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Effective Neonatal Resuscitation: A Must for Child Survival in An Asphyxiated Birth

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Abstract
Birth asphyxia is one of the most common causes of neonatal mortality and long-term neurological damage globally, accounting for nearly one million neonatal fatalities yearly. The burden is disproportionately higher in low- and middle-income countries (LMIC) particularly sub-Saharan Africa and South Asia where limited access to skilled birth attendants, inadequate obstetric care, late recognition of foetal distress and lack of neonatal resuscitation resources are major contributors to poor outcomes. Neonatal resuscitation is a life-saving intervention that can avoid a considerable proportion of death and disability from birth hypoxia. The key elements of a successful newborn resuscitation are rapid assessment, early beginning of breathing, airway patency, adequate chest compressions when necessary, and proper post-resuscitation care. The application of evidence-based neonatal resuscitation guidelines developed by the World Health Organization (WHO), the International Liaison Committee on Resuscitation (ILCOR), and the Neonatal Resuscitation Program (NRP) have dramatically increased neonatal survival in many healthcare settings. Nurses, midwives, neonatologists and other health care workers have a key role in readiness, early recognition of neonatal compromise and provision of high quality resuscitation care. However, many resource-restricted settings still struggle with obstacles such as inadequate equipment, limited healthcare staff, lack of training and poor health system infrastructure that hinder good newborn outcomes. Ongoing in-service training, simulation training, quality improvement projects and investment in important infant care services are key to improving neonatal survival. This review discusses the burden of birth asphyxia, underlying pathophysiology, current evidence-based neonatal resuscitation practices, post-resuscitation management, the existing obstacles, and possible futures that aim to strengthen neonatal survival and reduce preventable neonatal mortality worldwide.

Keywords: *Neonatal mortality, neonatal resuscitation, neonatal intensive care, neonatal outcomes, nurses, newborn survival, ventilation, birth asphyxia.*

INTRODUCTION

The neonatal period, first 28 days of life, is the most vulnerable period of human survival. During this period the newborn undergoes important physiological adjustments needed for extrauterine existence. Failure to establish adequate spontaneous respiration shortly after birth can lead to birth asphyxia, a major cause of infant mortality and long-term neurological damage worldwide[1]. Birth asphyxia is defined as a condition in which the neonate fails to start and maintain respiration soon after delivery, resulting to inadequate oxygen delivery, carbon dioxide retention, metabolic acidosis and numerous organ failure if not addressed rapidly [2].

Globally, roughly 10% of babies require assistance to begin breathing at birth, 3-6% require positive pressure ventilation and less than 1% require intensive resuscitation such as chest compressions and medicines [3] Recent advances in obstetric and neonatal care have led to decreased neonatal mortality in many high-income countries, but birth asphyxia remains a

significant public health issue in low- and middle-income countries where healthcare systems are often constrained by a lack of skilled workers, critical equipment, and efficient referral systems. Neonatal resuscitation is one of the most effective therapies to reduce mortality from birth asphyxia. Data suggest that starting breathing during the "Golden Minute" after birth increases infant survival and minimises the risk of hypoxic-ischemic brain damage [4]. International standards propose an organised, evidence-based strategy that includes prompt assessment, airway management, adequate ventilation, chest compressions where required, administration of medications, and comprehensive post-resuscitation care. Ongoing training of health workers particularly nurses and midwives who conduct most deliveries in many settings is still required to maintain competency and adherence to standardised resuscitation methods. This review highlights epidemiology, pathophysiology, concepts and clinical practice of efficient neonatal resuscitation and the vital role of neonatal resuscitation in enhancing newborn survival in infants with birth asphyxia[5].

Birth Asphyxia Burden

Although there have been major advances in maternal and newborn health care, birth asphyxia remains to be a major global health problem. It is a major cause of newborn mortality, contributing for almost one-quarter of all neonatal fatalities globally [6]. Nearly 2.3 million babies die each year in the neonatal era, with a substantial portion of these preventable deaths due to intrapartum-related hypoxia (birth asphyxia) (United Nations Inter-Agency Group for Child Mortality Estimation [7]

The burden is particularly heavy in low- and middle-income nations, in sub-Saharan Africa and South Asia, where more than 95% of neonatal deaths due to birth asphyxia happen. Contributing factors include inaccessibility to excellent antenatal care, delayed diagnosis of obstetric problems, prolonged/ obstructed labour, inadequate foetal monitoring, poor referral systems, lack of skilled birth attendants and poor neonatal intensive care facilities. Transportation delays and the lack of emergency obstetric care often result in greater mortality in rural settings[8].

