preferred method of chest compressions is by two hands wrapped around the chest with two thumb technique, and care should be taken to concentrate the pressure on the heart and not over the entire chest. The thumb should be positioned just above the xiphisternum. Intubation is strongly recommended when compressions begin. The compressions must be such that the chest compresses to a length that is 1/3rd the anterior-posterior diameter of the chest cavity. For every three compressions, there should be one ventilation 3:1 and these four events should be administered in two seconds such that a cycle of 90 compressions to 30 ventilations per minute is established. The rhythm of the compressions can be matched by saying One & two & three & breathe & One & two & three & breathe while performing the compressions. The resuscitation team may consider using higher ratios (e.g., 15:2) if the arrest is believed to be of

cardiac origin. Once the cardiac compressions are started, the FiO_2 should be increased to 100% and adjusted according to the pulse oximetry readings. The supplementary oxygen concentration should be stopped to reduce the risks of complications of hyperoxia when the heart rate recovers. It should be kept in mind that the pulse oximetry may not work while the newborn is receiving chest compressions.[12]

Umbilical vein catheterization (UVC)

Aseptic placement of UVC could be considered when compressions are commenced or if there is chance of extended resuscitation to be required. Chest compressions can be continued by moving around to the head of the bed using the thumb technique to allow room for the insertion of UVC. The intraosseous needle is a reasonable alternative.[12] Intraosseous line (IO) is a life-saving in case of inability to secure the UVC due to congenital anomalies or other conditions. The IO needle must be available during neonatal resuscitation with a small sterile drill to minimize the time of insertion of the IO line, which can be used for blood sampling, IV fluids, and emergency medications.[12]

Epinephrine / Adrenaline

Epinephrine is indicated if the heart rate remains <60 bpm despite effective ventilations and another coordinated compressions and ventilations of 60 seconds. It can be administered through the ETT route or UVC, or intraosseous line (IO) if UVC cannot be secured. Although absorption through the ETT route is unreliable and less effective, it is readily available, and moreover, it is necessary to establish the UVC route. So, while establishing UVC, the first dose of epinephrine should be given by the ETT route in most instances, The UVC route is the preferred method, but it requires skills for the placement of the UVC line. Once the line is placed, the dose will be continued through the UVC soon, even after being given via ETT.

The epinephrine has to be given rapidly, and the concentration is 1: 10,000 (0.1mg/ml). The recommended IV dose through the umbilical vein is 0.01 to 0.03 mg/kg per dose (equal to 0.1 to 0.3 mL/kg), and through the ETT, a higher dose of 0.05 to 0.1 mg/kg (equal to 0.5 to 1 mL/kg). Administration of epinephrine through the ETT although faster, studies showed the absorption is unreliable and thus less effective.[3,12,16] The administration of epinephrine should be followed by a 3ml flush of normal saline in all babies. After one minute of compressions and ventilations, heart rate should be re-checked. The dose can be repeated every 3–5 minutes. Epinephrine can be given again immediately after UVC placement if given initially through ETT without waiting for a further 3 minutes.[12]

Volume Expander

Volume expansion is considered when blood loss is known or suspected as evidenced by pale skin, weak pulse, poor perfusion, prolonged Capillary refill time (CRT) and no adequateheart response after other resuscitative measures. The volume expander to be useful in the delivery room could be an isotonic crystalloid solution or O-negative blood.[12]

Sodium Bicarbonate and Naloxone

Babies with metabolic acidosis, sodium bicarbonate should not be given routinely. There is insufficient evidence to evaluate the safety and efficacy of administering naloxone to a newborn with respiratory depression for fear of inducing pulmonary oedema cardiac arrest, and/or seizures.[12]

When to stop resuscitation?

Decisions to continue or discontinue resuscitation efforts vary at different regions with underlying resource availability. In a newly born baby with the conditions of high mortality and the outcomes are poor, withholding of the resuscitative actions can be applicable. But here parental agreement is an important factor.[3,16] In the case of newly born baby with no detectable heartbeat, the decision to stop or discontinue resuscitation is considered justified as these babies showed either a high morbidity and mortalityor severe neurological disability.[3,16] However, considering the baby's gestation week, any complications, aetiology of arrest, presence of hypothermia and parents feelings about the acceptable risk of morbidity, resuscitation can be continued beyond 10 minutes with no detectable heart rate.[3] Effective communication between the obstetric and paediatric services is essential to assess the need for resuscitation and adequate preparation.[7]

Team leader and closed loop

The team leader is the person selected from the team member who is ample efficient in the neonatal

resuscitation procedure as well as have effective leadership skills. The team leader must possess good communication skills and be able to give clear directions to specific individuals. He/she should share the relevant information and distribute responsibilities to the members accordingly to ensure coordinated care while maintaining a professional environment. All team members should be allowed to use the resources available and should be aware of the entire clinical situation and should not be distracted by any activity. If the leader is involved in a procedure that diverts their attention, the leader may need to appoint another qualified person with a clear verbal statement.[12] Skills in communication is an art,[20] and communication can be offered best by relating to theacronym TEA that stands for 'tell, explain and assess'.[21,22] and thus ensured that the message of the team leader has been transmitted to all team members accurately.

