جمعية القلب السعودية
Saudi Heart Association

National Life Support Committee

SNRP

SHA Neonatal Resuscitation Program
Provider Manual

Saudi Neonatal Resuscitation Program Provider Manual

2026

The Saudi Neonatal Resuscitation Program
Provider Manual
(SHA SNRP - 2026)
Second Edition

PREFACE

The SHA SNRP course is structured into six primary modules, each designed to meet specific learning objectives. It reviews the most critical concepts for providing care to critically or seriously ill neonates, drawing upon the latest evidence-based literature.

This course is intended for a wide range of healthcare professionals, including neonatologists, nurses, paramedics, and respiratory therapists.

For further, in-depth information, please refer to the references detailed in the final chapter.

ACKNOWLEDGEMENTS

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Their vital support and collaborative spirit were crucial in the development of this course's content, particularly in advancing the integrated simulation technologies and pedagogical approaches.

Furthermore, the SHA wishes to acknowledge and thank Dr. Khalid Otaif for his distinguished contribution to the design of the SNRP Provider Course manuals.

The Saudi Neonatal Resuscitation Program Provider Manual (SHA SNRP - 2026) Second Edition

AUTHORS

Fahad Alharbi	MD Consultant Neonatologist Dr Sulaiman Alhabib Medical Group Riyadh, Saudi Arabia
Ali Almudeer	MD Consultant Neonatologist King Saud University Medical City Riyadh, Saudi Arabia
Fawaz Kashlan	MD Consultant Neonatologist Prince Sultan Military Medical City. Riyadh, Saudi Arabia
Sameh Abozaid	MD Consultant Neonatologist King Fahad Medical City Riyadh, Saudi Arabia
Adnan Hadid	MD Clinical Assistant Professor of Pediatrics College of Medicine,King Saud University, Riyadh, Saudi Arabia
Mohammed Al-Hindi	MD, MSc Associate Professor of Pediatrics College of Medicine, King Saud bin Abdulaziz University for Health Sciences Consultant Neonatologist King Abdulaziz Medical City - Western Region, Jeddah Saudi Arabia Ministry of National Guard
Hakem Shakour	RN, MSN Simulation Specialist , Clinical Skill & Simulation Center King Saud University, Riyadh, Saudi Arabia
Fahad Alsohime	MD Associate Professor of Pediatrics College of Medicine, King Saud University, Riyadh, Saudi Arabia

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Course overview

INTRODUCTION

The Saudi Heart Association Neonatal Resuscitation Program (SHA SNRP) Provider Course is an evidence-based educational initiative. It is designed for healthcare professionals who care for newborns during delivery and in acute care settings, focusing on facilitating learning and promoting effective team-based care. Participants in the SHA SNRP Provider course will be trained to rapidly assess a newborn, make appropriate decisions regarding interventions, and practice the necessary steps for resuscitation.

Course Description

The SHA SNRP Provider Course provides the following components to facilitate the achievement of course objectives:

- Pre-course Textbook
- Educational Sessions:
  - Didactic lectures
  - Interactive Discussion
- Practical Application:
  - Skills stations
  - Simulation sessions with debriefing
- Assessment:
  - Case scenario testing
  - Post-test online exam

PURPOSE OF THE SHA SNRP PROVIDER COURSE

The Saudi Heart Association Neonatal Resuscitation Program (SHA SNRP) Provider Course is an evidence-based training program. It is designed for healthcare professionals who provide care to newborns during delivery and in acute care settings, aiming to enhance their learning and promote effective, team-based care.
Participants in the SHA SNRP Provider course will gain proficiency in rapidly assessing a newborn, determining the necessary interventions, and practicing the steps required for successful resuscitation.

SHA NRP
Course Agenda
Registration & Course Introduction
Neonatal Resuscitation Fundamentals
Preparation for Neonatal Resuscitation (History taking, prepare equipment & team and initialsteps)
Break
Respiratory management in neonatal resuscitation
Positive pressure ventilation Advanced Airway Management
Cardiovascular management in neonatal resuscitation
Break
Vascular access Medication administration
Special considerations And post-resuscitation Care
Simulation based practice & testing scenario
Written Exam

Chapter 2

Neonatal Resuscitation Fundamentals

CHAPTER OBJECTIVES :

Upon completion of this chapter, you will be able to:

- Describe the physiological changes that occur prenatally, perinatally, and postnatally.
- Identify neonates who require resuscitation based on the mother's prenatal history and established risk factors.
- Identify all newborns needing resuscitation.
- Know how to assemble and check the necessary equipment and supplies for performing resuscitation.
- Understand the importance of high-performance team dynamics, including the specific roles and responsibilities of resuscitation team members.
- Initiate the neonatal resuscitation procedure.

INTRODUCTION

The shift from intrauterine to extrauterine existence involves significant physiological changes at birth, which can reveal issues previously undetected. Consequently, a neonatal resuscitation expert must be present at every delivery. Assessing the risk of newborn pathology is aided by considering gestational age and growth characteristics.

A minority of newborns, specifically 10%, require some form of respiratory assistance immediately after birth, with only 1% needing prolonged resuscitation. Various factors necessitate resuscitation at birth, often leading to depression (as shown in a corresponding Table). The presence of maternal or fetal comorbidities significantly increases the likelihood of requiring resuscitation.

The failure of newborns to initiate and sustain adequate spontaneous respiration substantially contributes to early mortality and the burden of unfavorable neurodevelopmental outcomes among survivors.

Therefore, prompt and effective resuscitation at birth is crucial for improving newborn outcomes. Further details on the physiological changes during the transition from intrauterine to extrauterine life are available.

Successful newborn resuscitation, essential for optimizing the chances of survival, hinges on a series of rapid, successive critical steps. The International Liaison Committee on Resuscitation's (ILCOR) Formula for Survival emphasizes three core elements for favorable resuscitation outcomes: protocols based on reliable resuscitation science, high-quality education for resuscitation providers, and the prompt and effective implementation of resuscitation efforts.

In response to this need, the Saudi Heart Association (SHA) launched an initiative to develop a national program. This program is designed to be simplified, concise, and adaptable to the needs of the Kingdom of Saudi Arabia, while remaining grounded in the latest and best evidence-based practices.

The transition of a newborn from the intrauterine environment to life outside the womb involves numerous physiologic and functional changes.

Fetal Cardiovascular Function and Circulation

Fetal circulation is distinctive because blood bypasses the non-ventilating lungs via right-to-left shunting. This is achieved through two primary structures: the patent ductus arteriosus (connecting the pulmonary artery and the aorta) and the foramen ovale (connecting the right and left atria).

The right side of the heart ejects blood, 90-95% of which is redirected away from the lungs and into the systemic circulation. This circulatory pattern is maintained by two primary factors: high resistance in the pulmonary arterioles and the relatively low systemic resistance provided mainly by the placenta.

The patency of the ductus arteriosus is maintained by local prostaglandin production and the low fetal systemic oxygen level (approximately 25 mm Hg).

The foramen ovale remains open due to the pressure difference between the atria. The right atrial pressure is elevated because a large volume of oxygenated blood returns from the placenta, whereas the left atrial pressure is low since the non-functional lungs return minimal blood.

Since the lungs are non-functional, they require only a small amount of blood. Consequently, the majority of the blood from the right heart is redirected through the foramen ovale and the ductus arteriosus. Both of these crucial structures typically close shortly after birth (as shown in Figure 2.1).

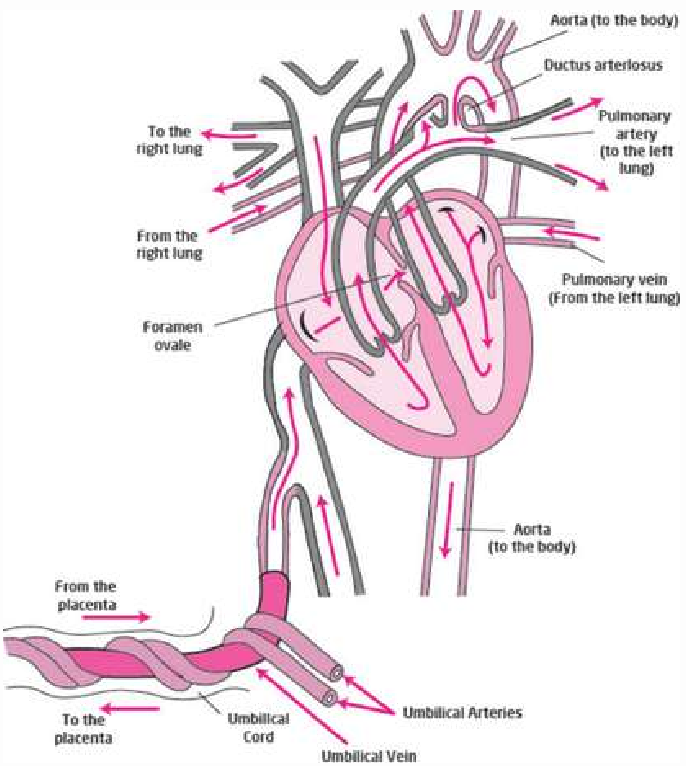

Figure 2.1 Fetal Circulation Path

Postnatal Transition to Adult Circulation

The shift from fetal to neonatal circulation is marked by significant changes in the cardiopulmonary system following the first few breaths, leading to increased pulmonary blood flow and the functional closure of the foramen ovale.
The transition from fetal to adult circulation involves three critical changes:

1- Pulmonary Arteriolar Resistance Drop (Pulmonary Circulation):

- The expansion of the lungs, combined with the increase in oxygen (PaO2) and decrease in carbon dioxide (PaCO2) levels, triggers vasodilation in the pulmonary vessels.

- This vasodilation results in a significant reduction in pulmonary arteriolar resistance, promoting blood flow to the lungs.

- The mechanical effect of the ribs and chest wall's elastic recoil also lowers pulmonary interstitial pressure, further improving capillary blood flow.

2. Foramen Ovale Closure:

- Increased blood flow from the lungs elevates pressure in the left atrium.
- Simultaneously, the cessation of placental circulation decreases venous return to the right atrium, lowering right atrial pressure.
- This resulting pressure gradient (Left Atrium > Right Atrium) functionally forces the fetal septa (septum primum and septum secundum) together, closing the foramen ovale.
- Permanent closure typically occurs as these septa fuse over time.

3- Ductus Arteriosus Closure (Transitional and Adult Circulation) :

- Immediately postpartum, the systemic vascular resistance surpasses pulmonary resistance, reversing the fetal shunt. This initial phase is characterized by a left-to-right shunt through the still-patent ductus arteriosus, known as transitional circulation.

- The ductus arteriosus typically constricts and closes within 24 to 72 hours.

- The primary stimuli for this closure are the high oxygen content (PO2) in the aortic blood supplying the ductus (via the vasa vasorum) and changes in prostaglandin metabolism.

- Once closed, the circulation becomes an adult-type series circuit, with ventricles pumping sequentially and the elimination of significant shunts between the pulmonary and systemic systems.

Persistent Pulmonary Hypertension of the Newborn (PPHN) - Reversion to Fetal Circulation

Severe neonatal stress, such as asphyxia-induced hypoxia and hypercarbia, can cause a reversion to the fetal circulatory pattern. This stress leads to pulmonary vasoconstriction and ductus arteriosus widening, resulting in a right-to-left shunt through the patent ductus arteriosus and/or a reopened foramen ovale. This condition, Persistent Pulmonary Hypertension of the Newborn (PPHN), causes severe hypoxemia. Treatment targets reversing the underlying causes of pulmonary vasoconstriction.

Neonatal Pulmonary Function : Lung Development and Transition at Birth

Fetal lung development is an ongoing process of organogenesis and differentiation.
Surfactant - producing Type II pneumocytes appear around 25 weeks of gestation and mature throughout pregnancy . The lungs continuously produce fluid , a mix of transudate from pulmonary capillaries and surfactant from type II pneumocytes.
For successful air exchange to begin at birth, both the alveolar and interstitial fluid in the lungs must be cleared rapidly. The primary mechanism for this clearance is the opening of sodium channels on the lung epithelium, which draws fluid into the lung cells. Notably, fetal thoracic compression during delivery contributes minimally to this fluid evacuation. A delay in this crucial clearance process is the likely cause of transient tachypnea in the newborn (Figure 2.2)

During birth, the powerful initial inspiratory efforts, combined with the elastic recoil of the ribs, draw air into the pulmonary tree, establishing air-fluid interfaces within the alveoli. Surfactant is released into these interfaces with the first breath.

Its critical function is to lower high surface tension, which, if unchecked, would lead to atelectasis (lung collapse) and significantly increase the work of breathing.

In some newborns, insufficient surfactant production can lead to diffuse atelectasis and the development of respiratory distress syndrome (RDS). Factors such as maternal hyperglycemia, neonatal meconium aspiration, and neonatal sepsis can negatively affect surfactant development and function. To help premature newborns, surfactant synthesis can be enhanced by administering corticosteroids to the mother 24 to 48 hours before delivery. Alternatively, the newborn can receive intratracheal surfactant after birth.

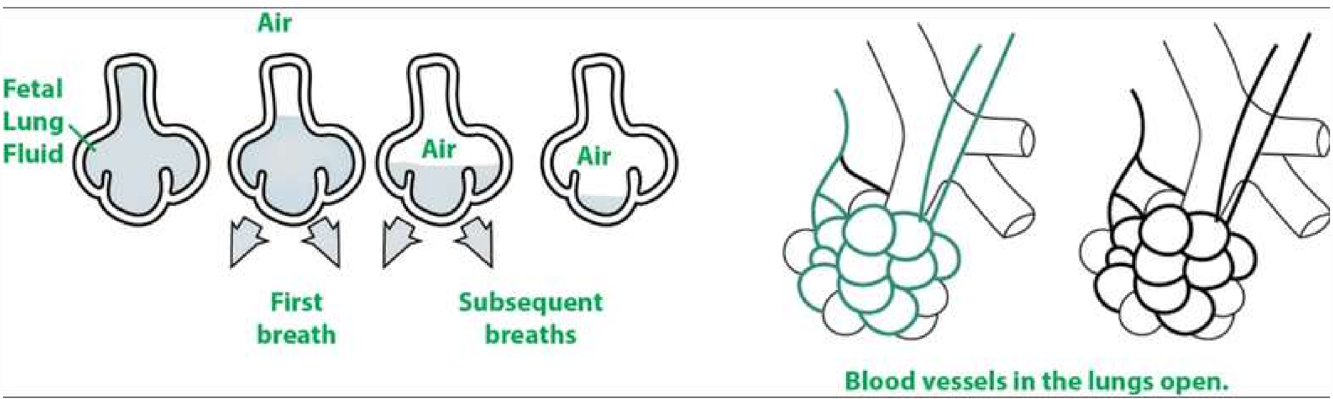

Figure 2.2 Fluid in the alveoli is replaced by air.

The Newborn Chain of Survival and Well-being

The "Newborn Chain of Survival" is a vital, integrated, and sequential series of actions designed to maximize a newborn's chances of survival following a perinatal emergency and ensure their long-term health. This approach emphasizes interdependence among its links, promoting proactive, team-based, and family-centered care that spans from preconception through the recovery phase.

1- Prevention: The Foundation of Fetal Well-being

This critical first link focuses on optimizing the health of the pregnant individual long before and throughout gestation. It encompasses robust antenatal care, including regular check-ups, nutritional guidance, and education on warning signs. A thorough risk assessment is paramount, identifying factors that could predispose the fetus to complications (e.g., prematurity, multiple gestation, maternal infections, hypertensive disorders, or poorly controlled diabetes). Proactive management of these risks, such as administering corticosteroids for threatened preterm birth or prescribing anti-hypertensive medication, is essential to mitigate potential fetal distress, congenital anomalies, and the need for resuscitation at birth. The goal is to reduce the incidence of complications requiring intervention later in the chain.

2- Anticipation and Activation: Preparedness and Mobilization

Anticipation is key in neonatal resuscitation. This link recognizes that approximately 5–10% of all newborns will require some form of breathing assistance at birth. It necessitates the immediate recognition of high-risk births (e.g., emergency cesarean section, meconium-stained amniotic fluid, prolonged rupture of membranes, or known fetal compromise).

This recognition triggers the pre-emptive mobilization and preparation of a fully trained and equipped resuscitation team. The team must ensure all necessary equipment is functional, warmed, and readily accessible (including radiant warmer, oxygen, suction, and resuscitation devices). A clear plan, including assigned roles and a designated communication strategy, must be in place to ensure a rapid and coordinated response when the newborn is born.

3-Initial Steps: Essential Care for All Births

These simple, yet vital, steps are necessary for nearly all newborns to successfully transition from fetal to neonatal life. The fundamental components include:

- **Providing Warmth**: Placing the newborn under a radiant warmer or against the mother's skin and to mitigate the risks of hypothermia by preventing heat loss, they must be covered.
- **Drying:** Thoroughly drying the newborn, especially the head and body, helps to prevent evaporative heat loss.
- **Stimulation:** Gentle tactile stimulation, such as rubbing the back or soles of the feet, encourages spontaneous breathing. Vigorous or harmful stimulation is avoided.
- **Positioning and Suction (as needed):** Positioning the head in a "sniffing" position to open the airway. Suctioning of the mouth and nose is performed only if the airway is obstructed by secretions or if the newborn is not vigorous.
- **Deferring Cord Clamping:** For term and preterm newborns not requiring immediate resuscitation, **delayed cord clamping** (at least 60 seconds) is recommended. This beneficial placental transfusion increases blood volume and oxygen-carrying capacity, reducing anemia and intraventricular hemorrhage risk, especially in preterm infants.

4- Ventilation: The Cornerstone of Resuscitation

If, after the initial steps, the newborn remains apneic (not breathing) or has a heart rate of less than 100 beats per minute (bpm), ventilation becomes the single most crucial intervention. The principle is to establish effective air exchange. This is typically achieved using positive-pressure ventilation (PPV) delivered via a face mask connected to a self-inflating bag, T-piece resuscitator, or flow-inflating bag. Proper technique, including achieving a tight seal and ensuring the chest rises symmetrically, is continuously assessed. If mask ventilation is ineffective; LMA or ETT must be considered promptly to prove the oxygenation to vital organs.

5- **Advanced Cardiovascular Management : Intervention for Persistent Compromise**

If the newborn's heart rate remains below 60 bpm despite 30 seconds of effective ventilation (usually with supplemental oxygen), advanced resuscitation is initiated. This involves a coordinated sequence of highly skilled interventions:

- **Chest Compressions.**
- **Medication Administration**: Epinephrine (adrenaline) is the primary medication used, typically given intravenously or intraosseously, to stimulate the heart.
- **Vascular Access:** Securing either umbilical venous catheter (UVC) or intraosseous (IO) access is critical for the reliable and rapid administration of medications and volume expanders.
- **Consideration of Volume Expanders**: If blood loss is suspected, volume expanders (e.g., normal saline or blood) may be administered.
- **Targeted Temperature Management**: Therapeutic hypothermia may be initiated for term or near-term newborns who experienced moderate to severe hypoxic-ischemic encephalopathy (HIE).

6-Postresuscitation Care : Stabilization and Surveillance

Following successful resuscitation and stabilization, the newborn requires a period of intensive observation and specialized care. This link focuses on managing the potential immediate complications that follow a significant perinatal event. Key aspects include:

- **Close Monitoring:** Continuous monitoring of vital signs, including heart rate, respiratory rate, oxygen saturation, and blood pressure.
- **Metabolic Management:** Aggressive prevention and management of hypoglycemia (low blood sugar), which can severely damage the recovering brain.
- **Thermal Regulation:** Strict maintenance of normothermia, avoiding both hypothermia and hyperthermia.
- **Respiratory Support**: Ongoing assessment and management of any persistent respiratory issues , which may necessitate CPAP or mechanical ventilation.
- **Addressing Potential Organ Dysfunction:** Monitoring for signs of injury to other organs, such as the kidneys or brain.

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7- Long-Term Recovery : Sustained Support and Family Reintegration

The final link extends beyond the hospital stay, focusing on the long-term well-being of the newborn and the psychosocial needs of the family.

- **Long-term Follow-up**

  Providing specialized developmental follow-up services (e.g., high-risk newborn clinics) to monitor growth , neurological status, and developmental milestones. Early identificatio n and intervention for developmental delays are crucial.

- **Specialized Services:**

  Access to physical therapy , occupational therapy, speech therapy , and nutritional support as needed.

- **Family Support:**

  Addressing the emotional trauma and stress experienced by the parents. This includes counseling, connecting families with support groups, and ensuring they are fully integrated into the ongoing care and decision-making process for their child's developmental trajectory. The ultimate goa l is to facilitate the newborn's full potential and support the family unit after discharge.