Birth asphyxia, besides death, is a significant cause of long-term disability in survivors. Prolonged oxygen deprivation at delivery can cause hypoxic-ischemic encephalopathy (HIE), cerebral palsy, epilepsy, developmental delay, hearing loss, visual impairments, intellectual disability, and learning disabilities. These complications have important emotional, social and economic consequences for the families involved and for health care systems. Neonatal mortality in Nigeria still ranks among the highest in the world. Birth asphyxia still ranks among the top three causes of neonatal deaths. Initiatives like the Helping Babies Breathe (HBB) programme, Essential Newborn Care training and the increase in skilled birth attendance have demonstrated measurable reductions in neonatal mortality in several regions, but the gap between urban and rural healthcare facilities remains significant. Neonatal outcomes are compromised by limited availability of functioning resuscitation equipment, uneven staff training and inadequate quality improvement mechanisms [9].

Evidence suggests that timely and successful newborn resuscitation could prevent around one third of neonatal deaths due to intrapartum hypoxia[10]. Therefore, enhancing neonatal resuscitation capacity through ongoing professional education, simulation-based training, adequate provision of equipment and supportive health policies is one of the most cost-effective strategies to improve neonatal survival and achieve the Sustainable Development Goal target of reducing neonatal mortality to fewer than 12 deaths per 1000 live births by 2030.

Birth asphyxia pathophysiology

Birth asphyxia is a stoppage or reduction in the delivery of oxygen to the foetus or baby before, during, or soon after delivery resulting in hypoxia (lower oxygen levels), hypercapnia (elevated carbon dioxide levels), and metabolic acidosis. This is usually caused by decreased placental gas exchange, umbilical cord compression, maternal hypotension, placental abruption, uterine rupture, prolonged labour or difficulty of the newborn to establish adequate spontaneous respiration after birth [11]

When the foetus is deprived of oxygen, it first activates compensatory reactions to maintain blood flow to essential organs such as the brain, heart, and adrenal glands. This redistribution of cardiac output is mediated by peripheral vasoconstriction and enhanced sympathetic nervous system activity. With continued hypoxia these compensatory mechanisms become depleted resulting in myocardial depression, decreased cardiac output, systemic hypotension and decreased perfusion of vital organs. Cellular metabolism changes from aerobic to anaerobic pathways, resulting in lactate buildup, depletion of adenosine triphosphate (ATP), intracellular acidosis and increasing cellular dysfunction[12].

The brain is particularly vulnerable to hypoxia damage because of its high demand for oxygen. Severe or chronic hypoxia may cause hypoxic-ischemic encephalopathy characterised by neuronal damage, cerebral oedema, excitotoxicity (driven by glutamate release), oxidative stress, inflammation and apoptotic cell death. Reperfusion following successful resuscitation may further increase tissue damage through ischemia-reperfusion injury, underlining the significance of cautious post-resuscitation management[13].

Birth asphyxia also affects many organ systems. Cardiovascular complications include myocardial dysfunction and hypotension, pulmonary effects include persistent pulmonary hypertension of the newborn, renal hypoperfusion may lead

to acute kidney injury, hepatic dysfunction can interfere with metabolic processes, and gastrointestinal ischaemia increases the risk of necrotising enterocolitis. The severity of these consequences relies on the duration and intensity of oxygen deprivation and the timeliness and efficiency of resuscitative interventions[14]. Understanding these pathophysiological processes underlines the vital significance of adequate ventilation in the first minute of life to restore oxygenation, rectify metabolic derangements, and minimise irreparable organ damage. Thus, early evidence-based newborn resuscitation is critical for increasing survival and long-term neurodevelopmental outcomes.