What is closed-loop communication?

Closed-loop communication is a communication technique that confirms instructions or messages are heard and understood by the team members. Successful coordination via sharing information and through closed-loop communication with each other is important in a team work. Each team member in the neonatal resuscitation team bears the responsibility that the correct interventions are performed following the correct orderand technique. Therefore, when an order is given by the team leader, it should be directed to the specific individual by calling the person in the team by name and making direct eye contact with a clear voice. On the other hand, after receiving instructions, the receiver repeats back the message to the sender confirming his/her understanding. After giving order, the receiver need to be informed to report back immediately after completion of the task. The accurate documentation of all these communications is very important.

Key Behavioural Skills necessary for the neonatal resuscitation program

There are 10 NRP key behavioural skills identified for effective teamwork which are: (1) knowledge of the environment such as location and access to the resuscitation equipment, (2) anticipation and planning, (3) clear identification of the team leader, (4) effective communication, (5) distribution of workload, (6) attention allocation wisely, (7) use of all available information, (8) use of all available resources, (9) calling for help early and (10) maintenance of professional behaviour.[12]

Equipment preparation

The essential types of equipment necessary for neonatal resuscitation are listed in a simplified algorithm by the American Academy of Paediatrics,[12] and the World Health Organization.[23] In the checklist it includes: equipment to provide warmth, such as (1) radiant warmers, (2) plastic wrap with a cap, (3) thermal mattress, (4) warmed humidified gases, (5) increased room temperature to 23 to 25° C (74 to 77° F), (6) skin-to-skin contact and (7) portable incubator. The suction devices including bulb syringe, suction catheter and tracheal aspirator are needed to clear the airway. Ventilation devices, equipment for oxygenation and intubation, and stethoscopes for auscultation are important equipment for resuscitation. Important medication in the list includes epinephrine, normal saline, dextrose and necessary syringes, three-way stopcocks or connectors, a table of medication dosages and necessary umbilical vessel catheterization supplies. The other important miscellaneous things include gloves, towels/cloths, head covering, scissors, ties, a suction device, a ventilation device, a stethoscope and a timer.[12]

Cord clamping

Placenta contains a significant amount of baby's blood immediately after delivery that plays an important role in the newly born baby's transition. The perfect timing for clamping is still under research. In pre-term newborns, delayed cord clamp for more than 30 secondshave some benefits such as higher blood volume and blood pressure, decreased need of medications, decreased blood transfusions required during hospitalization, lesser chance of cerebral haemorrhage and decreased incidence of necrotizing enterocolitis (NEC) and improved survival.[14,18] The haematologic counts are improved in term and late pre-term newborns and the neuro-developmental outcomes are better as well. However, there arean increased chance of requiring phototherapy for hyperbilirubinemia. It is suggested to plan the timing of umbilical cord clamping with the obstetric team before birth. [14,18]

In most vigorous term and preterm babies, clamping can be delayed for 30 to 60 seconds. During delayed cord clamping, the baby may be placed skin-to-skin or kept warm using a dry towel or blanket. It is to be remembered that until the cord is clamped, the baby will receive warm blood from the placenta. The baby's tone and breathing effort should be evaluated while the initial management steps are continued.[17,18.] However, there are situations where the immediate cord clamping is required such as cases of placental insufficiency. Delayed cord clamping is also excluded in multiple gestations. For the cases with limited safety data on delayed cord clamping, for example, cases of intrauterine growth retardation (IUGR), abnormal umbilical arterial (UA) doppler measurements, abnormal placentation etc; decision to be taken by both neonatal and obstetricians.[17]

Conclusion:

Many babies are born each year worldwide who fail to establish immediate crying and respiration at the time of birth, resulting in increased mortality or long-term complications in the future. It is imperative that they get effective neonatal resuscitation, and the faster it is started, the better the likelihood of the outcome. This is why prompt interventions in the golden minute of life are crucial to ensure the survival and avoidance of long-term complications in these babies. For resuscitation to be effective, the healthcare providers must be adequately trained in the NRP guidelines and follow the guidelines properly and should be up to date in knowledge regarding the changes in the NRP guidelines.

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Authors' Contribution

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