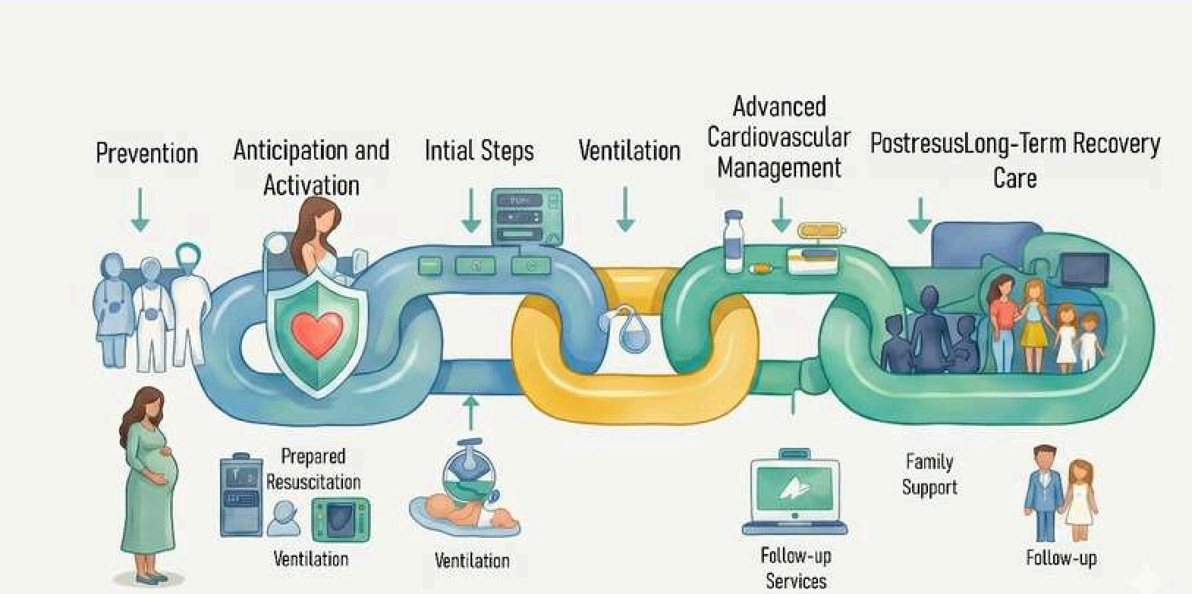

Figure 2.3 Neonatal Resuscitation chain of survival links

Indicators for Neonatal Resuscitation

Several factors can predict the need for resuscitation in newborns. Premature newborns, as previously noted, have an increased risk. Furthermore, studies show that babies born to mothers with obesity are more likely to require ventilation.

Muscle tone also serves as a critical indicator related to ventilation status: strong muscle tone is suggested by flexed extremities, while flaccid extremities may signal inadequate ventilation.

CATEGORY	SPECIFIC CONDITIONS
Respiratory Issues	Respiratory distress or failure.
Airway Obstruction	Presence of blood, meconium, or mucus; anatomical airway abnormalities (e.g., atresia, agenesis, stenosis).
Maternal Medications / Substance Use	Exposure to drugs causing respiratory depression: analgesics, hypnotics, anesthetics, magnesium sulfate, opioids, or maternal drug abuse.
Antepartum Disorders	Maternal diabetes, toxemia, placental insufficiency, placenta previa, placental abruption, renovascular hypertension, maternal smoking, or uterine tetany.
Intrapartum Asphyxia	Cord compression, cord prolapse, fetal blood loss, maternal hypotension, maternal hypoxemia, or placental insufficiency.
Central Nervous System (CNS) Issues	Congenital abnormalities of the brain stem, intracerebral hemorrhage, or spinal cord injury.
Lung and Chest Disorders	Diaphragmatic hernia, pneumothorax, pulmonary hypoplasia, or congenital pneumonia.
Congenital Heart Diseases	Ductal-dependent lesions causing hypoxia due to decreased pulmonary blood flow, or mixing lesions.
Surfactant Deficiency	Prematurity or being a newborn of a diabetic mother.
Other	Hypotension.

Table 2.1 Conditions in the Neonate Requiring Potential Resuscitation at Birth

Others

Perinatal risk factors, detailed in the attached appendix, increase the likelihood of needing resuscitation, NICU admission, and perinatal mortality.
A validated antenatal risk score index is used to categorize pregnancy risk as low, moderate, or high (see Table 2.2). This risk categorization allows institutions to develop guidelines for various actions, including: transferring high-risk pregnancies to tertiary centers, allocating appropriate personnel and resources, and determining the need for a specialized team's presence in the delivery room.

The Apgar score

The Apgar score serves as an assessment of a newborn's cardiorespiratory and neurological status immediately following birth. This score, however, is not intended to predict a patient's long-term prognosis or to guide immediate resuscitation efforts or future medical care.

The Apgar score is derived from five indicators of neonatal health: appearance, pulse, grimace, activity, and respiration (detailed in Table 2.3). Each indicator is assigned a score ranging from 0 to 2. The resulting total score is influenced by factors such as the newborn's physiological maturity, birth weight, maternal therapy during the perinatal period, and the fetus's cardiorespiratory and neurological condition.
Interpretation of the Apgar score at five minutes is as follows (refer to Table 2.3) :

- Normal: 7 to 10
- Intermediate: 4 to 6
- Low: 0 to 3

A low Apgar score (0 to 3) is considered a clinical observation, not a specific diagnosis. Such low scores can stem from a variety of underlying issues, including acute, treatable conditions with good outcomes, as well as severe, chronic problems with poor prognoses.

ANTEPARTUM RISK FACTORS

- Preterm (less than 36 weeks) or post-term (41+ weeks) gestation,
- Preeclampsia/eclampsia
- Maternal hypertension
- Multiple gestation
- Fetal anemia
- Polyhydramnios
- Oligohydramnios
- Fetal hydrops
- Fetal macrosomia
- IUGR
- Significant fetal anomalies
- Absent prenatal care

INTRAPARTUM RISK FACTORS

- Complicated deliveries:
- Shoulder dystocia
- Emergency C-section
- Meconium-stained fluid
- Forceps/vacuum use
- Abnormal presentation
- (e.g., breech)
- Category II/III fetal heart rate
- Maternal general anesthesia /magnesium/opioids (within
- 4 hours of delivery)
- Placenta abruption/previa,
- Intrapartum bleeding
- Chorioamnionitis
- Prolapsed cord

Table 2.2 Factors Increasing Neonatal Resuscitation Likelihood

Criteria	Mnemonic	0	1	2
Color	Appearance	Blue/pale	Pink body, blue extremities	All pink
Heart rate	Pulse	Absent	< 100 beats/min	> 100 beats/min
Reflex response	Grimace	None	Grimace	Sneeze / cough
Muscle tone	Activity	Limp	Some extremity flexion	Active
Respiration	Respiration	Absent	Irregular/slow	Good/ crying

Table 2.3 Apgar Score

The required staffing for neonatal resuscitation varies based on the newborn's risk assessment:

- **Low Risk (Score 0-3) :**
  A minimum of one person trained in initial neonatal resuscitation, including PPV, must attend every birth.
  Other staff capable of full resuscitation should be readily available, even without risk factors.

- **Moderate Risk (Score 4-6) :**
  If risk factors are present, a minimum of two skilled individuals whose sole focus is the newborn is required.

- **High Risk (Score >7) or Complex Resuscitation :**
  A team of four or more members may be necessary. Ideally, the entire resuscitation team should be assembled before the birth occurs.

Staff Qualifications

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Every resuscitation team must include certified personnel who are fully trained in advanced resuscitation techniques, such as endotracheal intubation, chest compressions, emergency vascular access, and medication administration. The full team must be present at birth if these advanced interventions are anticipated.

The Importance of High-Performance Teamwork

Every resuscitation team must include certified personnel who are fully trained in advanced resuscitation techniques, such as endotracheal intubation, chest compressions, emergency vascular access, and medication administration. The full team must be present at birth if these advanced interventions are anticipated.

Teamwork is a highly productive work style that consistently delivers superior outcomes compared to individual efforts. In healthcare, effective teamwork has tangible benefits, including reduced medical errors, shorter patient wait times, and improved patient safety.

Furthermore, for healthcare professionals, successful teamwork contributes to greater job satisfaction by fostering a sense of belonging and social connectedness.

Communication	Task Execution	Team Dynamics
Good communication	Complete tasks efficiently	Cooperating effectively
Speaking out loud	Clear roles and responsibilities	Team synergy
Sharing information	Coordination of roles and responsibilities	Conflict resolution
Closing the loop	Delegating specific roles to the right team members	

Table 2.4 Key Elements of High-Performance Teamwork in the NICU

Pre-Birth questions and Team Preparation

Effective communication between obstetric and newborn healthcare professionals is essential for coordinated care. Prior to every delivery, it is essential to assess both antepartum and intrapartum risk factors. Ensure you obtain answers to the following four crucial prenatal questions:

1. What is the typical gestational age?
2. Is the amniotic fluid clear?
3. Are there any additional risk factors present?
4. What is the management plan for the umbilical cord?

The answers to these questions will guide the assembly of the necessary team members and equipment.

Neonatal Resuscitation Team and Preparation

Preparation is paramount. This involves:

- Assigning specific tasks to team members.
- Identifying perinatal risk factors.
- Preparing and inspecting all necessary equipment.

The required team members and their qualifications will be determined by the risk assessment. Establish a documented policy that outlines who must attend births, the credentials required based on the perinatal risk assessment, and the procedure for obtaining additional assistance if needed.

Figure 2.4 Neonatal resuscitation team

1. Effective Communication : The Foundation of Teamwork in Newborn Resuscitation

Successful teamwork during newborn resuscitation (a "code") heavily relies on effective communication, which encompasses three core techniques: speaking aloud, sharing information, and clarifying what one has heard.

Speaking Aloud (Saying It Out Loud)

This technique involves clearly vocalizing one's thoughts, actions, or intentions. Essential information that should be reported aloud includes:

- The newborn's vital signs.
- Team members' interventions (e.g., counting chest compressions, medication administration).
- The code's progression (e.g., duration of the resuscitation).

It is also vital to provide a concise summary of the code's events to new team members as they arrive. The effectiveness of team collaboration is influenced by factors such as the volume, frequency, and tone used when speaking aloud.

Figure 2.5 : Closed loop communication

Sharing Information (Sharing One's Views)

Sharing information involves expressing one's opinions or ideas—distinct from simply speaking facts aloud—to convey significant insights. Examples include:

- Offering advice, particularly to the team leader.
- Voicing objections to actions being taken by others during the code.

Teams that actively promote an environment where "everyone to voice their ideas" and encourage new members to speak up facilitate the sharing of information. Participants stressed that the tone in which ideas are shared influences how they are received, much like speaking aloud. They recommended offering comments in a "pleasant and low-toned" manner rather than a harsh one.

Closing the Loop: Ensuring Mutual Understanding

Effective communication requires a "back and forth" process, which includes clarifying what is heard and offering feedback to those who provide information or express opinions. This procedure, illustrated in Figure 2.5, encompasses several actions to ensure mutual understanding, such as:

- Repeating what was said.
- Verifying that a team member's input has been heard.
- Confirming one's observations with other team members.
- Seeking clarification if anything was expressed unclearly.

2. Efficient Task Completion

Executing tasks effectively is fundamental to successful collaboration during a neonatal resuscitation (code). This process is built upon the team's organized structure. To optimize teamwork during NICU resuscitations, three key elements are essential: effective communication, proficient task execution, and seamless teamwork.

Defining and Assigning Roles

A successful code requires clear role assignment for every team member. Responsibilities that must be delegated include, but are not limited to, chest compressions, assisted ventilation ("bagging"), medication administration, equipment management, documentation, procurement of necessary items ("running"), patient monitoring, and overall situation awareness ("viewing the complete picture").

Team members without specific duties can feel ineffective and awkward as they wait for direction. Furthermore, a lack of assigned roles may necessitate team members to "multi-task," potentially reducing efficiency.

Coordination and Leadership

Explicit and direct instructions from the team leader are vital behaviors that facilitate effective task coordination.

Strategic Role Delegation

A successful code also depends on well-defined tasks, strong leadership, and assigning the most suitable personnel to carry them out. The ideal team must have the optimal number of members. Too many people ("bombarded with bodies") can cause confusion, while being "short-handed" forces team members to multi-task, both of which compromise efficiency.

3. Effective Cooperation : Working Well Together

Effective teamwork in a neonatal unit during a code relies fundamentally on the third component: Working Well Together, which centers on positive coworker interaction. This is achieved through two key processes: "Team Synergy" and "Conflict Resolution."

Team Synergy

The most successful resuscitation teams are those that work synergistically—where every member is "in sync" and the group is cohesive. This synchronization is rooted in mutual confidence, trust, and prior collaboration among team members. A strong sense of being "close to" and "supported by" colleagues is strongly associated with achieving team synergy.

Conflict Resolution

Effective collaboration requires skilled management of the disagreements that frequently arise during a code. Interpersonal issues are exacerbated if the team leader is insensitive to team members' feelings. When a code is not progressing well, a common reaction is "finger-pointing" and blaming others.

The "debrief" following the code is the most effective mechanism for resolving interpersonal disputes. Debriefing allows teams to reflect on how they can collaborate more effectively and prevents "resentments" from festering. To successfully resolve problems, team members must be willing to openly discuss their concerns and inquire about the concerns of others who appeared unhappy during the code.

Neonatal Resuscitation Team Roles

Team Members

Team members are expected to be competent and knowledgeable in their assigned roles.
A standard high-performing resuscitation team includes:

- Team leader
- Compressor
- Airway manager
- I.V./I.O. provider
- Time recorder/documenter and monitoring

Equipments and Supplies Preparation for Neonatal Resuscitation

All necessary and functional equipment and supplies must be available and ready to use for every birth. particularly those anticipated to be high-risk (Figure 2.7). Utilizing a routine, standardized checklist before each birth is crucial for organized and effective preparation, ensuring immediate use of equipment and identifying any missing items (Table 2.5).
For preterm deliveries, the room temperature should be set to between 23 and 25 °C beforehand.

Figure 2.6 Team Members positions.

Figure 2.7 Equipment and Supplies preparation

Category	Required Items
Warmth	• Preheat warmer (in every delivery room, and at least one unit in E.R.) • Warm towels or blankets • Long-term resuscitation headgear with temperature sensor and sensor cover • Hat • Plastic bag or plastic wrap • Chemically activated warming pad • Transport incubator ready
Clear Airway	• Bulb syringe • 10F or 12F suction catheter attached to wall suction set at 80-100 mm Hg (when occluded) • Meconium aspirator
Auscultation	• Stethoscope (Pediatric/newborn size)
Oxygenation	• Method for free-flow oxygen (mask, tubing, air-inflating bag, or T-piece) • Gases flowing between 5 and 10 L/min immediately before birth • Blender configured in accordance with protocol • Pulse oximeter and oximeter pulse probe (detached until needed)
Ventilation	• Positive-pressure ventilation (PPV) device(s) present with term and preterm masks • T-piece resuscitator • Self-inflating bag size 240 ml or PPV device(s) functioning • Connected to air/oxygen source (blender) • 8F feeding tube and 20-mL syringe • Cardiac monitor and leads
Intubation	• Laryngoscope Size 0 and Size 1 (and size 00) blades with bright light • Endotracheal tubes, sizes 2.5, 3.0, 3.5, 4.0 • Stylets • Laryngeal mask airway (size 1) and 5-mL syringe • Measuring tape
Medication	• Access to 1:10,000 epinephrine and normal saline • Supplies for administering medications and placing emergency umbilical venous catheter • Documentation supplies

Table 2.5 Pre-Resuscitation Checklist

Initial Assessment of a Newborn

All newborns require immediate evaluation, conducted between delivery and umbilical cord clamping, the initial evaluation, performed right after birth, involves answering three key questions:

1. Is the baby born at term?
2. Is the baby crying or breathing?
3. Does the newborn have good muscle tone?

A stable newborn, having met all three criteria, initial procedures can be done on the mother chest or abdomen. If the newborn fails to meet even one of these criteria, the next steps for assessment and intervention must be immediately implemented.

Umbilical cord management

The management of the umbilical cord is essential for the newborn's circulatory transition from the fetal to the neonatal period.
The precise moment of birth—when the last part of the fetus is delivered—must be recorded with a timer.For newborns who do not need immediate resuscitation, a delay in umbilical cord clamping of at least 60 seconds is recommended.

Deferred Cord Clamping (DCC):

Vigorous newborns

Vigorous newborns (not needing immediate resuscitation): Defer clamping for at least 60 seconds, ideally with the newborn skin-to-skin or securely wrapped. Initial newborn care steps should be performed during this time in the mother's abdomen or abdomen before cord clamping.

- Preterm newborns : DCC is linked to increased survival, decreased need for blood pressure support, and fewer transfusions, but it increases the risk of hypothermia.
- Term newborns: DCC increases hematocrit and iron levels , potentially improving neurodevelopment, but it may increase the need for phototherapy for hyperbilirubinemia.

Early (Immediate) Cord Clamping (ECC):

- ECC is indicated when placental circulation is compromised (e.g., abruption , previa , cord avulsion).
- ECC may be considered in multiple gestations (due to limited data and theoretical risks) and other scenarios with affected utero-placental perfusion (e.g. , fetal growth restriction, abnormal Doppler), based on unit policy and shared decision-making.

Non-vigorous newborns:

Delayed Cord Clamping and Initial Care:

- Vigorous Newborns: If placental circulation is intact, a brief deferral of cord clamping is suggested while initiating initial newborn care and gentle stimulation, although definitive evidence for a specific recommendation is insufficient.
- Need for Immediate Resuscitation: Clamp the cord and immediately begin assisted ventilation at the warmer if the newborn remains apneic or the HR <100 bpm by 60 seconds after birth.

Umbilical Cord Milking (UCM):

- Term/Late Preterm (Non-Vigorous): For non-vigorous term or late preterm newborns who do not respond to approximately 20-30 seconds of stimulation, performing umbilical cord milking towards the newborn 3-4 times is a reasonable alternative to early cord clamping (ECC).
- Preterm (< 28 weeks): For non-vigorous infants born before 28 weeks' gestation, the resuscitation team should initiate stimulation and perform initial steps (on the mother's abdomen and chest). However, early cord clamping is required if the baby remains limp and apneic, as Intact Cord Milking is not routinely advised. Crucially, assisted ventilation must be started without delay if the infant remains apneic and the heart rate is less than 100 bpm by 60 seconds of birth.
- Preterm (28–34 weeks): Umbilical Cord Milking is not recommended for non-vigorous preterm newborns at 28–34 weeks' gestation.

Gestational Age Group	Vigour Status	Umbilical Cord Management Strategy	Rationale/Recommendation
Term and Late Preterm (35–42 Weeks)	Non-vigorous	Milking the intact umbilical cord (pushing residual placental blood into the baby)	May be considered a reasonable alternative to immediate clamping to support the transition to extrauterine life.
Preterm (28–34 Weeks)	Non-vigorous	Intact umbilical cord milking	Insufficient evidence to routinely recommend. Established resuscitation protocols should be prioritized.
Extremely Preterm (<28 Weeks)	Non-vigorous	Intact umbilical cord milking is NOT recommended	Significant association with an increased riskof severe intra-ventricular hemorrhage (IVH). Safer alternatives (DCC or ICC + resuscitation) are preferred.

Table 2.6 Umbilical Cord Management Strategy

Initial Steps :

- Vigorous, term newborns: Perform routine initial steps (warmth, drying, positioning, clearing the airway if needed) with the cord intact while the newborn is skin-to-skin.
- Non-vigorous and preterm newborns: Those needing immediate resuscitation go directly to the radiant warmer. Newborns qualifying for a DCC trial may receive initial steps before clamping. Non-vigorous or preterm newborns are moved to the radiant warmer after clamping for assessment and intervention.

Initial Steps for the Unstable Newborn

If any of the initial three questions received a negative response, continue with the subsequent assessment and initial steps:

1- Provide Warmth :

- Move the newborn under a radiant warmer.
- Attach a temperature sensor to monitor the newborn and prevent both hypothermia and hyperthermia.
- Keep the newborn uncovered for better visualization.
- Maintain the newborn's body temperature between 36.5°C and 37.5°C.

Figure 2.8 Provide warmth using warmer radiant

2-Drying and Temperature Management

For very premature newborns born, immediate drying is not necessary. Instead, the baby should be wrapped in polyethylene plastic right away to minimize heat loss through evaporation. For other newborns, dry the baby thoroughly with a warm blanket, then promptly replace the wet blanket with a dry one to prevent further heat loss (Refer to Figure 2.8).

Figure 2.9 Dry the baby

3- Open the Airway

Position the head/neck in the "sniffing position" (neutral or slightly extended) to keep the baby's airway open.This ensures air can enter without obstruction. The baby's gaze should be directed straight up toward the ceiling when in this position (Figure 2.10).

4- Stimulation

To increase respiration, apply gentle stimulation, such as softly rubbing the back or flicking the sole of the foot, if the child's breathing is insufficient.

Important Note: Avoid intense stimulation and never shake a child.

5- Suctioning

To ensure a patent airway, a rolled towel should be placed under the newborn's shoulders.
Generally, routine suctioning is not necessary for active newborns. However, secretions must be cleared in specific situations: if the newborn is gasping, apneic (not breathing), has an obstructed airway, struggles to clear secretions, shows weak muscle tone, or if ventilation is anticipated.
Turn the newborn's head laterally before suctioning. Suction the mouth before the nose to minimize aspiration risk (see Figure 2.12).
During the initial minute of a procedure, it is important to avoid excessive suctioning of the posterior pharynx, as this may trigger a vagal response, potentially resulting in bradycardia (slow heart rate) or apnea (cessation of breathing).
If a suction catheter is employed, the suction control should be set to generate a negative pressure between 80 and 100 mm Hg when the tubing is occluded (blocked).

Figure 2.10 Open newborn airway by sniffing position

Figure 2.11 Stimulate the newborn by gently rubbing the back, trunk, or limbs.

Figure 2.12 Using a bulb syringe, suction the mouth prior to suctioning the nose.