Risk Factors of Birth Asphyxia

Birth asphyxia is due to a complicated interaction of maternal, foetal, placental, and intrapartum variables which impairs the transport of oxygen to the foetus before to, during and soon after birth. Early detection of these risk factors is important for timely obstetric intervention and newborn resuscitation readiness (World Health Organization [15] Maternal-related risk factors include hypertensive disorders of pregnancy such as pre-eclampsia and eclampsia, gestational diabetes mellitus, severe anaemia, maternal infections, prolonged hypotension, cardiac diseases and substance abuse. Inadequate antenatal care, advanced maternal age, teenage pregnancy, malnutrition and multiple pregnancies also increase the risk of foetal compromise. Obstetric complications such as prolonged or obstructed labour, uterine rupture, placental abruption, placenta previa, umbilical cord prolapse and meconium stained amniotic fluid are major contributors to intrapartum hypoxia (International Liaison Committee on Resuscitation [16]

Foetal risk factors include prematurity, post-term pregnancy, foetal growth restriction, congenital malformations of the airway or circulatory system, intrauterine infections, oligohydramnios, polyhydramnios, malpresentation (e.g. breech or transverse lying) and repeated pregnancies. The irregular foetal heart rate pattern during labour is called foetal distress. Foetal distress is generally an indication of inadequate oxygenation and requires immediate attention to prevent birth asphyxia.

In low-resource countries, health care system issues also have an important role in the occurrence of birth asphyxia. These include insufficient foetal monitoring, delayed recognition of obstetric emergencies, paucity of competent birth attendants, delayed referral to higher level hospitals, absence of crucial neonatal resuscitation equipment and poor communication among healthcare providers. Addressing these modifiable risk factors with quality antenatal care, good intrapartum surveillance, appropriate obstetric treatments and preparedness for newborn resuscitation can go a long way in reducing the incidence of birth asphyxia and improving neonatal survival [17]

Principles of Effective Resuscitation of the Newborn

Effective neonatal resuscitation is a systematic, evidence-based method to establish adequate ventilation and circulation in newborn infants who do not initiate or sustain spontaneous breathing at birth. About 90 % of neonates will make the transition without assistance. About 10 % will need some type of aid. Less than 1 % will need advanced resuscitative efforts. Therefore, a timely and professional resuscitation is crucial to reduce infant mortality and avoid hypoxic-ischemic brain injury [18]

Successful neonatal resuscitation starts before to delivery of the infant. Every birth should be attended by at least one health care clinician skilled in neonatal resuscitation and whose only role is to care for the newborn. More skilled individuals who are able to undertake advanced interventions are needed for high risk deliveries. Preparation include an overview of the maternal and foetal risk factors, assessment of resuscitation equipment, proper room temperature to prevent hypothermia, and assignment of duties for the team prior to delivery [19].

The minimum equipment comprises a radiant warmer, a suction device, a self-inflating or T-piece resuscitation bag, face masks of appropriate size, an oxygen source with blender (where available), a pulse oximeter, a laryngoscope, endotracheal tubes, emergency medications, and umbilical venous catheterisation equipment.

Immediately after birth, the newborn should be quickly examined by asking three crucial questions:

- Was the baby born full term?
- Does the infant have good muscle tone?
- Does the infant breathe or cry?

If the answer to all three questions is yes, the infant needs simply regular care of drying, keeping warm, delayed cord clamping as needed, skin-to-skin contact with the mother and ongoing observation. If any answer is “no,” begin newborn resuscitation without delay.

The first steps of newborn resuscitation should ideally be accomplished during the first Golden Minute, the important first 60 seconds after birth during which effective ventilation should be commenced if required. These steps include:

- Providing warmth on a radiant warmer.

*Position the head in a neutral ("sniffing") position to maintain airway patency.
- Clear the airway only if secretions are visible if secretions restrict breathing.
• Removing damp linens and drying the infant thoroughly;
• Stimulate gently by massaging the back or flicking the soles of the feet if there is no spontaneous breathing

Routine deep suctioning is no longer suggested even in vigorous infants born through meconium-stained amniotic fluid, as it may delay ventilation and cause damage.

Positive pressure ventilation is the most crucial intervention in newborn resuscitation. If the newborn is apneic, gasping, or has a heart rate <100 beats per minute after the initial steps, begin PPV immediately using room air for term newborns and lower concentrations of oxygen for preterm infants, titrating oxygen to pulse oximetry.