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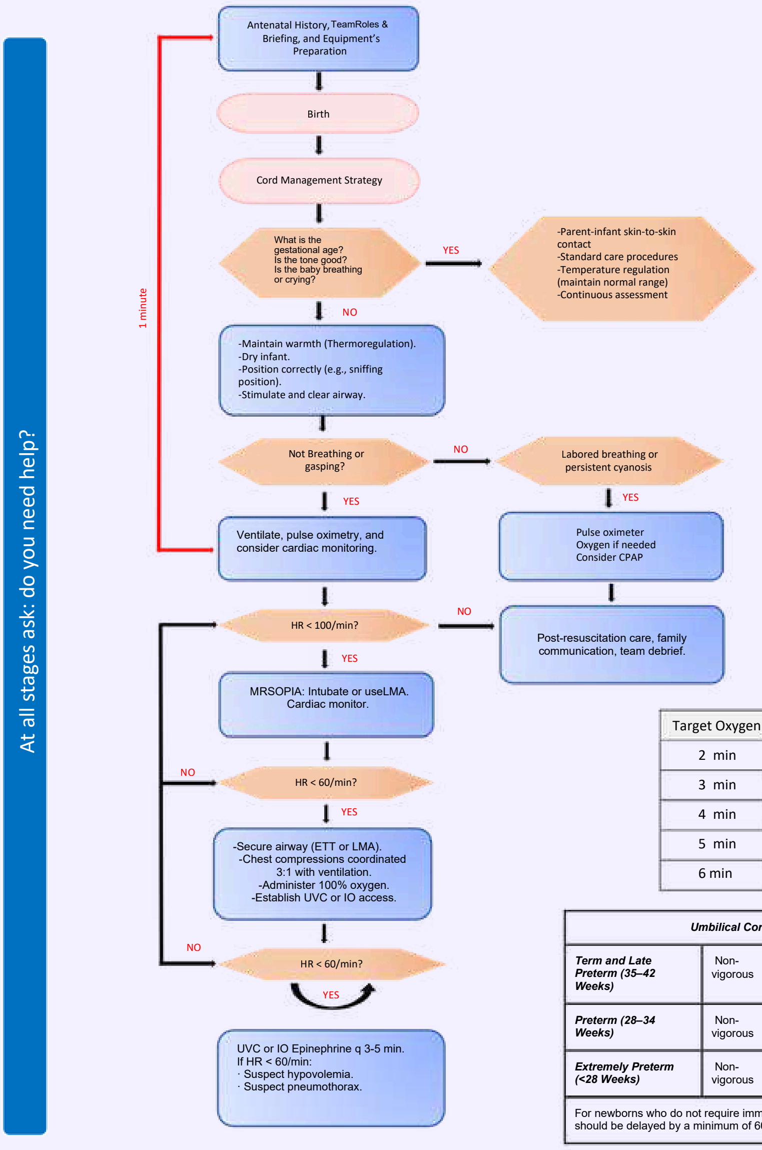

Target Oxygen Saturation Table	
2 min	65% - 70%
3 min	70% - 75%
4 min	75% - 80%
5 min	80% - 85%
6 min	85% - 95%

Umbilical Cord Management Strategy		
Term and Late Preterm (35–42 Weeks)	Non-vigorous	***Milking the intact umbilical cord*** (pushing residual placental blood into the baby)
Preterm (28–34 Weeks)	Non-vigorous	Intact umbilical cord milking
Extremely Preterm (<28 Weeks)	Non-vigorous	***Intact umbilical cord milking is NOT recommended***
For newborns who do not require immediate resuscitation, umbilical cord clamping should be delayed by a minimum of 60 seconds.		

Figure 2.13 SNRP algorithm

Evaluating the Newborn's First Reaction

Evaluate newborn response to initial resuscitation within the first minute post-delivery.

When to Start Positive Pressure Ventilation(PPV): Apnea or Gasping

If a newborn remains unresponsive after initial stabilization and shows any of the following signs, immediately start Ventilation and call for assistance:

- The newborn is still apneic (not breathing).
- The newborn is gasping for air.
- The newborn's heart rate is under 100 bpm, despite breathing.

Assessing Heart Rate

The most accurate heart rate measurement during a physical examination is obtained by using a stethoscope to listen over the baby's left chest (Figure 2.14).

Heart Rate (HR) Estimation Guidelines

- **Pulse Check:** Avoid checking the pulse near the umbilical cord's base, as this method is less reliable and may result in an overestimation of the heart rate.
- **Team Assistance:** To help the team keep pace, you can tap out the rhythm on the bed while simultaneously listening for the heartbeat (auscultating).
- **Monitoring:** If accurate HR cannot be determined using initial methods, connect the cardiac monitor. Note that this step requires requesting additional assistance.

Heart Rate Calculation Method:

count the number of heartbeats heard over a six-second period and then multiply this count by ten. For instance, a count of 12 beats in six seconds indicates a heart rate of 120 bpm.

Figure 2.14 Newborn heart rate assessment

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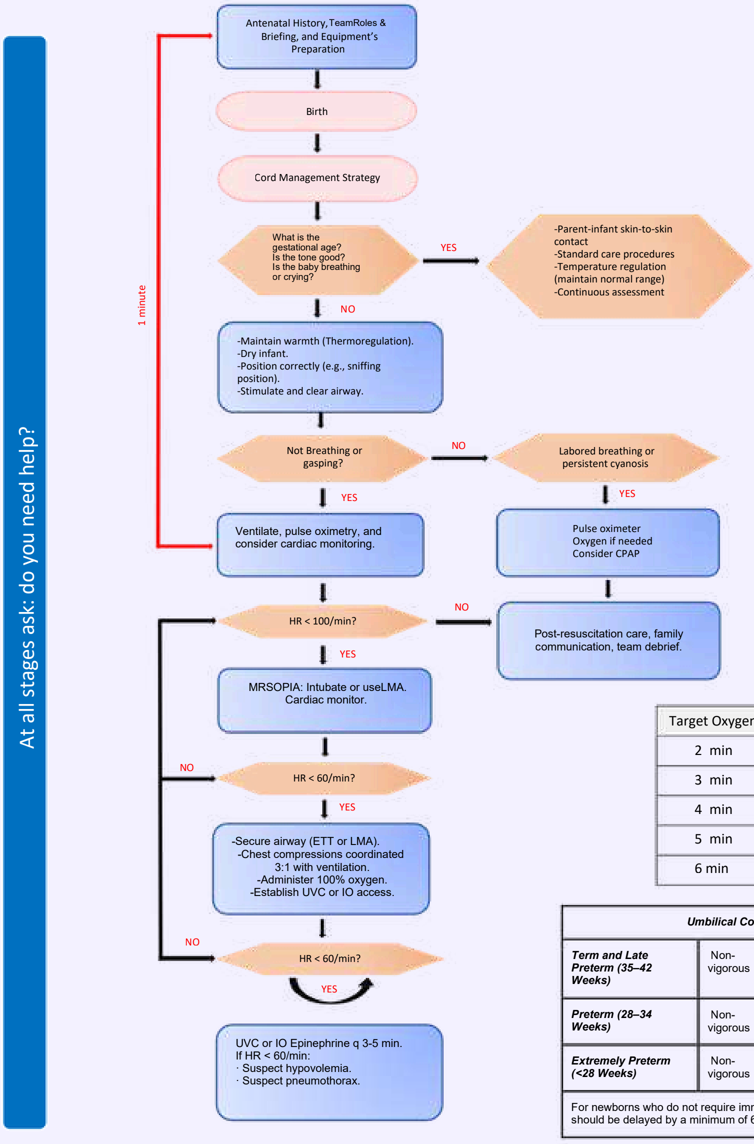

Target Oxygen Saturation Table	
2 min	65% - 70%
3 min	70% - 75%
4 min	75% - 80%
5 min	80% - 85%
6 min	85% - 95%

Umbilical Cord Management Strategy		
Term and Late Preterm (35–42 Weeks)	Non-vigorous	***Milking the intact umbilical cord*** (pushing residual placental blood into the baby)
Preterm (28–34 Weeks)	Non-vigorous	Intact umbilical cord milking
Extremely Preterm (<28 Weeks)	Non-vigorous	***Intact umbilical cord milking is NOT recommended***
For newborns who do not require immediate resuscitation, umbilical cord clamping should be delayed by a minimum of 60 seconds.		

Figure 2.15 SNRP algorithm

Central Cyanosis vs. Acrocyanosis: Understanding Skin Discoloration and Oxygen Levels

Cyanosis is characterized by a blue discoloration of the skin or mucous membranes, indicating low blood oxygen levels. It is important to distinguish between two types:

1. Acrocyanosis: This common, benign condition in newborns affects only the hands and feet. It does not signify low oxygen saturation and typically requires no intervention.
2. Central Cyanosis: signifies low systemic oxygen, making the baby's body, lips, and tongue appear blue. Although common briefly after birth in healthy newborns, persistent central cyanosis requires attention.

Management of Persistent Central Cyanosis

If central cyanosis is suspected to be persistent, oxygenation must be assessed.

- A pulse oximeter should be used to measure the baby's oxygen saturation. The probe should be placed on the baby's right hand or wrist.
- Supplemental oxygen therapy is only necessary when the oxygen saturation level falls below the desired clinical range, and treatment should be guided by this measurement.

Target Preductal Oxygen Saturation

The typical transition for a healthy newborn involves the blood oxygen saturation gradually increasing from the usual intrauterine level of approximately 60% to over 90% (the final saturation for healthy neonates breathing air). This process usually takes several minutes.

After establishing a reliable pulse oximeter signal, compare the newborn's preductal oxygen saturation to the goal ranges in Table 2.7.

Time from Birth	Target Oxygen Saturation Range (SpO_2)
2 minutes	65% - 70%
3 minutes	70% - 75%
4 minutes	75% - 80%
5 minutes	80% - 85%
10 minutes	85% - 95%

Table 2.7: Target Oxygen Saturation (SpO_2) for Neonates During Resuscitation

ADMINISTERING SUPPLEMENTAL OXYGEN

If preductal oxygen saturation drops, begin free-flow oxygen via tubing near the newborn's mouth and nose (Figure 2.16).

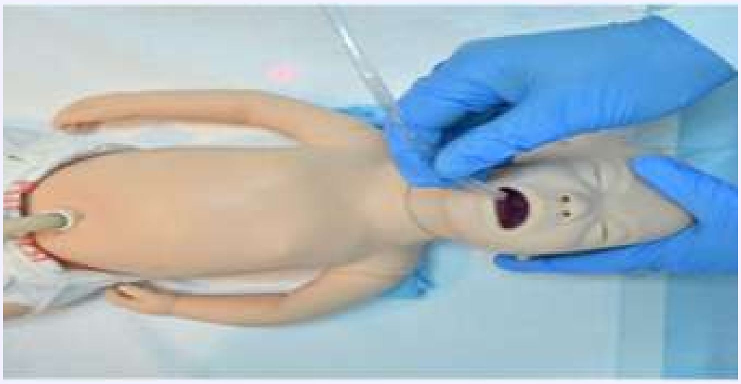

Figure 2.16 Give free-flow oxygen near the baby's mouth and nose.

NOTE : For T-piece resuscitators, ensure the cap opening is uncovered and the pressure manometer reads zero.

Figure 2.17 Providing Free-flow oxygen given by T-piece resuscitator

Figure 2.18 Free-flow oxygen via self-inflating bag tail with open reservoir.

Administering Supplemental Oxygen After Initial Stabilization

For stable newborns needing supplemental oxygen after the initial minutes, use pulse oximetry to guide the appropriate FiO2.

- To minimize heat loss, oxygen administered for an extended duration should be heated and humidified.

Managing Persistent Low Oxygen Saturation or Labored Breathing

CPAP may be needed if a newborn's oxygen saturation stays low despite 100% oxygen and labored breathing. This respiratory support maintains lung openness with a constant, low-pressure airflow.

Only initiate CPAP in the delivery room if the baby is breathing and HR <100 bpm. CPAP requires a flow-inflating bag or T-piece resuscitator; a self-inflating bag is unsuitable.

Chapter 3

Respiratory Management

CHAPTER OBJECTIVES :

Upon completion of this chapter, you will be able to:

- Describe the indications for positive pressure ventilation.
- Outline the correct procedure for delivering PPV.
- Assess the anticipated effects of adequate ventilation.
- List the appropriate actions regarding ventilation issues (MRSOPIA).
- Outline the correct procedure for inserting a laryngeal mask.
- Recognize when endotracheal intubation (ETI) is necessary.
- List the circumstances in which ETI is necessary for resuscitation.
- Know the steps to perform tracheal intubation.
- Describe the proper technique for endotracheal intubation using a laryngoscope.
- Confirm the endotracheal tube's correct placement.
- Know how to perform suctioning of heavy tracheal secretions via an endotracheal tube.

POSITIVE PRESSURE VENTILATION INDICATIONS

Successful newborn resuscitation is fundamentally reliant on effective breathing. If a newborn remains apneic, exhibits abnormal breathing (such as gasping), or has a heart rate below 100 beats per minute after the initial assessments, ventilation must be promptly initiated. When assisted ventilation is required, it should be started within the first minute of birth using the appropriate devices.

To maintain an open airway, position the baby's head in a neutral position while under the radiant warmer (Figure 3.1). Alternatively, a shoulder roll may be used, which is especially important for premature newborns (Figure 3.2).

Figure 3.1 Sniffing position

Figure 3.2 Shoulder roll.

Term/Abbreviation	Definition
Peak Inflation Pressure (PIP)	The highest pressure reached during the inflation phase of each assisted breath.
Inflation Time (IT)	The length of time (in seconds) that the positive-pressure breath is delivered (the inflation phase).
Rate	The rate at which assisted breaths are delivered, expressed as the number of breaths per minute.
Positive End-Expiratory Pressure (PEEP)	The level of air pressure maintained within the lungs throughout the exhalation phase of assisted breathing.
ntinuous Positive Airway Pressure (CPAP)	The constant air pressure maintained in the lungs when the baby is breathing independently (without assistance).

Table 3.1 PPV is described using various terms and abbreviations:

Important Note: Always ensure the baby's head position is maintained consistently both during and after the initial resuscitation steps.

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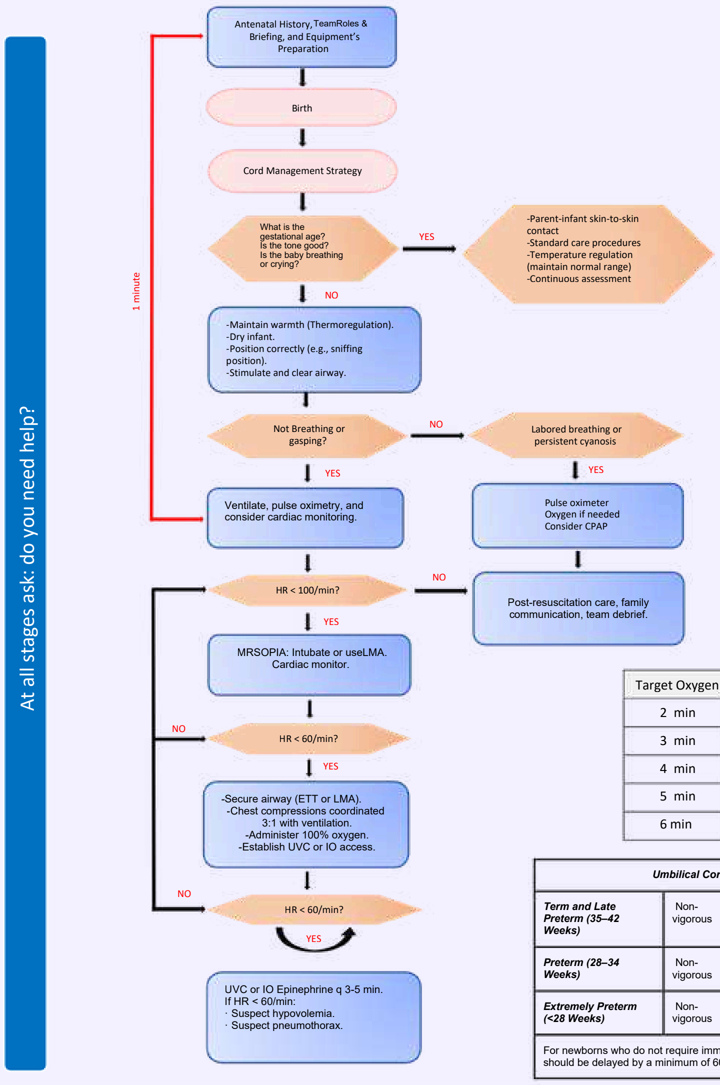

Target Oxygen Saturation Table	
2 min	65% - 70%
3 min	70% - 75%
4 min	75% - 80%
5 min	80% - 85%
6 min	85% - 95%

Umbilical Cord Management Strategy		
Term and Late Preterm (35–42 Weeks)	Non-vigorous	***Milking the intact umbilical cord*** (pushing residual placental blood into the baby)
Preterm (28–34 Weeks)	Non-vigorous	Intact umbilical cord milking
Extremely Preterm (<28 Weeks)	Non-vigorous	***Intact umbilical cord milking is NOT recommended***
For newborns who do not require immediate resuscitation, umbilical cord clamping should be delayed by a minimum of 60 seconds.		

Figure 3.3 SNRP Algorithm

1- Self-Inflating Bag

A device for positive pressure ventilation. It operates by being squeezed and then released, causing it to spontaneously refill with air (either air, oxygen, or a mixture).
Key Characteristics:

- **Self-Inflation:** Bag inflates automatically and draws in air when released, unless squeezed.
- **Gas Source**: Fills with oxygen at the set flow rate if connected to a source; otherwise, it draws in room air (21% O_2).
- **No Compressed Gas Needed:** Self-inflating nature means compressed air or a tight seal is not required to maintain inflation.
- **Pressure Release Valve (Pop-off Valve):** Most bags have a pop-off valve (typically set to 30-40 cm H_2O) to limit pressure.

Caution: Valves can be unreliable. Blockage for higher pressure should be rare, and extreme pressure must always be avoided.

- **Ventilation Rate and Timing:** The frequency of bag squeezes dictates the ventilation rate, while the speed of the squeeze affects the inflation time.
- **Peak Inspiratory Pressure (PIP):** The force used to squeeze the bag directly determines the resulting PIP.
- **Positive End-Expiratory Pressure (PEEP)**: PEEP can be administered only if the bag device is equipped with an additional valve.
- **Pressure Monitoring:** To ensure accurate measurement of air pressure, a manometer is essential. This can be either a built-in feature or an attached device. Any attachment site must be sealed to prevent air leakage.
- **Pre-Use Testing:** It is critical to test the bag-mask device before it is needed—ideally, even before the baby's delivery (refer to Table 3.2).

- .

Figure 3.4 Self-inflating bag

Observation / Action	Troubleshooting / Implication
Test 1 : Squeeze with Blocked Outlet	
Squeeze the bag while blocking the mask or air outlet.	
Does your hand feel resistance/pressure ?	If not, the bag may have a break or leak.
Does the manometer show pressure readings ?	The level of air pressure maintained within the lungs throughout the exhalation phase of assisted breathing.
Test 2 : Pressure-Release Valve Function	
Does the pressure-release valve open at a pressure between 30 and 40 cm H_2O (as indicated by the manometer) ?	Is the pressure-release valve obstructed or missing ?
Test 3 : Re-Inflation	
Does the bag immediately re-inflate after you release the squeeze ?	Is there an open attachment site, possibly due to a missing manometer ?

Table 3.2 Testing a Self-Inflating Bag: A Checklist

How To Use Self-Inflating Bag ?

Use a 240 mL self-inflating bag for neonatal CPR. This volume is sufficient to inflate the lungs of any newborn, as the required tidal volume is typically 5–10 mL/kg of body weight.

Mask :

Select a mask size appropriate for the newborn's face.

- The rim of the mask should cover only the mouth, nose, and the tip of the chin.
- The mask should not conceal the eyes or extend below the chin.
- A mask that is too large will prevent an adequate seal, hindering effective ventilation.

Ventilation Procedure:

1. **Positioning**:
   Place the baby's head in a neutral position.

2. **Mask Application:**
- Press the "guide finger" onto the baby's chin.
- Roll the mask onto the face, starting from the chin and moving upwards. The outside edge of the mask should fit into the groove between the guiding finger and the tip of the chin.

3. **Achieving a Seal (Two-Point Top Hold and Jaw Lift):**
- Using the thumb and index finger, apply even, downward pressure near the outer border of the flat mask ("two-point top hold").
- Use the remaining fingers to apply upward pressure via a jaw lift. This counteracts the downward pressure to create a tight seal.

4. **Ventilation Rate:**
   Deliver ventilations at a rate of 30 to 60 inflations per minute.

Caution (Avoiding Hyperventilation) :

- In babies with healthy lungs (e.g., a term newborn with peri-partum hypoxic-ischemic injury), avoid hyperventilating.
- Hyperventilation in these cases can lead to dangerously low CO_2 levels (below 30 mmHg), which may further depress the breathing center and decrease cerebral blood flow.

Oxygen Use in Neonatal Resuscitation

- **Term newborns and late-preterm neonates (⩾ 35 weeks):**
  Begin resuscitation with air (21% oxygen).

- **Premature neonates (32-34 weeks):**
  Start with an oxygen concentration between 21% and 30%.

- **Premature neonates (<32 weeks):**
  Start with an oxygen concentration more than or equal 30%.

- **If an oxygen blender is unavailable,**
  use air.

- **The continued use and precise amount of supplemental oxygen should be guided by pulse oximetry.**

2- Flow-Inflating Bag

A flow-inflating bag, also known as an anesthetic bag, requires a continuous flow of compressed air to inflate and maintain its shape.

- **Inflation:** Inflation happens when compressed air enters the bag and the mask outlet seals the baby's face.
- **Deflation:** If air flow ceases or the outlet opens, the bag deflates like a balloon.
- **Ventilation Control:** Inflation duration depends on bag compression speed.

A T-piece resuscitation device continuously directs compressed air toward the newborn. Occlusion of the T-shaped device's top aperture causes a resultant pressure increase (Figure 3.7).

Figure 3.5 flow-inflating bag

Figure 3.6 The flow inflating bag is deflated when compressed air is not entering it.

3- T-piece Resuscitator

A device using internal valves to regulate pressurized air, requiring a compressed source like a flow-inflating bag. The operator manually delivers breaths by blocking and releasing the air escape port on the T-piece cap.

Air is directed toward the baby when the entrance is blocked; conversely, a small amount escapes through the cap when the aperture is opened.

Both the ventilation and pressure limits of the T-piece resuscitator are managed by its controls.

1- Ventilation Control

- The frequency and duration of covering the T-piece cap's opening determine the ventilation rate and inflation time, respectively.

2- Pressure Regulation

There are two control dials to limit the pressure:

- Peak Inflation Pressure (PIP) Regulation: This constraint, which may feature a detachable protective shield, acts as a safety mechanism, similar to a self-inflating bag's pop-off valve. Its purpose is to set the maximum pressure for aided breaths, thereby preventing the peak pressure from exceeding a selected limit.
- PEEP/CPAP Adjustment: The dial, positioned on the T-piece cap, controls the amount of air released between breaths. This mechanism allows for the adjustment of both Positive End-Expiratory Pressure (PEEP) and Continuous Positive Airway Pressure (CPAP).

Setting the PIP

- Set the desired PIP by covering the T-piece cap and adjusting the inflation pressure control (Figure 3.8).

The T-piece resuscitator's integrated manometer allows for the measurement of both inflation (PIP) and expiratory (PEEP) pressures (Figure 3.9).

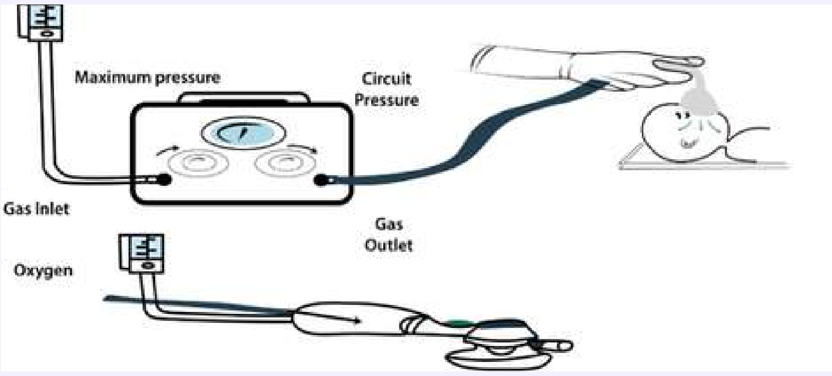

Figure 3.7 illustrates the components of the T-piece resuscitator, alongside the self-inflating bag.

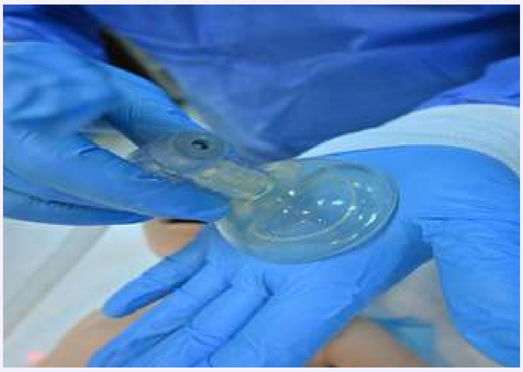

Figure 3.8 Testing a T-piece resuscitator

Figure 3.9 Adjusting the peak inflation pressure (PIP) with T piece

Test	Expected Result/Condition	Troubleshooting (Check if...)
PEEP Test	When the mask or outlet is blocked (without obstructing the T-piece cap's aperture), is the PEEP reading 5 cm H_2O?	The T-piece air exit is sealed when pressure is off.
Maximum Pressure (PIP) Test	After closing the T-piece cap's aperture, is the maximum pressure maintained between 20 and 25 cm H_2O?	The air flow is set correctly to 10 L/min.
General Checks		The air inlet's tubing is connected.
		The nearby air outlet is disconnected.

Table 3.3: T-Piece Resuscitator Device Testing Checklist

Ventilation :

Indications and Assessment of Effectiveness

PPV should be initiated if:

- HRis > 100 bpm.
- The newborn is apneic or gasping.
- Assisted ventilation must be initiated within the first minute after birth when indicated.

If the baby is breathing with a HR < 100 bpm and free-flow oxygen or CPAP fails to meet target O_2 saturation, consider PPV.

Signs of Effective Positive Pressure Ventilation:

Effective PPV is indicated by the observation of three key signs:

1. An increase in the HR.
2. Visible chest movement.
3. An increase in oxygenation.

Initiating PPV Procedure and Team Positioning :

1. **Positioning:** Place yourself near the radiant warmer.

2. **Airway Management :** The team member managing the airway and maintaining the mask's position should be at the neonate's head.

3. **Team Assistance:** Other team members should position themselves at the side of the bed. This location facilitates:

- Placement of the pulse oximeter and cardiac monitor.
- Listening to heart and breath sounds.
- Observing chest movement.

4. **Calling for Help (If Alone):** If you are alone, immediately call for assistance.

Figure 3.10 Correct position to provide assisted ventilation.

Proper Positioning for Airway Patency

The baby's head and neck should be placed in the "sniffing position" to keep the airway open. This means the head is in a midline, neutral, or slightly extended position, with the baby's eyes looking directly up toward the ceiling.

- Key Point: Incorrect head positioning (overly flexed or stretched) is a frequent cause of inadequate mask ventilation as it blocks the airway.
- Tip: To maintain the correct position, slightly elevating the baby's shoulders with a small, rolled towel or blanket can accommodate the newborn's prominent occiput (back of the head).

Choosing and Placing the Appropriate Mask

Ensure appropriate neonatal mask sizes are always available. Use anatomical masks with the pointed end over the nose. The mask must cover the nose and lips, resting on the chin, but not the eyes. A correct mask size is key to achieving a tight seal; an insufficiently inflated cushioned mask rim may compromise the seal.

1- Applying the One-Hand Hold Technique

To properly use the anatomic mask with a one-hand hold:

1. Position the Mask: Place the mask's bottom on the baby's chin, covering the mouth and nose. The tip should rest near the nasal bridge, avoiding the eyes and preventing leaks.
2. Secure the Seal : Hold the mask in place by encircling its rim with your thumb and index finger.
3. Lift the Jaw: Using the remaining three fingers, lift the bony angle of the jaw upward toward the mask.
4. Maintain Position: With the baby's head in the sniffing position, apply consistent downward pressure on the mask's rim to create and maintain an airtight seal.

Note on Mask Types: Some circular masks are secured by a central stem rather than the rim, this allows for direct positioning over the nose and mouth. Distortion of the mask's shape, resulting in a leak, will occur if pressure is applied to its rim.

Figure 3.11 Anatomically shaped face mask

Figure 3.12 Maintain a proper seal with a 1-hand hold and anatomic mask.

2- Using the Two-Hand Hold with Jaw Thrust Technique

When a single hand is insufficient to maintain both a secure mask seal and the correct head position, the two-hand hold with jaw thrust technique should be employed. This allows for a better seal by raising the jaw while stabilizing the mask with both hands.

Two-Hand Hold Technique:

1. **Mask Seal:** Use both thumbs and index fingers to firmly fix the mask on the infant's face.
2. **Mandible Positioning:** Place the remaining three fingers of each hand beneath the bony angle of the mandible (jaw).
3. **Mandibular Elevation:** Gently elevate the jaw toward the mask to create an optimal seal.

Team Responsibilities During Resuscitation:

Primary Roles:

- **Mask and Positioning:** Focus on securing a strong mask seal and ensuring correct midline head positioning.
- **Ventilation:** A designated team member handles ventilation, either by squeezing the bag or operating the T-piece cap, positioned beside the infant.

Support Role:

- **Monitoring:** A third individual is responsible for observing and reporting the baby's response to the procedure.

Figure 3.13
The two-handed hold technique for maintaining a mask seal with an anatomic mask.

Precautions for Mask Application

- Handle the mask with care.
- Avoid contact between your hand and the baby's eyes.
- Do not forcefully press the mask against the face or obstruct the baby's nasal passages.
- Exercise caution to prevent compression of the soft tissue of the baby's neck. Such compression can lead to the mask becoming clogged, air leakage around the edges, unintentional neck bending, or facial bruising.
- Routinely check and adjust the mask's position and the baby's head alignment as necessary.

Optimal Oxygen Levels for Initiating Positive Pressure Breathing (PPB)

The initial FiO2 (Fraction of Inspired Oxygen) should be selected using the oxygen blender and then adjusted (increased or decreased) based on the oxygen saturation measured by a pulse oximeter.

The recommended initial FiO2 varies according to the newborn's gestational age:

- **Gestational age 35 weeks or greater:** Start with an initial FiO2 of **21%.**
- **Gestational age 32 to 34 weeks:** Set the initial FiO2 to **21% to 30%.**
- **Gestational age less than 32 weeks:** An initial FiO2 **greater than or equal to 30%** may be necessary.

Once ventilation begins, a second person is responsible for attaching a pulse oximeter sensor to the newborn's right hand or wrist. After acquiring a stable reading, this preductal oxygen saturation level should be assessed against the established target range.

Figure 3.14
Adjust blender to desired F102.

Parameter	*GA*	*Recommended Value*	*Notes*
Initial FiO2	>=35 weeks	21% (Room Air)	Term/Near-term.
	32-34 weeks	21%-30%	Start low, titrate to target
	< 32 weeks	>= 30%	Start higher, titrate to target
Ventilation Rate	All	30-60 breaths/min	Effective range.
Initial PIP	>=32 weeks	25 cm H2O	Range: 25-30 cm H2O.
	< 32 weeks	20-25 cm H2O	Lower for very preterm.
PEEP	All (if used)	5 cm H2O	Recommended level.

Table 3.4
Initial settings for Positive Pressure Ventilation
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Setting	Initial Value
Gas flow	10 liters per minute
Rate	30-60 breaths/minute
Peak Inspiratory Pressure (PIP)	More than or equal 32 weeks: 25-30 cm H2O Less than 32 weeks: 20-25 cm H2O
Positive End-Expiratory Pressure (PEEP)	5 cm H2O

Table 3.5 The initial settings for Positive-Pressure Ventilation

How to Ventilate ?

Ventilation Rate:

The recommended rate for positive pressure ventilation is **30 to 60 breaths per minute.**

Maintain the correct tempo by utilizing the following rhythm:

1. Count aloud: **"Breathe, two, three, breathe."**
2. Repeat the rhythm.
3. Squeeze the bag or cover the T-piece cap as you say **"Breathe,"** and release during **"two and three."**

higher than typical pressure may be necessary for the first few assisted breaths to transfer the fluid out and inflate the alveoli.

Caution: Applying excessive airway pressures and lung volumes can cause harm, Inflate and aerate the lungs using the minimum necessary pressure to achieve an increase in heart rate and oxygen saturation.

When performing ventilation , the goal is to observe a rise of the chest with each breath, which indicates effective lung inflation. Excessive chest movement, however, signals high pressure and carries the significant risk of lung overinflation and a potential pneumothorax (air leak).

It is crucial to remember that a standard resuscitation bag holds significantly more air than a normal breath. Although adequate ventilation can sometimes be achieved in preterm newborns without obvious chest rise, this approach is less reliable and increases the likelihood of injury from overinflation.

Monitoring the newborn newborn's response is paramount during resuscitation, and the single most critical indicator of successful positive pressure ventilation (PPV) is a rising heart rate. Upon initiating ventilation, a dedicated team member, the assistant, must be tasked with continuously monitoring the newborn newborn's heart rate response to the intervention.

HR Assessment :

The very first heart rate assessment, prior to or immediately upon starting ventilation, may be rapidly performed using a stethoscope to confirm cardiac activity. However, this is a transient step.

As soon as effective ventilation is established, the assistant must immediately apply a pulse oximeter sensor, typically to the right hand or wrist (pre-ductal site), to continuously and non-invasively assess two vital signs:

1. **Oxygen Saturation (SpO_2):**
   Essential for guiding oxygen therapy titration.

2. **Heart Rate (HR):**
   Provides continuous, objective feedback on the effectiveness of ventilation and circulation.

In some clinical settings, or for newborns requiring advanced monitoring, the consideration of continuous monitoring with a three-lead or five-lead cardiac monitor is also appropriate, as it offers a highly reliable, continuous display of the electrical activity of the heart.

Interpreting the Heart Rate Response to Ventilation :

The immediate goal of ventilation is to achieve oxygenation and improve myocardial perfusion, which is directly reflected in the heart rate:

- **HR Improving (Effective Ventilation):**

Shortly after beginning effective ventilation, the newborn's heart rate should begin to increase. If this positive trend is observed, the team must continue ventilation with the same technique, recognizing that the current method is effective. The first formal check of the HR response is performed after 30 seconds of sustained ventilation.

- **Heart Rate is Not Increasing (Ineffective Ventilation – Initial Assessment) within 15-30 seconds:**

If, after the initial period of ventilation, the HR is not increasing, the team must immediately suspect ineffective ventilation. The primary question to ask the assistant is: **"Is the chest moving?"**
This assessment is crucial for differentiating between correct technique with poor heart response and technically inadequate ventilation.

- **Scenario A: Chest is Moving, but HR Not Rising:**

If the assistant confirms visible and symmetrical chest movement, it suggests that air is successfully entering the lungs, but the newborn's physiological response is suboptimal. In this case, the team should **continue ventilation** while the resuscitator meticulously **monitors and refines their ventilation technique** (e.g., ensuring a proper seal, checking the pressure setting). A formal check of the heart rate response remains scheduled for 30 seconds of ventilation.

- **Scenario B: Chest is Not Moving:**

If the assistant reports that the chest is not moving within 15- 30 seconds of starting ventilation, it is a definitive sign that air is likely not entering the lungs adequately. The newborn is not being ventilated. In this critical situation, the resuscitator must immediately **pause standard ventilation** and initiate the **ventilation corrective steps** (the "MR. SOPIA" mnemonic is commonly used) described in the resuscitation protocol. These corrective actions must be performed sequentially and systematically until successful chest movement is achieved with ventilation, indicating proper lung inflation.

Ventilation Corrective Steps

If a baby's HR fails to improve and there is no chest rise during ventilation, corrective steps are required. This sequence of adjustments, detailed in Table 3.6, addresses common issues such as poor mask seal (leaks), blockages in the airway, or inadequate pressure, which are the typical causes of ineffective mask ventilation.

You should select the most beneficial steps based on your assessment of the newborn and the clinical situation, prioritizing their order of performance. After completing these corrective steps, proceed to attempt ventilation and then reassess for chest movement.

Corrective Step	Action
Examine chest movement and breath sounds	If necessary, reapply the mask and then move the jaw forward. A two-hand hold technique may be considered.
R: Reposition Head and Neck	Place the head in a neutral or slightly extended position.
5 breaths and assess chest movement.	
Suction Mouth and Nose	Use either a suction catheter or a bulb syringe.
O: Open the Mouth	Gently open the mouth using a finger.
5 breaths and assess chest movement.	
PI: Pressure Increases	Increase the pressure in increments of 5-10 cm H2O. The maximum pressure should not exceed 30 cm H2O for term newborns and 30 cm H2O for preterm newborns.
5 breaths and assess chest movement	
A: Alternative Airway	**Insert an endotracheal tube or a laryngeal mask.**
Examine chest movement and breath sounds	

Table 3.6: The steps for corrective ventilation for MR. SOPIA

Endotracheal & LMA Intubation

When a newborn's chest starts to rise after a corrective ventilation step, you must immediately state, "The chest is moving NOW." This vital declaration informs the whole team of the successful assessment outcome and signals that further MR. SOPIA interventions are no longer required.

Next Steps (Maintaining Effective PPV):

Continue effective PPV for 30 seconds, monitoring rate, pressure, and the heart rate response. Insert an alternative airway if maintaining effective face mask ventilation remains difficult.

Reassessing Ventilation Effectiveness:

After 30 seconds of effective lung-ventilation PPV (confirmed by chest movement or an increasing heart rate), you must recheck the HR response.
Assisted ventilation is deemed successful when a consistent heart rate of 100 beats per minute or more is achieved in the newborn, followed by continuous monitoring:

- Continue ventilation at a rate of 30-60 breaths per minute.
- Monitor the newborn's heart rate, breathing effort, and chest movement closely.
- Adjust the FiO2 (fraction of inspired oxygen) based on the results of the pulse oximetry.
- Monitor the newborn's oxygen saturaton and adjust the Fractional Inspired Oxygen (FiO2) as needed to achieve the target saturation range specified in Table 3.5.

after 30 seconds of effective ventilation (verified by chest movement), preferably via LMA or ETT, increase FIO2 to 100% and start compressions.

Weaning Off Ventilation:

- Gradually reduce PPV if heart rate stays above 100 bpm and spontaneous respirations are effective.
- During this process, provide gentle stimulation to encourage the newborn to breathe.
- once the newborn maintains a heart rate exceeding 100 beats per minute and has established and ongoing spontaneous breathing.

If HR Does Not Increase:

immediately review and potentially modify your ventilation strategy by confirming the following:

- Is the chest visibly moving?
- Are you delivering 30 to 60 breaths per minute?
- Are breath sounds audible?

Additional Interventions:

- Adjust the FiO2 to reach the desired oxygen saturation.
- If not already done, attach cardiac monitor leads.
- Consider inserting an endotracheal tube (ETT) or laryngeal mask airway (LMA).
- Seek assistance if airway placement proves difficult.

If the newborn's heart rate remains < 60 bpm after 30 seconds of effective ventilation (verified by chest movement), preferably via LMA or ETT, increase FIO2 to 100% and start compressions.

Monitoring Ventilation Performance with a CO2 Detector During Corrective Measures

A CO2 detector is a valuable tool during ventilation corrective phases, providing a visual indication of effective lung aeration and expansion. To use it, place the detector between the Positive Pressure Ventilation (PPV) device and the mask.

Indications of Effective Ventilation :

- Color Change: If effective air exchange and proper lung ventilation are occurring, the CO_2 detector should turn yellow during each exhalation as CO_2 is evacuated through the mask.
- Successful Correction: A shift in the detector's color from purple to yellow immediately following a corrective measure confirms its success. An improvement in the HR is then expected shortly.

Indication of Ineffective Ventilation :

- Inadequate ventilation of the newborn's lungs with a face-mask may be indicated if the CO_2 detector fails to change to yellow.

Laryngeal Mask Airway (LMA)

An airway is secured by a laryngeal mask, which is a breathing tube with a small mask attached.

Advantages and Use:

The Laryngeal Mask Airway (LMA) offers superior ventilation by creating a better seal than a face mask. Its placement is simpler than endotracheal intubation, not requiring specialized tools or vocal cord visualization. The LMA is a reliable rescue airway when face mask ventilation is ineffective and intubation is difficult or fails.

Figure 3.15
The carbon dioxide detector was utilized when performing corrective adjustments to the ventilation system

Figure 3.16
Insertion of laryngeal mask into the baby's mouth.

IInsertion of a Laryngeal Mask

1. **Preparation and Positioning:**

- Remove the device and apply grease to the sides and rear (optional).
- Stand next to the baby and position them in the 'sniffing position'.
- Prepare the mask and then place it into the baby’s mouth.

2. **Device Placement:**

- Position the mask so that the open, bowl-shaped part is over the baby's chin, and the closed base rests against the baby's palate, following the alignment of the airway tube.
- If necessary, gently pull on the baby’s chin to encourage the mouth to open.

3. **Advancing the Device:**

- Position the mask's leading point above the tongue and the bottom firmly against the palate.
- Guide the device forward, carefully tracing the curves of the mouth and palate.
- Glide the device lower and backward, following the curve of the palate, applying constant but gentle pressure until significant resistance is felt.

4. **Securing and Ventilation:**

- While holding the tube securely in place, attach a CO2 detector and a Positive Pressure Ventilation (PPV) device.
- Begin PPV concurrently with the final positioning of the device.

Figure 3.17 Example of laryngeal masks

Figure 3.18 Gently pulling baby’s chin while LMA insertion

Figure 3.19 Guide the device along the curve of the mouth and the palate.

Removal of a LMA

A laryngeal mask can be removed when the newborn is breathing effectively and independently, or once an endotracheal tube has been successfully placed. Babies can breathe actively through the device, and sounds like grunting and weeping may be heard.

Procedure for Removal:

- Prior to removal, ensure the mouth and throat are clear of any mucus.
- Before removing the device, ensure that any inflatable rim is fully deflated.

Continuous Positive Airway Pressure (CPAP)

CPAP is an appropriate intervention for spontaneously breathing newborns with a HR<100 bpm who exhibit signs of respiratory distress, such as difficulty of breathing, grunting, or persistent decreased saturation despite receiving free-flow oxygen.

CPAP functions by maintaining continuous slight pressure within the airways and lungs. This is particularly beneficial for premature newborns with surfactant deficiency, as the constant pressure prevents the tiny air sacs (alveoli) from collapsing at the end of each breath.

CPAP should not be initiated if the newborn is gasping, apneic (not breathing), or has a heart rate below 100 beats per minute.

CPAP Benefits and Risks

Benefits: CPAP lessens breathing effort for babies and, when used early in preemies, can reduce the need for intubation and mechanical ventilation.

Risk: CPAP increases pneumothorax (air leak) risk. Providers must anticipate and manage this potential complication.

CPAP is delivered during initial stabilization using a mask sealed to the baby's face, connected to either a flow-inflating bag or a T-piece resuscitator. Note: A self-inflating bag is unsuitable for delivering CPAP, even with a PEEP valve.

Procedure for CPAP Administration:

Setup and Pressure Verification for CPAP

1. **Adjust the Pressure:**
   Set the required Continuous Positive Airway Pressure (CPAP) level by adjusting the flow-control valve (if using a flow-inflating bag) or the Positive End-Expiratory Pressure (PEEP) dial (if using a T-piece resuscitator). The target pressure should be set to 5 to 6 cm H2O or higher.

2. **Verify Delivered Pressure:**
   Before masking the newborn, confirm the pressure. Hold the mask firmly to your hand and check the manometer (pressure gauge) to verify the set pressure.

3. **Application:**
   Use the **2-hand hold with jaw thrust** technique to ensure a firm seal of the mask against the newborn's face.