Visible chest movement and improvement in HR confirms effective ventilation. If chest movement is inadequate, corrective steps should be taken as summarised by the MR SOPA sequence:
• M – Adjust Mask
• R – Re-position airway
• S – Suction mouth and nose if obstructed
• O – Open your mouth
• P – Increase in pressure
• A – Alternative airway (endotracheal tube or laryngeal mask)

Reassess the heart rate after about 30 seconds of effective breathing.
If the heart rate is not greater than 60 beats per minute for at least 30 seconds of efficient ventilation, chest compressions are necessary. Compressions should be performed using the two-thumb encircling approach with a 3:1 compression-to-ventilation ratio, aiming for roughly 120 events per minute (90 compressions and 30 breaths).

Reassess the effectiveness of the compressions every 60 seconds by measuring heart rate and clinical reaction. The priority is still to ventilate since the most common cause of neonatal cardiac compromise is respiratory failure. If the heart rate is less than 60 beats per minute despite good respiration and chest compressions, epinephrine should be delivered, preferably through an umbilical venous catheter. Endotracheal absorption is unreliable hence intravenous delivery is preferred. If blood loss or hypovolemia is suspected, isotonic crystalloid volume expansion may be advised. Continuous electrocardiographic monitoring, pulse oximetry and frequent reassessment guide continued resuscitative operations. Effective cooperation, closed-loop communication, and use of standardised resuscitation methods increase performance and patient outcomes throughout the process.

The Role of Nurses and Midwives

Nurses and midwives are usually the first health professionals to check newborns soon after birth. Their role includes preparing resuscitation equipment, identifying infants in need of resuscitation, initiating ventilation, helping with advanced procedures, documenting resuscitation events, working well as part of a multidisciplinary team, and supporting parents during and after the resuscitation. Regular competency-based training, simulation exercises, and involvement in quality improvement programs are critical to maintain proficiency and ensure high-quality newborn resuscitation[20].

Successful newborn resuscitation does not end with return of spontaneous circulation and respiration. Newborns who require resuscitation continue to be at substantial risk for recurrent respiratory failure, hypoxic-ischemic encephalopathy, metabolic derangements, convulsions, and multiorgan dysfunction. Therefore, comprehensive post-resuscitation care is needed to increase survival and optimise long-term neurodevelopmental outcome [21]. Once stable, infants should be transferred to a neonatal intensive care unit or special care baby unit, if available, for close observation. Continuous measurement of heart rate, respiration rate, oxygen saturation, blood pressure, body temperature, blood glucose, urine output and neurological condition might help identify issues early. It is vital to maintain normothermia since both hypothermia and hyperthermia might aggravate the brain damage. Therapeutic hypothermia, commenced within six hours of birth in eligible term and near term infants with moderate to severe hypoxic-ischaemic encephalopathy, has been proven to reduce mortality and improve neurodevelopmental outcome in centres with the proper equipment[22]. Continue appropriate respiratory care based on the clinical status of the newborn with supplementary oxygen, continuous positive airway pressure (CPAP) or mechanical ventilation as necessary. Oxygen therapy should be properly titrated to avoid hypoxia and hyperoxia which can contribute to oxidative damage. Normal blood glucose levels should be maintained, and electrolyte imbalance and metabolic acidosis should be treated in time[23].

Neurological assessment is important because seizures can arise after hypoxic-ischemic brain injury and require prompt identification and management. Also monitor renal, hepatic, cardiovascular, and gastrointestinal functions as birth asphyxia sometimes involves several organ systems. The initiation of nutritional supplementation should be cautious, taking into account the cerebral condition and gastrointestinal perfusion of the infant[24].