4. **Monitoring and Adjustment:**

- Ensure the selected pressure level is maintained. A drop in pressure suggests a poor (not airtight) seal between the mask and the baby's face.
- The CPAP level may need adjustment based on the newborn's respiratory effort, but **do not exceed 8 cm H2O.**

CPAP for Extended Use:

After the initial period of stabilization with CPAP, the patient should be transitioned to the use of a nasal mask or nasal prongs for continued CPAP therapy. CPAP can then be delivered via a mechanical ventilator, a specific CPAP device, or a bubbling water system.

Figure 3.20
Administering face-mask Continuous Positive Airway Pressure (CPAP) with a T-piece requires a two-hand hold and jaw thrust technique.

Orogastric tube

Prolonged Continuous Positive Airway Pressure (CPAP) or Positive Pressure Ventilation (PPV) via a face or laryngeal mask can lead to stomach air accumulation, hindering effective ventilation. If extended ventilation is necessary for a newborn, insert an orogastric tube to vent the stomach.

Necessary Equipment

- 8F orogastric tube
- 20-mL syringe
- Tape

Insertion procedures

- To determine the correct insertion length, measure two distances: from the earlobe down to the xiphoid process, continuing to the umbilicus, and separately, from the bridge of the nose to the earlobe.
- Observe and record the centimeter mark on the tube corresponding to this total measured distance. When a mask is in place, the orogastric tube can be pre-measured to minimize interruptions to ventilation.
- Insert the tube orally. After the tube is positioned, resume ventilation. Re-evaluate the face-mask seal.
- Extract the stomach's contents by attaching a syringe to the tube after it has been inserted to the correct depth.
- Remove the syringe and leave the end of the tube open to allow air to exit the stomach.
- Secure the adhesive tape to the baby's cheek.

Figure 3.21
Measuring the orogastric tube depth of insertion.

Figure 3.22
Tube insertion

Figure 3.23
Aspirating the orogastric tube

Figure 3.24
Taping the orogastric tube into place.

Effective teamwork is crucial when providing Positive Pressure Ventilation (PPV), as this intervention offers numerous opportunities for well-coordinated teams to apply Neonatal Resuscitation techniques.

Table 3.7 Outlines key Effective teamwork skills for a team in a resuscitation setting, focusing on four main areas:

1. **Consider and plan things:**
   Emphasizes proactive planning based on risk factors, such as ensuring adequate staffing and assigning specific roles (like PPV, heart rate monitoring, recording events) during a pre-resuscitation brief.

2. **Optimize your workload assignment:**
   Highlights the need to involve multiple capable providers for tasks like positive pressure ventilation (PPV), and the importance of calling for additiona l assistance if needed (e.g., for a 2-hand hol d during PPV or for intubation).

3. **Speak clearly:**
   Stresses the necessity of clear, frequent communication and information exchange between team members, especially between the person performing PPV and the person evaluating its effectiveness.

4. **Recognize and be familiar with your surroundings:**
   Encourages familiarity with and proper use of available resources and equipment, such as PPV equipment, heart monitors, and laryngeal masks.

Endotracheal Tube

is a slender tube that is inserted into the trachea. This is achieved by passing the tube through the glottis and between the vocal cords.
Digital intubation offers an alternative to the standard endotracheal intubation technique. Standard intubation requires a laryngoscope, a lighted instrument, to visualize the larynx, which in turn guides the tube's placement between the vocal cords. Digital intubation, however, is a documented method where the operator relies exclusively on tactile sensation from a finger for guidance.

Neonatal resuscitation necessitates endotracheal intubation in these circumstances :

Persistent Bradycardia: If the newborn's heart rate remains below 100 beats per minute and does not increase after effective positive pressure ventilation (PPV) via a face mask or laryngeal mask.

Prior to Chest Compressions: ETT placement is strongly recommended before initiating chest compressions to optimize ventilation during this critical intervention. If ETT insertion is unsuccessful or not feasible, a laryngeal mask airway (LMA) can be used, provided the newborn weighs more than 1.5 kg.

Need for Enhanced Ventilation:

- Thirty seconds of effective ETT ventilation may improve overall ventilation and prevent the need for chest compressions.
- If compressions are needed, ETT breathing aids coordination of ventilation and compressions.
- Consider an ETT for prolonged PPV to improve assisted ventilation.

Direct Tracheal Access:
An ETT is required for:

- Direct tracheal suctioning to clear thick meconium or other secretions that are obstructing the airway.
- Delivery of surfactant.
- Management and stabilization of a neonate suspected of having a diaphragmatic hernia.

Once the Endotracheal Tube (ETT) is successfully inserted, the individual responsible for chest compressions may reposition themselves to the head of the bed to facilitate better logistical flow during post-intubation management.
Endotracheal intubation should be performed as quickly as possible when indicated. Personnel with intubation expertise must be immediately accessible. If intubation is anticipated, this expert should be present in the delivery room before the birth.

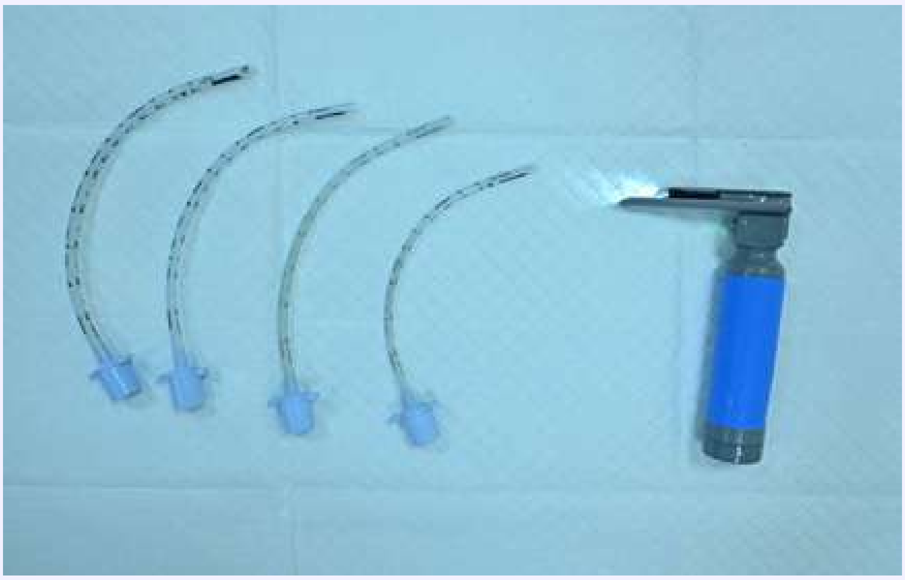

Figure 3.25 Endotracheal tubes and Laryngoscope

Preparation

Intubation supplies and equipment must be kept readily available and easily accessible. Prior to any high-risk birth, it is crucial to plan for and anticipate the need for intubation by preparing the necessary materials.

The following comprehensive set of items should be stocked in every birth room, nursery, and emergency room:

- **Laryngoscope:**
  - Laryngoscope handle (grip)
  - Extra batteries and bulbs if the handle is not rechargeable.
  - Straight (Miller) Laryngoscope blades in sizes:
    - No. 1 (for term newborns)
    - No. 0 (for preterm newborns)
    - No. 00 (optional for extremely preterm newborns)

- **Endotracheal Tubes (ETTs):**
  - Available in internal diameters (ID) of 2.5 mm, 3.0 mm, and 3.5 mm.

Note: While ETTs ranging from 2.0 mm to 4.0 mm, including cuffed tubes, are available for specific situations, they are not standard for routine neonatal resuscitation.

- **Stylet:** To facilitate tube insertion into the trachea.
- **Tube Securing**: 1/2- or 3/4-inch waterproof adhesive tape, or an alternative tube-securing device.
- **Insertion Depth Measurement:** A measuring tape for determining the correct depth of ETT insertion.
- **Rescue Airway:** Laryngeal mask (size 1).
- **Tracheal Aspirator.**
- **CO2 Detector**.
- **Stethoscope:** With a neonatal head.
- **Positive-Pressure Ventilation (PPV) Device:** Either a bag-and-mask or a T-piece resuscitator.
- **Gas Delivery:** Tubing for blended air and oxygen.
- **Pulse Oximeter:** Sensor and cover.
- **Syringe:** 5-mL syringe (if a laryngeal mask is used).
- **Suction Setup:**
  - Suction catheters: Size 8F (for throat suctioning)
  - Suction catheters: Size 5F or size 6F (for clearing obstructed ETTs).
- **Scissors:** To cut tape.

Figure 3.26
Endotracheal intubation supplies and equipment

Weight (grams)	Gestational Age (weeks)	Endotracheal Tube Internal Diameter (mm ID)	Suction Catheter Size (French)
< 800	22–25	2.5	5
800–1,200	26–28	2.5	5 or 6
1,201–2,200	29–34	3.0	6 or 8
> 2,200	> 34	3.5	8

Table 3.8
Guidelines for ET Tube and Suction Catheter Sizes in Neonates

Procedure Note:
A clean technique must be used when performing intubation. During intubation, use a cardiac monitor for the most accurate heart rate assessment, as auscultation is difficult and pulse oximetry may be unreliable during newborn resuscitation.
A cardiac monitor is particularly crucial for determining whether to continue chest compressions after intubation, as an increase in heart rate serves as a key indicator of correct endotracheal tube placement, to prevent contamination, all supplies must be opened, assembled, and then kept sealed in their packaging until the moment of use. Following each use, the laryngoscope handle and blades must be cleaned according to the hospital's established protocols.

Depth of insertion measurement

For newborn resuscitation, use a non-tapered endotracheal tube (ET) of uniform diameter. The ETT tip must sit in the mid-trachea, 1–2 cm below the vocal cords, avoiding the carina or main bronchus. Proper insertion depth can be estimated using one of two team-preferred methods.
The Nasal-Tragus Length (NTL) technique is a validated method for estimating endotracheal tube (ETT) insertion depth in both term and preterm infants. Measure the NTL (nasal septum to ear tragus in cm) and calculate the required depth as NTL + 1 cm. Insert the ETT until the estimated depth marking aligns with the infant's upper gum's anterior midline.
The vocal cord guide is an unreliable indicator for confirming correct tube depth; gestational age is a better estimate.

Preparing the Endotracheal Tube

The internal diameter (ID) of the endotracheal tube (ET tube) determines its size, measured in millimeters (mm). Selecting the correct size is crucial and is based on the baby's weight or gestational age.

Incorrect sizing consequences:
- **Too small** : Increased resistance and obstruction risk.
- **Too large**: Risk of airway injury.

Note on Cuffed Tubes:
While cuffed tubes, ranging from 2.0 mm to 4.0 mm, are available and may be used in certain situations, they are not standard practice for neonatal resuscitation.

Use of a Stylet for Endotracheal Intubation
Many operators opt to use a stylet to increase the rigidity and optimize the curvature of the endotracheal tube, though the decision ultimately rests with the operator.

Safety Precautions for Stylet Use:

- Tube Size Restriction: Stylet tip must not protrude beyond the end or side hole of 2.5 mm, 3.0 mm, or 3.5 mm endotracheal tubes, as this can cause tissue injury.
- Securing the Stylet: To prevent the stylet from advancing further into the tube during insertion, it should be secured at its top, either by bending it or using a stopper,to avoid the mistaken displacement of the endotracheal tube, it is essential that the stylet can be easily withdrawn after intubation, as forceful removal attempts could cause the tube to shift.

Figure 3.27
Neonatal endotracheal tube

Figure 3.28
stylet is used to preserve the curvature and stiffness of the Endotracheal Tube (ETT) during the intubation procedure

Laryngoscope and Equipment Setup

Set up the intubation equipment:

1. **Monitor:** Attach cardiac monitor leads for heart rate assessment, if needed.
2. **Blade:**
3. **Check**:
- Test the laryngoscope by clicking the blade open and turning on the light.
- If the light is dim or flickers , replace the laryngoscope, battery, or tighten/replace the bulb.
4. **Prevent Overheating:** Keep the laryngoscope closed until use (for light bulb models).

Preparation of Suction and Ventilation Equipment

1. **Set up the suction apparatus** and ensure the suction pressure is maintained between 80 and 100 mm Hg by occluding the end of the suction tubing, Ensure required suction catheters are ready:
- A 10F (or larger) catheter is necessary for oral and pharyngeal mucus removal.
- Smaller catheters (6F, 7F, or 8F) must be available for clearing post-placement endotracheal tube obstructions (see Table 3.8 for sizes).

2. **Prepare for Tracheal Suction (if needed):**
- An attachment called a tracheal aspirator can be used on the endotracheal tube to directly suction meconium or other viscous secretions clogging the trachea.
- Note that some endotracheal tubes have an integrated suction port, eliminating the need for a separate tracheal aspirator.

3. **Prepare the Ventilation Device:**
Have a Positive Pressure Ventilation (PPV) device with a mask ready to ventilate the newborn between intubation attempts, should it become necessary.

4. **Gather Additional Supplies:**
Make certain that a CO2 detector, stethoscope, measuring tape or insertion depth table, waterproof adhesive tape (1/2 or 3/4 inch), and scissors or another tube-securing tool are readily accessible.

Procedure

1- Proper Positioning for Newborn Intubation

To ensure the best possible visualization of the airway during intubation, position the newborn as follows:

1. **"Sniffing Position"**: Lay the newborn with the torso straight, the head centered, and the neck slightly extended into the "sniffing position." This posture is crucial because it aligns the trachea, providing a straight line of sight into the glottis once the laryngoscope is in place.
2. **Shoulder Roll**: Consider placing a small roll under the baby's shoulders to help maintain this slight neck extension.
3. **Operator Positioning:** Adjust the bed height, if possible, so that the baby's head is level with the operator's upper abdomen or lower chest. This optimizes the operator's eye level, enhancing the view of the airway.
4. **Assistance:** A team member should continuously assist in maintaining this optimal placement throughout the entire procedure.

The laryngoscope must always be held in the left hand, regardless of whether the user is right- or left-handed. The blade should face away from you, and your thumb should rest on the upper side of the handle. Using the right hand will obstruct your view through the open, curved part of the blade.
While true proficiency in endotracheal intubation requires substantial practical experience and observation, understanding the sequence of steps will allow you to provide effective assistance during the procedure.

Figure 3.29
Hold the laryngoscope in your left hand.

2- Preparation for Laryngoscope Placement:

1. **Patient Positioning:** Ensure the newborn is positioned correctly. Adjust the bed height if necessary. A team member should confirm the baby's body is straight and the head is in the "sniffing position." You can use your right hand to support the head.

2. **Opening the Mouth:** Gently open the newborn's mouth using your right thumb or index finger.

Laryngoscope Insertion:

1. **Insertion and Landmark Identification:** Insert the laryngoscope and note the key anatomical landmarks.

2. **Blade Placement:** The laryngoscope blade should be inserted along the midline, gently gliding over the tongue and across the oropharynx. Advance the tip until it rests in the space between the base of the tongue and the epiglottis, an area called the vallecula.

- **Note for Preterm newborns**:

The vallecula can be quite small in very preterm newborns, which may necessitate positioning the laryngoscope tip gently right under the epiglottis itself.

- Expose the glottis by opening the mouth and moving the tongue aside. Lift the entire laryngoscope in the direction of the handle. A slight upward inclination of the blade's tip may be necessary to lift the epiglottis, thus revealing the glottis and vocal cords. When performing the procedure for the first time, users commonly bend their wrists and "rock" the baby's upper gum. This is done by pulling the top of the handle toward themselves. This technique will not achieve the desired outcome and carries the risk of injury to the newborn's lips and gums).

Figure 3.30
Insert the laryngoscope blade in the midline

Figure 3.31
Correct method for lifting the laryngoscope to expose the larynx.

In cases where the vallecula is small or the epiglottis is large and flaccid, the blade tip might be needed to directly and gently lift the epiglottis.

• When performing laryngoscopy, the glottis and vocal cords should be visible in the upper part of your field of view. A helper can assist in visualizing the glottis by applying gentle pressure to the baby's thyroid and cricoid cartilage using their thumb and first finger. This pressure should be directed downward and toward the newborn's right ear.

• Proper positioning of the blade's tip in the vallecula is indicated by the epiglottis hanging. If the structures are not immediately visible, adjust the blade until they can be seen. Slow insertion or removal of the blade may be necessary to visualize the vocal cords).

Proper visualization of the vocal cords during intubation requires precise blade placement.

- Insufficient Depth: If the blade is not advanced deeply enough, the posterior pharynx and base of the tongue will be visible.
- Optimal Position: Once the epiglottis is seen, advance the blade slightly further.
- Excessive Depth: Inserting the blade too far will only reveal the esophagus. In this case, withdraw the blade slightly until the epiglottis descends into view.
- Managing Secretions: If secretions obstruct the anatomical landmarks, use a size 10F or 12F catheter to clear mucus from the mouth and throat.

Once the vocal cords are visualized, hold the laryngoscope steady. A helper should hand you the endotracheal tube in your right hand.

Figure 3.32
Using a curved portion of the laryngoscope blade to identify the landmarks.

Figure 3.33
Suctioning secretions

3- Tube Insertion Procedure:

1. **Initial Placement:** Insert the tube into the baby's right side of the mouth, keeping it outside the laryngoscope blade. The tube's concave curve should be in the horizontal plane; this initial position allows for suctioning of secretions.

2. **Advancement** : Advance the tube along the right side of the mouth until the tip nears the vocal cords.

3. **Rotation:** As the tip approaches the vocal cords, rotate the tube's curvature into the vertical plane to direct the tip upward.

4. **Final Insertion:** Insert the tube when the vocal cords are open, ensuring the cords are positioned between the tube's indicated guiding lines.

5. **Depth Check:** Note the centimeter depth marker on the tube that aligns with the newborn's upper lip.

Important Considerations:

- **Closed Vocal Cords:** If the vocal cords are closed, wait for them to open.
- **Avoid Force:** Never attempt to force the tube between closed cords, and do not touch the closed cords with the tube's tip.
- **Time Limit:** If the cords do not open within 30 seconds, stop the insertion attempt. Resume breathing through a mask until you are prepared to try insertion again.

4- Secure the Endotracheal Tube

To secure the endotracheal tube, use your right index finger to firmly press the tube against the newborn's hard palate. Carefully remove the laryngoscope, taking care not to dislodge the tube. If a stylet was utilized, have an assistant remove it from the endotracheal tube while you maintain a firm hold on the tube.

While it's crucial to hold the tube firmly, you ought to take care to avoid squeezing it too much and making it impossible to remove the stylet.

Figure 3.34
Removing the tube carefully while stabilizing the tube against baby cheeks

Figure 3.35
Remove the optional stylet while holding the tube in place.

Ventilation should be initiated through the endotracheal tube after a helper attaches a CO2 detector and a Positive Pressure Ventilation (PPV) device. To help prevent accidental extubation , the person assisting with ventilation can hold both the endotracheal tube and the PPV device simultaneously.

Time Limit and Team Effort for Intubation

An endotracheal intubation attempt should ideally be completed within approximately 30 seconds. A swift and effective team approach is crucial to achieving this, as the baby is not receiving ventilation during the tube insertion.

Managing Deterioration During Intubation

If the baby's vital signs decline during the procedure (e.g., severe bradycardia or low oxygen saturation), it is recommended to pause the intubation attempt, resume positive pressure ventilation (PPV) using a mask, and then reattempt the intubation once the baby stabilizes

Handling Failed Intubation Attempts

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Avoid multiple, consecutive intubation attempts, as this increases the risk of soft tissue injury and complicates future airway management. If initial attempts are unsuccessful, consider alternative strategies:

- Continue face-mask ventilation.
- Utilize a video laryngoscope, if available.
- Seek assistance from an experienced healthcare professional (such as an anesthesiologist, emergency room doctor, respiratory care practitioner, neonatal nurse practitioner, or physician's assistant).

5-Verification of Endotracheal Tube Placement

The two primary indicators that an endotracheal tube (ETT) has been correctly inserted into the trachea are the detection of exhaled CO2 and a rapid increase in the heart rate. Immediately after ETT placement, connect a CO2 detector to confirm the presence of CO2 during exhalation.
If the tube is correctly inserted and effective ventilation is provided, exhaled CO2 should be detectable within 8 to 10 positive-pressure breaths.

Figure 3.36
Connect a C02 detector and T- piece resuscitator to the endotracheal tube and begin ventilation and secure the endotracheal tube in place by right index.

Figure 3.37
The colorimetric C02 detector is purple or blue before detecting exhaled C02

Colorimetric devices change color in the presence of CO2. In the delivery room, the capnograph is the most common electronic monitor used to display the amount of CO2 with each breath.

The tube can be in the trachea even if CO2 is not detected, as the use of CO2 detectors has limitations. Insufficient CO2 detection can occur for several reasons, even with correct tracheal placement:

- **Inadequate Ventilation:**

The amount of exhaled CO2 may be too low to detect if the lungs are not sufficiently ventilated. This could be due to:
- An obstruction (e.g., secretions) in the trachea or endotracheal tube) .
- Insufficient ventilation pressure being applied.
- Significant bilateral pneumothoraces leading to collapsed lungs.

- **Low Cardiac Output:**

Newborns with very low heart rates or diminished cardiac output may not be delivering enough carbon dioxide to their lungs for the detector to recognize.

A colorimetric CO_2 detector can change color even when the endotracheal tube is misplaced (not in the trachea), although this is uncommon (Table 3.9).

Situations Rendering the Detector Useless

Malfunction:
If the detector is yellow when removed from its packaging, it is malfunctioning and must not be used.

Irreversible Yellowing:
Certain substances can cause the paper inside the detector to turn permanently yellow, making it useless. These substances include:

- Gastric secretions
- Epinephrine administration (through the endotracheal tube)
- Surfactant administration (through the endotracheal tube)
- Atropine administration (through the endotracheal tube)

False Negative (ET Tube in Trachea, but No Color Change)	False Positive (ET Tube NOT in Trachea, but Color Change)
<Conditions leading to insufficient CO2 delivery to the detector include:	**Causes of contamination leading to a misleading CO2 reading include:**
Inadequate ventilation	*** Epinephrine contamination**
Collapsed lungs	*** Surfactant contamination**
*** Bilateral pneumothoraces**	*** Atropine contamination**
*** Very low heart rate**	*** Gastric secretion contamination**
*** Insufficient cardiac output**	*** Device malfunction (color change in packaging before use)**
*** Obstruction in the endotracheal tube**	

Table 3.9 Potential Issues with Colorimetric CO2 Detectors

Indicators for Correct Endotracheal Tube Placement in the Trachea

The two primary methods for confirming that the endotracheal tube is correctly positioned in the trachea are:

1. **Demonstrating exhaled CO2.**
2. **Observing a fast-rising heart rate.**

In addition to these main indicators, you should also look for the following signs to confirm proper tube placement:

- **Audible and equal breath sounds** near both axillae during positive-pressure ventilation (PPV).
- **Symmetrical chest movement** with each breath.
- **Little to no air leak** from the mouth during PPV.
- **Decreased or absent air entry** over the stomach.

Note on Interpreting Breath Sounds :
Because noises are easily transmitted in neonates, exercise caution when interpreting their breath sounds. To accurately hear breath sounds, use a small stethoscope and position it close to the axilla. Placing a large stethoscope or one near the middle of the chest may lead to picking up sounds originating from the stomach or esophagus.

Management of Suspected Endotracheal Tube Misplacement

1. **Remove and Reattempt Ventilation:**
If the CO2 detector fails after 8-10 breaths, the ET is likely misplaced (e.g., in the esophagus). Generally, immediately remove the tube , resume mask ventilation, recheck equipment, optimize position, and repeat intubation with a new tube.

2. **Special Consideration for Low Cardiac Output:**
newborns with very low heart rates or poor cardiac function may not transport enough CO2 to trigger the detector. If confident in placement despite no CO2, stabilize the tube, re-insert the laryngoscope, and attempt visual confirmation through the vocal cords.
Note: This "second look" is difficult and risks delaying effective ventilation.

3. **Action After Confirmation of Placement:**
If tube location is confirmed but the heart rate doesn't rise with ET ventilation, begin chest compressions . CO2 will become detectable once cardiac output improves.

Figure 3.38
Confirm ETT placement by listening to equal breath sounds in both axillae and absent breath sounds over the stomach

Properly positioned, the endotracheal tube yields equal breath sounds bilaterally. If too deep, one side's sounds, usually the left, will be quieter because the tube often enters the right mainstem bronchus. Slowly withdraw the tube while listening to the quieter side until breath sounds become equal, indicating correct placement.

- To secure the tube, note the centimeter mark at the newborn's lip. The tube can be secured with a specialized device or water-resistant tape. An example method using tape involves cutting a 3/4- or 1/2-inch strip long enough to go across the upper lip and onto both cheeks (about 2 cm onto the second cheek), then splitting one end to resemble pants.

- To secure the tube, position the uncut tape with the split line beginning just inside the corner of the baby's mouth. Place the upper portion of the tape across the baby's upper lip. Carefully wrap the lower portion around the tube. Ensure the marker remains at the intended centimeter mark near the newborn's upper lip. Be careful during this process, as it is easy to inadvertently push the tube further in than desired.

- At the end of the tape, fold it over itself to form a small "tab." This tab will allow you to easily unwind the tape to adjust the insertion depth or remove the tube.

- Make sure the tube hasn't been moved by using a stethoscope to listen over both sides of the chest. Examine the CO_2 detector's color change and the chest's rise and fall with each aided breath.

- Get a chest x-ray to confirm the tube's final placement if it will remain in place after the initial resuscitation.

- An effective intubation procedure relies on swift, efficient teamwork. A competent assistant is crucial for enhancing this teamwork, accelerating the process, and increasing the success rate of initial attempts.

Figure 3.39
Cut the tape from the middle.

Figure 3.40
Place the uncut section on the baby's cheek near the mouth corner. The upper tape leg goes above the lip, and the lower leg wraps around the tube.

Figure 3.41
Leave a small tab of tape folded over at the end to assist removal.

Procedure for Suctioning Thick Tracheal Secretions via an Endotracheal Tube (ETT)

If a newborn's condition does not improve despite correct ETT placement and the application of all necessary ventilator correction measures, and you are still unable to induce chest movement, the airway may be clogged by thick secretions. These secretions can include meconium, vernix, blood, or cellular debris.

To clear the airway, the initial attempt should be to insert a suction catheter through the ETT, If a simple suction catheter is unsuccessful, a specialized device, often called a "meconium aspirator" (though effective for all thick secretions), can be used to apply direct suction to the ETT.

Steps for Using a Tracheal Aspirator:

1. After the ETT is secured, attach the tracheal aspirator directly to the ETT connector.
2. Connect the tracheal aspirator to a suction source set at 80–100 mm Hg.
   Note: Different types of tracheal aspirators exist, and some ETTs may have an integrated suction port.
3. As you continuously suction the secretions from the trachea, use your finger to block the suction-control port on the aspirator.
4. Slowly withdraw the ETT over a period of 3 to 5 seconds while maintaining suction (as illustrated in Figure 3.44).

If thick secretions block the endotracheal tube and prevent effective ventilation, repeat suctioning until the airway is clear enough to inflate the lungs and establish adequate ventilation. Be ready to re-intubate with a fresh tube, restart face-mask positive pressure ventilation (PPV), or insert a laryngeal mask if necessary.

When a newborn's condition deteriorates following endotracheal intubation, several issues must be considered. These potential problems can be easily remembered using the acronym DOPE:

- **D**isplacement of the Endotracheal Tube:
  The tube might have shifted, either pulling out into the pharynx (extubation) or advancing too far into the airway (mainstem bronchus intubation).
- **O**bstruction of the Tube:
  The tube can become blocked by thick secretions such as blood or meconium.
- **P**neumothorax (Tension):
  A tension pneumothorax can develop, causing lung collapse and restricting air exchange.
- **E**quipment Failure:
  The positive-pressure ventilation (PPV) device may have become disconnected from the endotracheal tube or compressed air source, or a leak may have occurred in the circuit.

Figure 3.42
Tracheal Suctioning using an endotracheal tube and tracheal aspirator

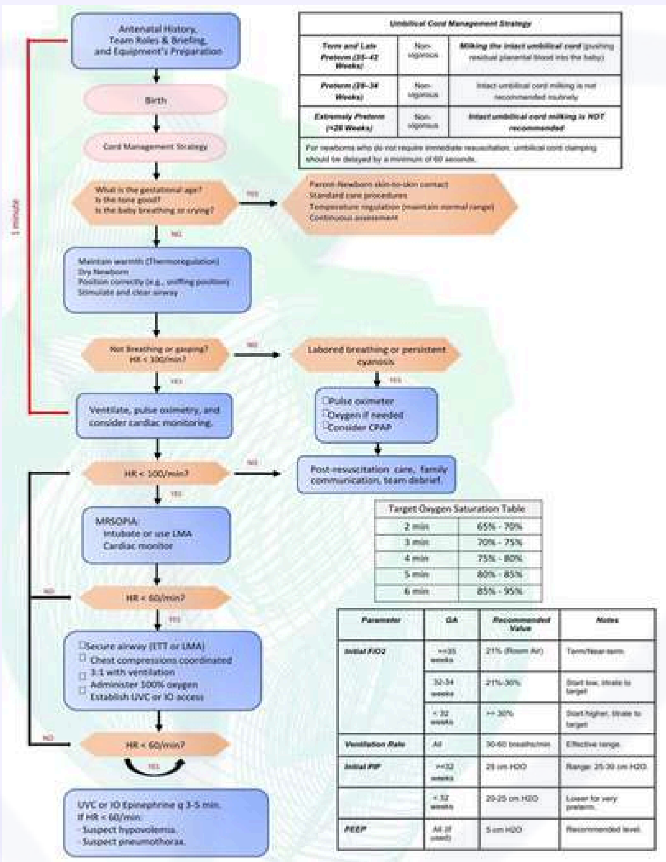
Chapter 4

Cardiovascular Management

CHAPTER OBJECTIVES :

Upon completion of this chapter, you will be able to:

- Identify the indications for performing chest compressions during neonatal resuscitation.
- Know how to demonstrate the correct technique for performing chest compressions.
- Understand the critical importance of coordinating chest compressions with positive pressure ventilation (PPV).
- Identify the indications for Epinephrine administration in neonatal resuscitation.
- Know when, where, and how to administer fluids during neonatal resuscitation.



Saudi Neonatal Resuscitation Algorithm

Chest Compression

The Critical Role of Chest Compressions in Neonatal Resuscitation

Approximately one to two out of every 1,000 neonates are expected to need intensive resuscitation, including chest compressions. These compressions are typically necessary in rare cases where the heart rate fails to improve following successful positive pressure ventilation. This lack of response is often associated with significant acidosis and hypoxemia, which can reduce myocardial perfusion and function due to low diastolic blood pressure.

Mechanically compressing the heart is vital as it enhances coronary artery perfusion and oxygenation, thereby improving the heart's pumping efficiency. Optimized chest compressions can achieve over 50% of normal cardiac and cerebral blood flow.
Crucially, coronary blood supply to the heart muscle occurs only during diastole—when pressure is released from the sternum during the compression cycle (Figure 4.1). This supply can be maximized through repetitive, uninterrupted chest compressions and the administration of a systemic vasoconstrictor, such as epinephrine.

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When to Initiate Chest Compressions

Chest compressions should only be started if the newborn's heart rate remains below 60 beats per minute after a full 30 seconds of effective positive-pressure ventilation (PPV). Optimally, this ventilation should be delivered via a laryngeal mask or an endotracheal tube.
Crucially, before beginning compressions, you must confirm that the chest is rising with PPV, indicating successful ventilation. If adequate chest rise is not observed, the necessary corrective ventilation steps (MR-SOPIA) must be performed to achieve effective ventilation first.

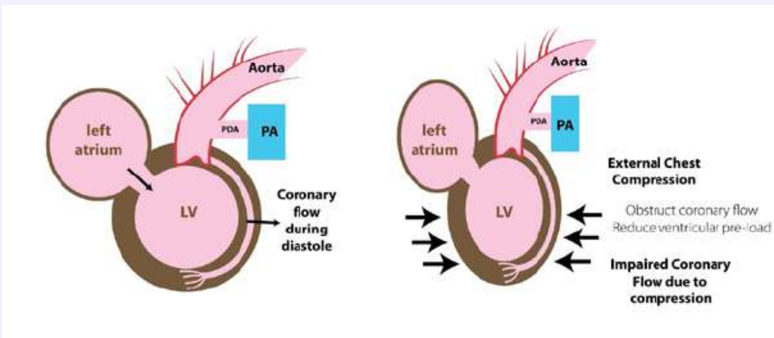

Figure 4.1
Chest compression's effect during diastole: coronary flow and ventricular filling occur. (PA=pulmonary artery, PDA=patent ductus arteriosus).

Positioning for Chest Compressions

Initially, before intubation, the person performing chest compressions can stand next to the warmer. Once the baby is intubated, the compressor should move to the baby's head. This allows the team member administering Positive Pressure Ventilation (PPV) to shift to the baby's side (Figure 4.2), thereby making space for a third person to insert an umbilical vein catheter.

To support the baby's back during compressions, use the thumbs technique (Figure 4.3). This involves placing your thumbs at the bottom third of the sternum, directly below the intermammillary line.

Note: Do not squeeze the xiphoid or the ribs (Figure 4.4).

To perform compressions, keep your thumbs in contact with the skin, moving only your thumbs to depress the sternum to approximately one-third of the anterior-posterior (AP) chest diameter (Figure 4.5). This technique prevents compression on other areas.

Ensure a complete release after each compression to allow the heart to refill, promote coronary perfusion, and permit lung expansion.

The compression rate is 90 per minute, coordinated with ventilation, maintaining a ventilation to compression ratio of 1/3. Each cycle, consisting of 3 compressions and 1 ventilation, should take 2 seconds.

Figure 4.2
Compressor position at the head side of the patient.

Figure 4.3
two thumbs-up method of chest compression

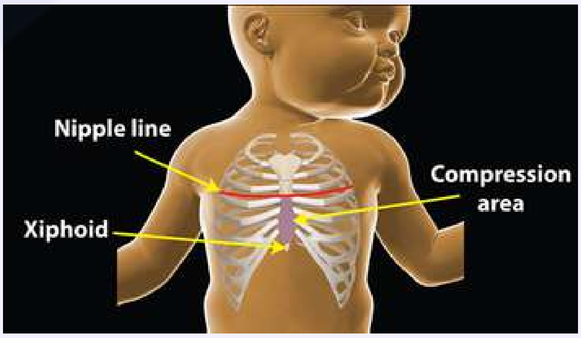

Figure 4.4
Landmark for chest compression.

Figure 4.5
Chest compression depth is approximately one-third of the anterior-posterior diameter of the chest.

Coordination of Chest Compressions and Positive Pressure Ventilation (PPV)

Effective coordination between chest compressions and PPV is essential, even if the newborn is intubated. The required ratio is **three rapid compressions followed by one breath (3:1).**
To maintain this rhythm, the person performing compressions should audibly count: **"One and two and three and breathe and."**

- **Compressions:** The first person performs compressions while counting "one, two, and three." This delivers 90 compressions per minute.
- **Ventilation:** The second person delivers the breath when they hear **"breathe and."**
- **Release:** Crucially, the compressor must release their thumbs at "breathe and" to allow the chest and lungs to expand fully during the PPV.

This coordinated effort results in the newborn receiving **90 compressions and 30 breaths over one minute.**

Oxygen Concentration Management During Chest Compressions:

Initiate chest compressions with the oxygen concentration (FiO2) set to 100%. Maintain this maximum concentration until the newborn's heart rate recovers to 60 beats per minute or greater. Once the heart rate target is met, adjust the FiO2 to achieve the desired oxygen saturation level.

Guidelines for Stopping Chest Compressions and Subsequent Actions

Chest compressions should be discontinued after 60 seconds of PPV-coordinated compressions, contingent upon heart rate assessment.

Heart Rate Assessment:

- **Recommended Tool**: Cardiac monitor.
- **Alternative Tools:** Stethoscope or pulse oximeter.
- **Limitation of Cardiac Monitor:** Cannot detect Pulseless Electrical Activity (PEA), which is managed the same way as asystole.

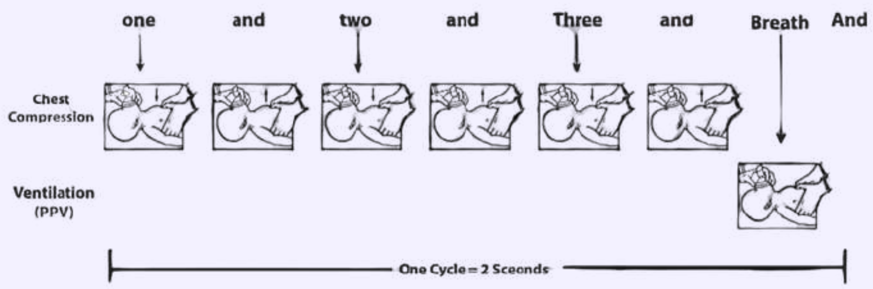

Figure 4.6 Coordination between chest compressions and ventilation

Action Based on Heart Rate:

- **If Heart Rate > 60 beats per minute:**
  - Stop chest compressions.
  - Adjust the fraction of inspired oxygen (FiO2) to achieve the desired oxygen saturation.
  - Increase the Positive Pressure Ventilation (PPV) rate to 30–60 per minute.

- **If Heart Rate is Still < 60 beats per minute (After 60 seconds of compressions):**
  Verify the following factors contributing to effective resuscitation:
  - Effective PPV administration (indicated by chest rise).
  - FiO2 is 100%.
  - Chest compressions are deep enough.

If the heart rate remains below 60 beats per minute and shows no improvement after one minute of coordinated chest compressions and ventilations, five specific questions must be addressed.
These questions ensure the delivery of high-quality compressions and ventilations and can be easily recalled using the acronym "CARDIO" (see Table 4.1).

If a newborn's heart rate remains below 60 beats per minute after 60 seconds of effective positive-pressure ventilation (PPV) and coordinated chest compressions, administer epinephrine and secure emergency vascular access (umbilical venous catheter insertion).

Key Action Points:

- **Initiate Chest Compressions :**
  Chest compressions are required if the heart rate is still less than 60 beats per minute after 30 seconds of effective PPV (demonstrated by chest movement) delivered via an endotracheal tube or laryngeal mask.
- **Monitoring :**
  Once PPV has begun , consider attaching a cardiac monitor to accurately assess the heart rate.
- **Prerequisite for Compressions :**
  Ensure effective PPV (chest movement) is established before starting chest compressions.
- **Staff Positioning :**
  To facilitate the third person's placement of the umbilical venous catheter, the compressor can move to the baby's head side after the endotracheal tube is secured

Acronym	Question	Explanation
C	Chest Movement	Is the chest rising and falling with each breath?
A	Airway	Is the airway secured (intubation or laryngeal mask)?
R	Rate	Is the rate of compressions and ventilation adequate (3 compressions and 1 breath in 2 seconds)?
D	Depth	Is the compression depth one-third of the chest's AP diameter?
I O	Inspired Oxygen	Are you ventilating the newborn with 100% oxygen?

Table 4.1: Five Questions If Compressions and Ventilation Fail to Improve Heart Rate

- **Oxygen Management During Compressions:** If chest compressions are necessary, increase the FiO2 to 100% until the heart rate exceeds 60 beats per minute. Subsequently, adjust the FiO2 based on the target oxygen saturation.

- **Compression Technique:** Use the two-thumbs technique for chest compressions. Place the thumbs together on the middle of the sternum, just below the imaginary intermammary line. Keep the rest of the fingers still to support the baby's back during compressions.

- **Compression Depth:** The depth of chest compressions should be approximately one-third of the chest's anterior-posterior diameter.

- **Compression and Ventilation Rate:** Maintain a coordinated rate of 90 chest compressions and 30 ventilations per minute.

- **Reassessment:** After 60 seconds of coordinated ventilation and chest compressions , reevaluate the newborn's heart rate.

- The preferred method for determining a neonate's heart rate is by using a cardiac monitor.

- Alternative tools for heart rate measurement include a stethoscope and a pulse oximeter.

- If the heart rate is 60 beats per minute or greater, stop chest compressions and continue with positive-pressure ventilation (PPV), adjusting the inspired oxygen concentration (Fio2) to meet the intended O2sat target.

- If the heart rate remains below 60 beats per minute after 60 seconds of effective chest compressions coordinated with PPV, prepare for the placement of an umbilical venous catheter to administer epinephrine.

Vascular Support , medication , and Volume Expander

Indications

The umbilical vein is readily acceible in a newborn . If you anticipate the need for administering medications during resuscitation, based on identified risk factors, one team member should prepare for the placement of an umbilical venous catheter (UVC) while the rest of the team continues with positive pressure ventilation (PPV) and chest compressions.

Procedure:

1. **Preparation:** Put on gloves and quickly gather the necessary equipment.
2. **Aseptic Technique:** Although maintaining sterility is important, the urgency of securing venous access must be weighed against the risk of contamination.
3. **Catheter Prep:** Attach a single-lumen umbilical venous catheter (3.5 F or 5 F) to a stopcock.
4. **Flushing:** Use a syringe to flush the catheter and stopcock with normal saline (3-10 mL).
5. **Stopcock Management:** Close the stopcock on the catheter (refer to the Figure 4-7) to prevent air from entering and fluid from leaking out. Ensure you are familiar with the stopcock's on and off positions.

Figure 4.7 The stopcock's off and directions

1- Clean the umbilical cord area by applying an antiseptic solution. Tie a loose knot at the base of the umbilical cord, around the Wharton's jelly or the skin edge (see Figure 4.8). This tie can be tightened if bleeding occurs when the cord is severed.

Figure 4.8
Tie placed at the base of the umbilical cord.

2- After gently instructing the team to cease chest compressions, use a scalpel to sever the cord. The cut should be made a few millimeters above the skin's surface and just below the umbilical clamp. It is best practice to cut directly across the cord rather than at an angle (Figure 4.9).
The umbilical vein and arteries can be distinguished by their size, wall thickness, and position (Figure 4.10). The umbilical vein is typically a larger, thin-walled vessel often observed at the 12-hour position. Conversely, the two umbilical arteries are smaller, possess thicker walls, and are usually situated close together.

Figure 4.9
Cut the umbilical cord 1 to 2 cm above the skin line.

3- Connect the catheter to the umbilical vein immediately (Figure 4.10).

Figure 4.10
The umbilical cord: one umbilical vein and 2 umbilical arteries.

The following steps should be followed for UVC insertion and medication administration:

A. **Catheter Insertion and Position Check**

1. Open the stopcock between the baby and the syringe.
2. Gently aspirate and insert the catheter 2 to 4 cm into the skin.
3. The catheter tip should only be inserted briefly into the vein, just to the point where blood can be easily aspirated. Avoid inserting the catheter further to prevent potential liver damage.

B. Securing and Medication Administration

1. Hold the catheter firmly in place with one hand until it is either secured or withdrawn.
2. Connect the syringe containing the medication to the stopcock port.
3. Turn the stopcock to open the connection between the syringe and the catheter.
4. Check for and ensure there are no air bubbles in the syringe or the catheter.
5. Administer the prescribed dose of medication.
6. Cleanse the catheter (refer to Figure 4.12).

C..Post-Medication Management (Temporary Access or Removal)

- The catheter can be secured for temporary intravenous access while the newborn is being transported to the NICU after medications have been given.
- Secure the catheter using suturing or sticky plaster.
- If the catheter is no longer needed, it can be removed.

D. Catheter Removal Procedure

- When removing the catheter, ensure the insertion site remains visible to check for any bleeding.
- If rapid removal is necessary, be sure to tighten the tie at the base of the umbilicus in case bleeding occurs.

Figure 4.11
Saline-filled catheter inserted into the umbilical vein.

Figure 4.12
Connect the umbilical venous catheter to a 3-way stopcock.