Post-resuscitation care includes parental counselling as a vital part. Healthcare personnel should clearly communicate the infant's status, projected prognosis, planned interventions, and potential long-term follow-up needs. Furthermore, a multidisciplinary follow-up including paediatricians, nurses, physiotherapists, occupational therapists, and developmental experts is indicated to detect and treat neurodevelopmental deficits early and improve the child's overall quality of life[25]. Despite substantial breakthroughs in the science of neonatal resuscitation, the transfer of evidence-based resuscitation procedures remains a major hurdle in many low-resource settings, particularly sub-Saharan Africa and South Asia, where the prevalence of birth asphyxia is highest. Poor health systems, lack of infrastructure, shortages of skilled healthcare professionals and limited access to vital neonatal equipment still contribute to unnecessary neonatal mortality [26] A key challenge is the lack of experienced delivery attendants who know newborn resuscitation. Many deliveries take place in primary healthcare institutions or in rural regions where health care providers are not formally trained or have sporadic refresher courses on current resuscitation recommendations. Overburdened workloads, staff attritions and inadequate supportive supervision also compromise quality of care in newborn units. Additionally, many health institutions lack working radiant warmers, newborn self-inflating bags, correctly sized face masks, suction equipment, pulse oximeters, oxygen delivery systems and neonatal critical care facilities, making prompt and efficient resuscitation difficult[27].

Maternal deaths occur when mothers are not provided with access to comprehensive emergency obstetric and neonatal care because of delayed recognition of obstetric emergencies, weak referral system, transportation problems and financial restrictions. Cultural beliefs, home deliveries with incompetent birth attendants and delayed health care seeking behaviour further enhance the risk of delivery asphyxia and newborn mortality. Poor documentation and limited use of quality improvement tools in many settings hamper the continual evaluation of newborn outcomes and identification of gaps in care[28].

Tackling these challenges calls for continued investment in health system infrastructure, equitable distribution of essential neonatal resuscitation equipment, strengthening of referral systems, regular competency based training using simulation, supportive supervision and implementation of national newborn care policies. Cooperation between governments, professional organisations, development partners and local communities is crucial to achieve universal access to high quality newborn resuscitation services and to promote child survival[29].

A persistent commitment to evidence-based practice, health system strengthening, technology innovation, and continuing professional development will be required to improve newborn survival among infants affected by birth asphyxia. Future strategies should focus on increasing access to high-quality neonatal resuscitation training programmes such as the Helping Babies Breathe (HBB) initiative and the Neonatal Resuscitation Program (NRP), especially for nurses, midwives, physicians and community health workers who are working in resource limited settings. Simulation-based education, low-dose high-frequency training, and periodic competency evaluations have all been shown to improve healthcare providers' knowledge, technical skills, and retention of resuscitation competencies[30].

Governments and health care organisations ought to emphasise the supply of basic newborn resuscitation equipment at all levels of health care delivery. Maternity and neonatal units should have standardised newborn resuscitation kits, reliable oxygen delivery systems, pulse oximeters, radiant heaters and neonatal monitoring devices. Quality improvement programs that incorporate monthly clinical audits, mortality evaluations and assessment of performance can increase adherence to worldwide resuscitation recommendations and improve patient outcomes[31].

New technologies, such as telemedicine, online learning platforms, artificial intelligence-based clinical decision support systems and mobile health applications, hold great promise for improving neonatal resuscitation education, remote mentorship and real-time clinical decision making, particularly in areas with limited resources. Further research is needed to evaluate cost-effective interventions appropriate for low-resource settings and to provide context-specific evidence for policy formulation[32].

Policymakers should boost maternal and newborn health programmes by incorporating neonatal resuscitation into national health plans, strengthening emergency obstetric referral systems, and providing universal access to expert birth attendance. International collaboration between governments, academic institutions, professional associations and global health organisations is needed to reach the Sustainable Development Goal of neonatal mortality of less than 12 per 1,000 live births by 2030 and to ensure that all newborns receive timely, high-quality resuscitative care.

Conclusions

Birth asphyxia continues to be one of the primary causes of infant mortality and long-term neurological impairment globally, especially in low- and middle-income nations. Effective neonatal resuscitation is among the most cost-effective and significant strategies to reduce unnecessary baby deaths and improve long-term developmental outcomes. Early recognition of compromise, commencement of ventilation within the "Golden Minute", following evidence-based resuscitation standards and extensive post-resuscitation care are key to successful management of the baby. Nurses, midwives, doctors and other health professionals are critical to providing preparation, prompt interventions and support to families across the continuum of care. Strengthening healthcare systems along with continuing professional education,

simulation based training, adequate provision of needed equipment, quality improvement programs and supportive national policies will go a long way in improving neonatal survival. Sustained investment in maternal and newborn health care and coordinated efforts at the global level are vital to minimise the burden of birth asphyxia and to guarantee that every newborn gets the opportunity to live and develop.

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