Figure 4.13
Securing the Umbilical venous catheter

The intraosseous (IO)

The intraosseous (IO) needle serves as a useful substitute for an umbilical venous catheter when vascular access is difficult or impossible to obtain during emergency resuscitation. IO needles are standard tools in emergency rooms and are sometimes used to establish access before patient transfer.

The procedure involves penetrating the epidermis and a large flat bone with the IO needle (Figure 4.13), advancing it into the bone marrow cavity. Fluids and medications can then be rapidly infused into the central venous circulation, achieving the same hemodynamic effect as intravenous (IV) administration. It is important to note that potential serious complications, such as infections, bone fractures, and limb ischemia, are possible.

Figure 4.13
IO needle

Intraosseous (IO) Needle Insertion Procedure

1. Locate the Insertion Site:

- Identify the tibial tuberosity (the bony prominence below the kneecap).
- For term newborns, the optimal site is on the flat area of the lower leg, approximately 2 cm below and 1 to 2 cm medial to the tibial tuberosity.

Figure 4.14
Needle insertion site.

2. Advance the Needle:

- Hold the IO perpendicular to the skin.
- Advance the needle through the skin until it contacts the bone surface (periosteum).
- **Manual Insertion:** Apply downward pressure while twisting to move the IO forward.
- **Drill Insertion:** Use the electric drill according to the manufacturer's directions, maintaining downward pressure while pushing the trigger.

3. Confirm Entry:
A noticeable reduction in resistance, often felt as a "pop," signifies that the needle has entered the bone marrow cavity.

4. Secure and Flush:

- Remove the stylet to secure the IO device, following the manufacturer's instructions (Figure 4.15).
- Attach an infusion set to the IO hub.
- Open the stopcock toward the needle.
- Flush the needle with 3 to 5 mL of standard saline to open the bone marrow space.

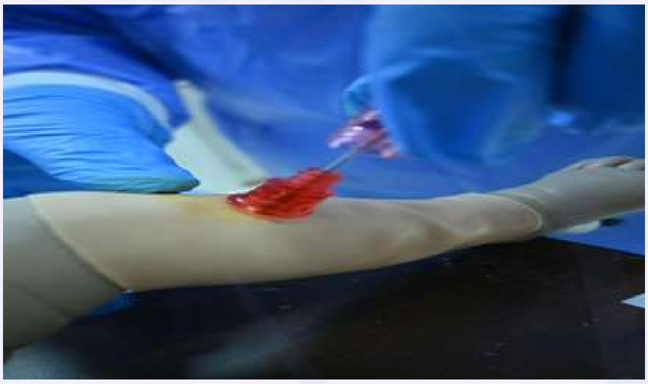

Figure 4.15
Removal IO stylet

5. Administer Medication:
Deliver the prescribed drug followed by a saline flush.

Figure 4.16
Connect the intraosseous needle to infusion set

6. Monitor Site:
Continuously monitor the insertion site for any signs of swelling or discoloration.

Epinephrine Administration in Neonatal Resuscitation

Indication for Use:

Epinephrine is indicated if the newborn's heart rate remains below 60 beats per minute (bpm) after the following two interventions have been successfully performed:

1. A minimum of 30 seconds of effective positive-pressure ventilation (PPV), confirmed by visible chest movement indicating lung expansion.
2. An additional 60 seconds of chest compressions coordinated with PPV using 100% oxygen.

Crucially, epinephrine is NOT recommended until successful ventilation and confirmed lung inflation (shown by chest movement) have been established.

Dosage and Route:

- Concentration: 1 mg/10 mL (or 0.1 mg/mL) (Refer to Figure 4.16).
- Route of Administration: Intravenous (IV) or intraosseous (IO) are the preferred routes.
- Alternative: An endotracheal (ET) dose may be considered only while vascular access (IV/IO) is being established.

Figure 4.17
Epinephrine 1: 10.000

Administration Details:

Syringe Setup:
1-mL syringe for IV/IO use (labeled Epinephrine-IV); 3- to 5-mL syringe for Endotracheal use (labeled Epinephrine-ET ONLY).

Repetition Interval:
May be repeated every 3 to 5 minutes.

IV/IO Dose:
Dose: 0.02 mg/kg (equivalent to 0.2 mL/kg).
Range: 0.01 to 0.03 mg/kg (0.1 to 0.3 mL/kg).

Rate:
Administer quickly, as soon as feasible.

Post-IV/IO Action:
Follow with a 3 mL saline flush.

Endotracheal (ET) Dose:
Dose: 0.1 mg/kg (1 mL/kg).
Range: 0.05 to 0.1 mg/kg (0.5 to 1 mL/kg).

Alternative Route:
If no improvement is observed, intravenous or intraosseous administration is suggested for subsequent doses.

Post-Epinephrine Expectations and Management

Following intravenous (IV) or intraosseous (IO) epinephrine administration, the heart rate should ideally reach 60 beats per minute (bpm) or greater within approximately one minute.

- If the heart rate remains below 60 bpm after the initial IV/IO dose of epinephrine, continue synchronized breathing and chest compressions.
- Repeat the epinephrine dose every 3 to 5 minutes. Consider increasing subsequent doses if the initial dose was the suggested minimum of 0.02 mg/kg or less.
- If there is no response, investigate other potential causes, such as hypovolemia or tension pneumothorax.

- **Timing of IV/IO dose:**
 If the heart rate is less than 60 bpm, the first IV or IO dose can be given immediately after an endotracheal dose.
- **Route for subsequent doses:**
Once an IO needle or umbilical venous catheter is in place, all subsequent doses must be administered via the IV or IO route.
- **Heart Rate Monitoring:**
Utilize a cardiac monitor for the most accurate heart rate assessment.
- **Assessment of Ventilation and Compression:**
Observe chest movement to confirm adequate ventilation, proper placement (not dislodged, bent, or clogged) of the endotracheal tube, and appropriate depth of chest compressions.
- **Compression Interruption:**
Minimize interruptions to chest compressions, as each interruption reduces coronary artery perfusion.

Volume Expander Expectations and Management

Shock can result from various conditions leading to significant blood loss, including acute fetal-maternal hemorrhages, vasa previa, significant vaginal bleeding, placenta lacerations, fetal injuries, umbilical cord prolapses, tight nuchal cords, and blood loss from the baby's umbilical cord. In these cases, the newborn's heart rate may be too low to respond to chest compressions, adequate breathing, or epinephrine alone.
Newborns in shock may present with pale skin, weak pulses, and delayed capillary refill.

- **Signs of Improvement:** A responding newborn will show improved capillary refill time, pinker skin, and palpable pulses.

Troubleshooting for Non-Response

If the newborn has received both epinephrine and a volume expander but has not improved, the team should evaluate the following:

1. Is there proper chest movement with breathing?
2. Is the airway secured with a laryngeal mask or an endotracheal tube?
3. Are the ratio of 3 compressions to 1.ventilation coordinated every 2 seconds?
4. Is the depth of compressions equal to the chest's AP diameter?
5. Is the Positive Pressure Ventilation (PPV) device delivering 100% oxygen?
6. Was the correct amount of epinephrine administered intravenously?
7. Has the intraosseous needle or umbilical venous catheter become dislodged?
8. Is a pneumothorax present?

Volume Expander Administration

A volume expander is recommended if the newborn is not responding to initial resuscitation steps and displays indicators of shock or has a history of significant blood loss.

- **A**. **Solution:** Normal saline (NS) or type O Rh-negative blood.
- **B**. **Route**: Intravenous or intraosseous.
- **C**. **Equipment**: A 30- to 60- mL capacity syringe (clearly labeled NS or O- blood).
- **D**. **Dose**: 10 mL/kg.
- **E**. **Rate:** Administer over 5 to 10 minutes.

Discontinuation of Newborn Resuscitation

The decision to stop newborn resuscitation must be individualized, balancing the slim chance of survival without severe disability against the futility of prolonged intervention. While some newborns survive after an absent heart rate for over 20 minutes, a lack of detectable heart rate after 10–20 minutes often results in non-survival or serious neurological impairment.

Key Factors for Discontinuation:

Consider the following before ceasing efforts:

- Duration of asystole.
- Completeness of all appropriate interventions.
- Patient characteristics (gestational age, severe congenital anomalies).
- Perinatal context (cause and timing of arrest).
- Family preferences.
- Availability of post-resuscitative care (e.g., therapeutic hypothermia).

Recommended Approach:

No single, fixed time interval for discontinuing CPR is appropriate.

- **Confirmed Asystole:** If no heart rate is present after all appropriate steps, discuss cessation with the team and family.
- **Timing Guideline:** Approximately **20 minutes after birth** is a reasonable point to consider cessation, but the final decision must be tailored to the individual patient and clinical context.

Other Scenarios:

Discontinuation may also be appropriate for prolonged bradycardia without improvement after complete resuscitation. Due to limited data, these non-asystolic decisions require a case-by-case approach and consultation with an expert.

Key Notes on Resuscitation Practices

- **Epinephrine Dosing Simplification:** The recommended dose of epinephrine has been streamlined to a single dose, rather than a range. This change aims to simplify preparation, enhance provider recall in emergencies, and potentially improve teamwork.
- **Increased Flush Volume:** Studies in animals have led to an increase in the flush volume following intravascular epinephrine administration from 1 mL to 3 mL. This addresses concerns that a smaller 1-mL flush might leave a significant amount of epinephrine in the umbilical vein or liver instead of effectively transporting it to the heart.

- **Epinephrine Dose Specification:** It is acceptable and safe to specify the emergency epinephrine dose as either a mass (mg/kg) or a volume (mL/kg).
- **IO Needle Placement Confirmation**: It is not necessary to aspirate the IO needle, especially in newborns. Proper placement is indicated when the needle feels securely held in the bone without "wiggling," and the surrounding soft tissue does not bulge upon fluid administration.
- **Extended Resuscitation Period:** The recommended time to consider stopping resuscitation attempts has been extended from 10 minutes to approximately 20 minutes, based on guidance from The International Liaison Committee on Resuscitation (ILCOR).

Chapter

5

Resuscitation and Stabilization of Preterm newborns

CHAPTER OBJECTIVES :

Upon completion of this chapter, you will be able to:

- Explain the heightened risk of morbidity and mortality in preterm newborns.
- Detail the necessary preparations for a safe and effective preterm delivery.
- Describe appropriate oxygen management and methods for delivering assisted ventilation to preterm newborns, when required.
- Identify strategies to minimize potential lung and brain injury in preterm newborns.
- Discuss specific disorders that may complicate resuscitation efforts.
- Outline the management protocols for various special newborn disorders.
- Outline the steps for maintaining a normal body temperature in premature babies throughout the resuscitation process.

RESUSCITATION AND STABILIZATION OF PRETERM NEWBORNS

I. Why Preterm newborns are Vulnerable ?

Preterm delivery is defined as birth before 37 completed weeks of gestation, whereas a term delivery occurs between 37 and 42 weeks. Prematurity presents significant hurdles, making the transition from the womb to external life more challenging. The degree of prematurity (lower gestational age) directly correlates with the amount of support required.
Preterm babies are exceptionally fragile and can be susceptible to injury from the resuscitation procedures themselves. Therefore, a delicate balance must be maintained: initiate timely resuscitation while avoiding unnecessary invasive interventions. The first minutes of life are critical for mitigating both short- and long-term complications. Some complications may also stem from the underlying cause of the early delivery.

Specific Risks Associated with Prematurity :

- Hypothermia: Thin skin, minimal subcutaneous fat, a large surface area relative to body mass, and a poor metabolic response to cold make preterm newborns prone to heat loss.

- Intracranial Hemorrhage: Immature and fragile cerebral blood vessels cannot adequately regulate blood flow, increasing the risk of bleeding in the brain.

- Respiratory Distress: Several factors increase the need for respiratory support post-birth:
  - Thin and weak chest muscles.
  - Stiff lungs due to Surfactant deficiency.
  - Potential infection of the amniotic fluid and placenta (chorioamnionitis) , which may have caused the early delivery.
  - Decreased efficiency of the respiratory control center.

- Infection: Preterm newborns are immunocompromised and have a higher susceptibility to infections.

- Hypovolemia and Hypoglycemia:
- A small total blood volume, limited metabolic reserves, and ineffective compensatory mechanisms elevate the risk of hypovolemia from blood loss and low blood sugar.

- Tissue Damage:

Generally , all immature tissues are vulnerable to damage from either an excess or a shortage of oxygen.

II. Preparation for Safe and Effective Preterm Delivery

The foundation of successful resuscitation is readiness—mentally, physically, and with the necessary resources.

A. Planning and Team Preparation:

- **Initial Call:** Upon notification of a high-risk delivery, gather a detailed history and formulate a clear plan encompassing manpower, equipment, and the assigned role of each team member.

- **Pre-Delivery:** Arrive early to discuss the latest updates with the obstetrician, thoroughly check equipment, and review the resuscitation plan with the team.

B. Essential Additional Resources for Preterm Deliveries:

In addition to standard resuscitation equipment for term babies, specific resources are required:

- Skilled personnel.
- A hat.
- Thermal mattress.
- A polyethylene plastic bag (for newborns <32 weeks gestation).
- Servo-controlled radiant warmer.
- Preterm-sized resuscitation masks and endotracheal tubes.
- Size 0 and 00 laryngoscope blades.
- A positive-pressure device capable of delivering Continuous Positive Airway Pressure (CPAP) and Positive-End Expiratory Pressure (PEEP).
- Surfactant (if the baby is expected to be <30 weeks gestation).
- A three-chest-lead cardiac monitor or limb leads for heart rate assessment if the pulse oximeter signal is poor.

III Oxygen Management and Assisted Ventilation in Preterm newborns

The immaturity of the lungs makes them susceptible to injury and challenging to ventilate.

Key Equipment and Strategy:

- **Monitoring:** A pulse oximeter with appropriately sized sensors and an oxygen blender must be available for all preterm births.
- **Respiratory Devices:** Equipment capable of providing CPAP and PEEP is preferred, such as a flow-inflating bag, a T-piece resuscitator, or a self-inflating bag with a PEEP valve.
- **Positive-Pressure Ventilation (PPV):** If PPV is required, use the minimal Peak Inspiratory Pressure (PIP) necessary to achieve and maintain a good heart rate response. It is preferable to use a device capable of delivering PEEP.
- **Early CPAP:** The early and proper use of CPAP is one of the most vital measures to avoid intubation in preterm newborns. Respiratory devices capable of delivering effective CPAP must be available at the delivery.
- **Indication for CPAP:** If a spontaneously breathing preterm baby has a heart rate of at least 100 beats/minute but shows low oxygen saturation or labored respiration, initiate CPAP immediately.
- **Limitation of CPAP:** CPAP alone is ineffective for babies who are apneic or whose heart rate is less than 100 beats/minute.
- **Primary Support:** For a spontaneously breathing preterm newborn with a heart rate of Less than 100 beats/minute, CPAP is the primary respiratory support.

Initiating Positive Pressure Ventilation (PPV) in Preterm newborns

Indications for PPV

The criteria for initiating PPV in preterm babies mirror those for term newborns, and include:

- Apnea
- Gasping
- Heart rate (HR) below 100 beats/minute

PPV should be started if any of these conditions persist beyond 30 seconds after birth, despite the completion of initial stabilization steps.

Preferred Equipment

When PPV is necessary, the use of a device capable of delivering Positive End-Expiratory Pressure (PEEP) is recommended:

- **T-piece resuscitator**
- **Self-inflating bag with an attached PEEP valve**

Begin PEEP at **5 cm H_2O.**

Ventilation Strategy (Pressure and Monitoring)

Given the immaturity and vulnerability of a preterm baby's lungs, the goal is to use the **minimum effective inflation pressure.**

- **Initial Pressure:** Start PPV at **20–25 cm H_2O**, which is typically adequate for most preterm newborns.
- **Monitoring Effectiveness: The best indicator** of successful ventilation is a rapid **increase in heart rate** (aiming for >100 beats/minute) within 10 seconds, followed by a gradual improvement in oxygen saturation.

- **Note on Chest Movement:** The volume of air required to ventilate a preterm baby's lungs is very small, and visible chest movement may not occur.
- **Maximum Face-Mask Pressure:** The absolute maximum inflation pressure for face-mask PPV in preterm newborns is **30 cm H_2O.**
- **Escalation:** If a pressure of 30 cm H_2O fails to result in clinical improvement after applying the MR. SOPIA corrective steps for ventilation, discontinue face-mask ventilation and secure the airway with an endotracheal tube (ETT). Providing ventilation through an ETT often allows for a reduction in required inflation pressure and leads to clinical improvement.
- **Adjunct Monitoring:** A CO_2 detector placed between the mask and the PPV device can be used to confirm effective PPV.
- **Common Issue:** A common cause of ineffective face-mask PPV is a leak at the face-mask seal (address as part of MR.SOPIA).

Surfactant Administration

Prevention and Treatment

- **Early and proper use of Continuous Positive Airway Pressure (CPAP)** immediately after delivery significantly decreases the need for subsequent mechanical ventilation in preterm newborns.
- **Prophylactic Surfactant:** Some experts still advise prophylactic surfactant for babies born at less than 26 weeks gestation.
- **Therapeutic Surfactant:** Preterm newborns who develop respiratory distress syndrome, fail CPAP, and require intubation and mechanical ventilation should receive therapeutic surfactant.

Surfactant Administration Methods

Surfactant can be administered to preterm babies via three main methods:

1. **Classical Way:** Through the endotracheal tube (ETT), followed by gradually weaning the baby from the mechanical ventilator.
2. **Less/Minimally Invasive**: While the baby is on Continuous Positive Airway Pressure (CPAP), a thin tube is passed through the vocal cords (Less Invasive Surfactant Administration - LISA or Minimally Invasive Surfactant Treatment - MIST).

3. ntubate-Surfactant-Extubate (INSURE): The baby is intubated, surfactant is administered, and the ETT is immediately removed, returning the baby to CPAP.

Note: Each Neonatal Intensive Care Unit (NICU) must establish its own criteria for defining CPAP failure and the appropriate timing for mechanical intubation and surfactant delivery. Surfactant administration should be performed by expert personnel; if they are not available in the resuscitation team, their arrival should be awaited.Oxygen Therapy and Injury Prevention in Preterm Babies

Preterm babies are highly susceptible to injury from excessive oxygen due to their development in a low-oxygen environment and their immature oxygen-associated injury protective mechanisms, making them vulnerable to reperfusion injury.

Despite these risks, most preterm babies require supplemental oxygen to maintain physiological saturation levels (refer to Table 5.2 for normal physiological levels compared to term babies).

Guidelines for Oxygen Use:

- During resuscitation, a balance must be maintained between low and high blood oxygen levels.
- For babies less than 35 weeks gestation, it is currently recommended to initiate oxygen therapy with a fractional inspired oxygen (FiO2) of 21-30%. The concentration should then be titrated to achieve the desired oxygen saturation level, utilizing a pulse oximeter and an oxygen blender.
- Resuscitation should never be initiated with 100% oxygen. An oxygen blender must be readily available in all delivery rooms.

Minimizing Lung and Neurological Injuries

Preterm newborns are prone to complications because all their systems and organs are not yet fully developed. The respiratory and central nervous systems are key contributors to significant morbidity and mortality.

- Preterm babies, particularly those born before 32 weeks gestation, have a fragile network of capillaries in the brain. Rupture of these vessels can lead to significant brain bleeding, causing brain tissue damage and lifelong disability.

Ways to Minimize Lung Injuries	Ways to Minimize Neurological Injuries
Ventilation & Oxygen Management:	Handling & Positioning:
Use blended oxygen and a pulse oximeter	Handle the baby gently.
Avoid high Positive Pressure Ventilation (PPV) and Continuous Positive Airway Pressure (CPAP) pressures (to prevent pneumothorax and decreased cerebral venous return/increased bleeding risk).	Avoid positioning the baby's legs higher than the head (Trendelenburg position).
Take blood aires to guide adjustments in ventilation and oxygen concentration.	Hemodynamics & Metabolism:
Start CPAP as early as possible to reduce the need for endotracheal intubation and mechanical ventilation.	Avoid rapid intravenous fluid infusions (administer normally between 5–10 minutes).
Avoid hypoxia and hyperoxia.	Avoid rapid changes in blood CO2 levels, blood pressure, or blood volume.
Procedural Avoidance:	Avoid hypoxia and hyperoxia.
Avoid multiple intubation attempts and frequent, unnecessary tracheal suction.	Environmental & Stimuli Control:
Avoid noisy, painful, or irritating stimuli.	

Table 5.1: Strategies to Minimize Neonatal Injuries

Preventing Hypothermia in Newborns: Thermoregulation Guidelines

Maintaining a normal body temperature is crucial for all newborns, especially premature newborns who are highly vulnerable to hypothermia (body temperature below 36.5 °C). Hypothermia affects a significant number of extremely premature babies and is associated with increased morbidity and mortality.

General Requirements for Thermoregulation:

A radiant warmer with servo-control functionality and a temperature sensor must be readily available.

Figure 5.1
Applying plastic bag for preterm baby.

Gestational Age	Resuscitation/Initial Care Measures	Ongoing Monitoring & Transport
Term and Late-Preterm newborns	Drying with warm towels, skin-to-skin contact, and early breastfeeding are typically sufficient	N/A
Preterm newborns (More than 32 weeks)	* Set the resuscitation room temperature to 23-25°C. * Preheat the radiant warmer. * Place a hat on the baby's head immediately. * Use heated towels to dry the baby thoroughly.	* Attach a temperature sensor and use the radiant warmer's servo-control. * Target axillary temperature: 36.5°C to 37.5°C. * Monitor closely to prevent both hypo- and hyperthermia. * Use a pre-warmed transport incubator for movement to the NICU.
Preterm newborns (32 weeks and less)	* Set the resuscitation room temperature to 23-25°C. * Preheat the radiant warmer. * Place a hat on the baby's head immediately. * Do not dry the baby; instead, immediately cover or wrap the baby with a polyethylene plastic bag or wrap (any commercially available type is acceptable). * A thermal mattress must also be prepared and used. * Note: A hole can be made in the plastic if an umbilical venous catheter (UVC) insertion is necessary.	* Attach a temperature sensor and use the radiant warmer's servo-control. * Target axillary temperature: 36.5°C to 37.5°C. * Monitor closely to prevent both hypo- and hyperthermia. * Use a pre-warmed transport incubator for movement to the NICU.

Table 5.2 Specific Measures Based on Gestational Age:

Special Precautions for Preterm Neonates

A. Blood Glucose Monitoring

- Preterm newborns have limited glucose stores.
- Resuscitation can rapidly deplete these stores, leading to hypoglycemia.
- **Action:** Essential steps include monitoring blood glucose and promptly initiating intravenous fluid containing dextrose.

B.Cardiopulmonary Events (Apnea , Bradycardia , and Desaturation - ABDs)

- Preterm newborns are prone to significant ABDs due to the immaturity of their respiratory center.
- **Action:** Close monitoring of ABDs is required during the stabilization phase, with timely intervention as needed.

C. Prenatal Counseling for Parents

- **Goal:** Provide full information, build a trusted relationship with the neonatal team, discuss goals of care, and facilitate shared decision-making. Counseling on the potential outcomes is a parental right.

- **Timing:**
  - It should be done as soon as comprehensive information about the pregnancy is available.
  - Ideally, NICU consultation should be performed for any potential NICU admission upon the mother's admission, even if delivery timing is uncertain.

- **Process:**
  - Ideally, both obstetric and neonatal providers should be present.
  - Counseling near delivery can be challenging due to the need to convey complex information quickly while the mother is stressed.

- **Content:**
  Present accurate , objective , and balanced information , including available treatment options, short- and long-term outcomes , and national/international outcome data.
  - Avoid being overly negative or unrealistically positive.
  - Use numbers only when clear data is available.

- **Communication**:
  Keep the discussion simple and clear. Allow sufficient time for questions by conducting the counseling early, before delivery progresses or medications take effect. Encourage follow-up questions and revisit the discussion if time permits.

Chapter

6

Special Considerations

CHAPTER OBJECTIVES :

Upon completion of this chapter, you will be able to:

- Recognize the newborns experiencing upper airway obstruction.
- Know how to manage a newborn with myelomeningocele.
- Diagnose a newborn with abdominal wall defects.
- Recognize and manage pneumothorax or pleural effusion.
- Address resuscitation challenges associated with congenital lung and heart diseases.
- Outline the newborn complications resulting from maternal opiate or anesthesia exposure.

This Chapter will focus on less common conditions encountered during neonatal resuscitation. Early recognition and a rapid, efficient response to these conditions are essential.

PNEUMOTHORAX: RECOGNITION AND MANAGEMENT

Pneumothorax is defined as the accumulation of air in the pleural space surrounding the lungs. This air prevents the lungs from fully expanding, leading to severe respiratory distress and persistent bradycardia.

Causes and Risk Factors:

While a pneumothorax can occur spontaneously, the risk is elevated in certain situations:

- Use of Positive Pressure Ventilation (PPV).
- Preterm babies.
- Babies with meconium aspiration.
- newborns with congenital lung anomalies (e.g., Congenital Diaphragmatic Hernia, Lung Hypoplasia).

Clinical Presentation and Types:

- **Mild Pneumothorax:** Involves a minimal air leak into the pleural space, resulting in mild or no respiratory symptoms. These often resolve spontaneously without the need for a chest drain, though close clinical and radiological monitoring is essential.

- **Tension Pneumothorax:** This is a life-threatening emergency. A large volume of trapped air exerts pressure, causing lung collapse and interfering with blood flow within the chest. This results in severe respiratory distress, oxygen desaturation, and bradycardia.

Diag.iosis and Suspicion:

A pneumothorax should be strongly suspected if a newborn fails to improve despite resuscitative measures or if there is a sudden clinical deterioration ("crashed baby") with severe respiratory symptoms.

Diagnostic Tools:

1. **Chest X-ray:**
   The definitive diagnosis is made by a chest x- ray showing air in the pleural space.

2. **Clinical Suspicion (for Tension Pneumothorax)**:
   Due to the emergent nature of tension pneumothorax, **treatment must not be delayed** while waiting for a chest x-ray. Clinical suspicion warrants immediate intervention.

3. **Physical Examination:**

- **Diminished Breath Sounds:** Breath sounds will typically be diminished on the affected side. However, caution is required, particularly in preterm newborns with small chests where sound transmission can make interpretation difficult.
- **Differential Diagnosis:** Be aware that a deep endotracheal tube misplaced into the right main bronchus can cause diminished air entry on the left side, mimicking a pneumothorax.

4. **Transillumination:**

- Using a high-intensity fiber-optic light in a dimmed room, the side of the chest with a pneumothorax will appear brighter and the light will spread further than the opposite side (Figure 6.2).

- **Caution**: Transillumination results can be misleading in very premature newborns due to their thin skin, which may cause a brighter glow even without a pneumothorax.

Management Principle

If there is a strong clinical suspicion of pneumothorax, especially tension pneumothorax, proceed with emergency treatment immediately, even if transillumination is unavailable or inconclusive.

Figure 6.1 Pneumothorax

Figure 6.2 Transillumination

Category	Cause of Respiratory Distress or Failure
Equipment/Technique Issues	Malposition of the endotracheal tube
	Failure of the ventilatory device
	Suboptimal ventilation techniques
Pulmonary/Thoracic Abnormalities	Tracheal obstruction
	Pneumothorax
	Pleural effusion
	Congenital lung anomalies (including lung agenesis, lung hypoplasia, and Congenital Diaphragmatic Hernia - CDH)
Cardiac Factor	Severe cardiomegaly

Table 6.1
Causes of diminished breath sounds

Pleural Effusion: Definition, Causes, and Management

Definition and Characteristics

Pleural effusion is the term for any collection of fluid in the pleural space.

Causes

Fluid can accumulate due to:

- Infection.
- Leakage from the lymphatic system.
- Generalized edema, often as part of hydrops fetalis, which is also characterized by generalized skin edema, ascites (abdominal fluid), and pericardial effusion (fluid around the heart).

Diagnosis and Complications

- **Diagnosis:** Pleural effusion is typically diagnosed definitively using a chest X-ray or chest ultrasound. Large effusions are often detected during routine antenatal ultrasound.

- **Complications:** Large pleural effusions can be linked to serious pregnancy complications such as twin-twin transfusion syndrome, severe fetal anemia, congenital heart disease, cardiac arrhythmias, congenital infection, and genetic syndromes.

- **Physiological Impact:** A large amount of fluid in the pleural space impedes normal lung expansion, impairs blood flow and air exchange, leading to severe respiratory distress and oxygen desaturation.

- **Clinical Sign:** Breath sounds on the affected side will be diminished.

Figure 6.3 Pleural Effusion

Management

Initial Approach (Minimal / Mild Cases)

- A minimal pleural effusion in an asymptomatic baby or one with mild symptoms generally does not require intervention.
- Management involves close observation and identifying the underlying cause.

Intervention (Significant/Symptomatic Cases)

- If a baby is symptomatic with a large pneumothorax or pleural effusion, drainage is required.
- **Antenatal Drainage:** If feasible, large pleural effusions may be drained antenatally by the obstetrician.
- **Postnatal Drainage (Thoracentesis):** When significant respiratory symptoms persist despite intubation and positive pressure ventilation (PPV), the fluid must be drained from the pleural space via a procedure called thoracentesis.

Thoracentesis Procedure

Thoracentesis involves inserting a catheter to drain air (for pneumothorax) or fluid (for pleural effusion) from the affected pleural space.

- **Technique:** The procedure is performed under sterile conditions with proper pain control in non-emergency situations. However, in emergencies like a tension pneumothorax, rapid execution is critical to save the newborn's life.
- **Preparation:** Prepare the site with topical antiseptic agents, sterile towels, and local anesthesia (if not an emergency).
- **Equipment:** Use an 18- or 20-gauge percutaneous catheter-over-needle device or a small "butterfly" needle. Insert the needle perpendicular to the chest wall and above the upper part of the rib to avoid puncturing the blood vessels located underneath.
- **Insertion Sites and Positioning:**

  * **For Pneumothorax (Air Drainage):**

  Site: Fourth intercostal space at the anterior axillary line OR the second intercostal space at the mid-clavicular line.

  Positioning: Supine with the affected side slightly elevated to allow air to accumulate at the insertion area.

  Direction: The catheter should be directed slightly upwards toward the front of the chest.

  * **For Pleural Effusion (Fluid Drainage):**

  Site: Fifth or sixth intercostal space along the posterior axillary line.

  Positioning: On the back (supine) to allow fluid to collect in the posterior part of the chest.

  Direction: The catheter should be directed slightly downward toward the back.

- **Drainage**: Once the pleural space is entered, remove the needle. Attach a large syringe (30-60 ml) connected to a 3-way stopcock, and use the stopcock correctly to drain the air or fluid.
- **Post-Procedure:** Obtain a chest X-ray to document the successful drainage of the pneumothorax or pleural effusion.
- **Long-Term**: In some cases, a plastic tube (thoracostomy) may need to be inserted into the chest cavity and removed after a few days.

Condition	Symptom Severity	Management
Minimal Pleural Effusion/Pneumothorax	Asymptomatic or mild symptoms	No drain required; close observation and supplemental oxygen to maintain normal saturation.
Large Pleural Effusion/Pneumothorax	Symptomatic	Requires thoracentesis (inserting a catheter/needle) to drain the air or fluid.

Table 6.2
Combined Management: Pneumothorax and Pleural Effusion

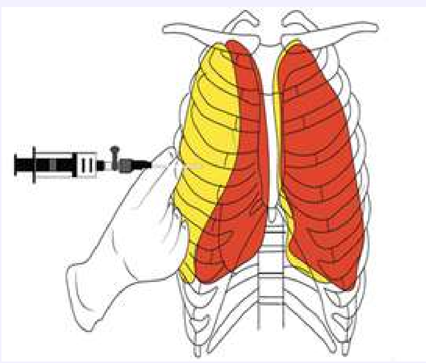

Figure 6.4 Thoracentesis for pneumothorax

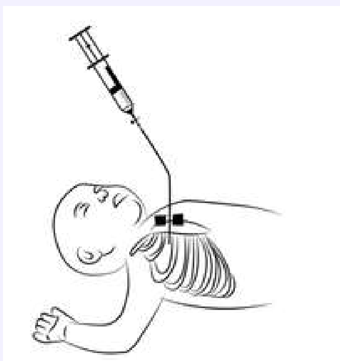

Figure 6.5 Thoracentesis for pneumothorax

Upper Airway Obstruction in Newborns

Upper airway obstruction is a common and potentially life-threatening condition in neonates, posing both a diagnostic and therapeutic challenge for clinicians. Obstruction can be categorized into two main types:

I. Obstruction Due to Thick Secretions

Thick secretions, such as meconium, blood, mucus, or vernix, can lead to a complete blockage of the trachea.

- **Initial Management (Ventilation Failure) :** If positive pressure ventilation (PPV) is attempted but the baby's condition does not improve and there is no chest movement, the standard ventilation corrective steps (MR.SOPIA) must be applied until improvement is noted.
- **Post-Intubation Obstruction:** If an endotracheal tube (ETT) has been successfully inserted but chest movement is still absent, a thick secretion obstruction inside the trachea should be suspected.
- **Clearing the Secretions:**
  - Initial attempts to clear the airway can be made using a small suction catheter (5F–8F) passed through the ETT.
  - If secretions are too thick to be removed by the small catheter, the ETT itself should be used as the suction catheter with the aid of a tracheal aspirator (Figure 6.6).
  - **Procedure:** Set the suction pressure to 80–100 mm Hg. Connect the suction tubing to the aspirator and then to the ETT. Apply suction while slowly removing the ETT over a 3–5 second period to extract all the obstructing secretions. Following this, a new ETT must be inserted immediately to ventilate the newborn.

Figure 6.6 Tracheal Aspirator

II. Anatomic Obstructions

Newborns are obligate nose breathers, typically breathing through their mouths only when crying. Anatomic obstructions disrupt the normal nasal airway.

1. Choanal Atresia

Choanal atresia is a condition where the nasal passage is obstructed by bone or soft tissue (Figure 6.7).

Clinical Presentation:

- **Unilateral Atresia:** Usually does not cause significant symptoms in the newborn period.
- **Bilateral Atresia :** Presents as severe respiratory distress and cyanosis immediately after birth when the baby is quiet, with symptoms resolving when the baby cries (mouth breathing).

Diagnosis:
The presence of meconium or mucus in the nasal airway can be suggestive. Diagnosis is confirmed by the inability to pass a thin suction catheter through both nostrils.

Management:
Management of bilateral choanal atresia focuses on establishing an oral airway until definitive surgery can be performed. This involves:

- Insertion of a modified pacifier (McGovern nipple, with the end cut off)
- Insertion of an oral airway
- Insertion of an endotracheal tube into the posterior pharynx.

Prognosis:
If choanal atresia is isolated (not associated with other major congenital anomalies), the outcome is generally excellent.

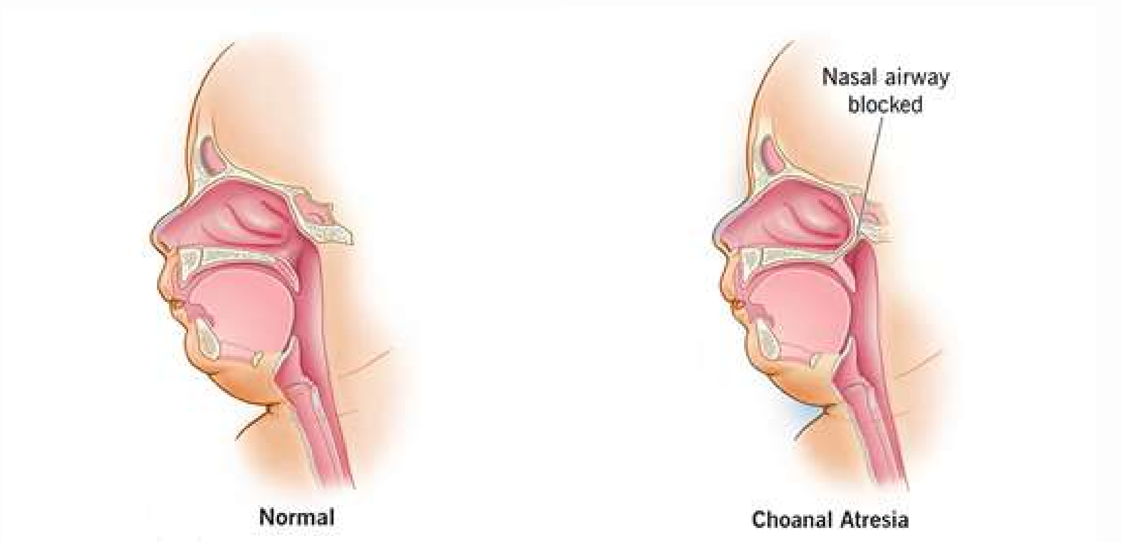

Figure 6.7 Choanal Atresia

Robin Sequence

This condition is characterized by a set of facial anomalies resulting from the incomplete development of the lower jaw. The lower jaw is notably smaller and recessed in comparison to the upper jaw. This anatomical configuration causes the tongue to be displaced backward (posteriorly), which subsequently leads to an obstruction of the airway (as depicted in Figure 6.8).

Management

- Robin sequence is associated with a cleft palate and can be an isolated finding or part of a genetic syndrome.

Mild Symptoms (Labored Breathing):

- Place the baby in the prone position. This often moves the tongue forward and opens the airway.
- If the prone position is ineffective, insert a small endotracheal tube (2.5 mm) into the posterior pharynx, past the base of the tongue, to bypass the obstruction.

Severe Symptoms (Breathing Difficulties):

- Bag and mask ventilation or endotracheal intubation may be challenging.
- A laryngeal mask can serve as a lifesaving rescue airway in these severe cases.

Other Rare Conditions

- Airway anomalies such as oral, nasal, or neck masses, and laryngeal or tracheal anomalies can present significant challenges.
- If upper airway obstruction is anticipated antenatally, a pediatric ENT specialist with the capability to perform an emergency tracheostomy must be present at the delivery.

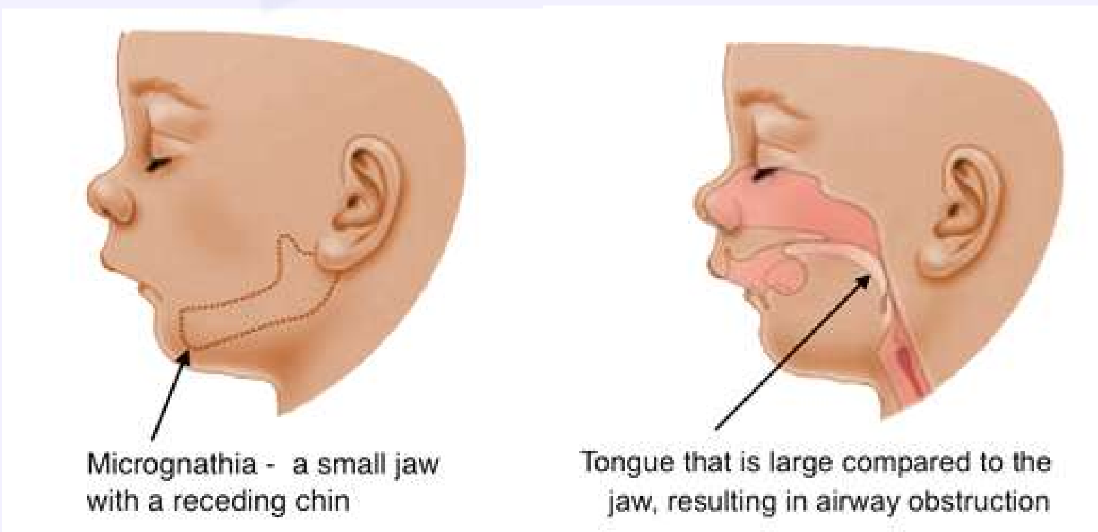

Figure 6.8 Robin Sequence

Management of Congenital Lung and Heart Diseases Complicating Resuscitation

1. Congenital Diaphragmatic Hernia (CDH)

Definition:

- CDH is a defect in the dome-shaped diaphragm (the tissue separating the chest and abdominal cavities) allowing abdominal organs to protrude into the thoracic cavity. This protrusion impedes normal lung development (both on the same side and the opposite side) (Figure 6.9).

Significance of the Diaphragm:
The diaphragm is essential for normal respiration.

Optimal Diagnosis & Delivery:
CDH should ideally be diagnosed before birth, and delivery planned at a specialized, high-risk center.

Clinical Presentation:
Newborns with CDH typically exhibit a scaphoid (sunk-in) abdomen, severe respiratory distress, and hypoxia.

Immediate Management Fundamentals:

- Immediate endotracheal intubation post-birth.
- Insertion of a large orogastric tube (10F) to decompress the stomach.
- **Crucially, avoid face-mask positive pressure ventilation.**

Common Complications:
Persistent pulmonary hypertension of the newborn (PPHN) and pneumothorax frequently complicate CDH.

Figure 6.9 Congenital Diaphragmatic Hernia (CDH).

2. Pulmonary Hypoplasia

Definition & Cause:
Pulmonary hypoplasia is the incomplete development of the lungs. It is caused by any condition that either occupies space within the chest or leads to a severe reduction in amniotic fluid volume.

Examples:

- Congenital Diaphragmatic Hernia (CDH).
- Obstruction or absence of both kidneys, resulting in minimal or absent amniotic fluid.

Management Consideration:
High inflation pressures may be necessary to ventilate the underdeveloped lungs, which significantly increases the risk of pneumothorax.

Prognosis:
Severe pulmonary hypoplasia may be incompatible with life.

3. Meconium Aspiration Syndrome (MAS)

Meconium Characteristics:

Meconium is the newborn's first intestinal discharge and it is a viscous, dark-green substance composed of lanugo, mucus, intestinal epithelial cells, and intestinal secretions like bile.

- **Composition:** Water is the major component (85-95%); the remaining 5-15% consists of solid elements (primarily intestinal secretions, mucosal cells, and solids from swallowed amniotic fluid, such as proteins and lipids).
- **Sterility:** Unlike stool, meconium is sterile and lacks bacteria, which is a key differentiator.

Passage in Utero:
Fetal distress in term and late preterm newborns can cause meconium to pass into the amniotic fluid before birth. This may stain the baby's umbilical cord, nail beds, or skin a greenish-yellow color.

Figure 6.10 Chest x-ray of Meconium aspiration syndrome (MAS)

MAS Definition:
Meconium Aspiration Syndrome (MAS) is the aspiration of this stained amniotic fluid, which can occur before, during, or immediately following delivery.

Risk Note:
Not all newborns with meconium-stained amniotic fluid will develop MAS.

SNRP Team Notification:
The SNRP team must be alerted immediately if meconium-stained amniotic fluid is noted after the rupture of the mother's membranes.

Pathophysiology:
MAS damages the lungs through:

- Mechanical obstruction of the airways by the meconium.
- Inactivation of surfactant.
- Chemical pneumonitis.

Radiological Findings:
Chest x-rays in MAS show characteristic areas of both atelectasis (collapse) and hyperinflation (Figure 6.10), which raises the likelihood of pneumothorax.

Management:
Management of MAS may require mechanical ventilation, inhaled nitric oxide, surfactant administration therapy, inotropes, and sedation. Antibiotic therapy is not universally required for MAS.

Observation & Follow-up:

- Babies born through meconium-stained amniotic fluid require close observation for any respiratory symptoms, even if they appear vigorous at birth. This does not necessarily mandate admission to the Neonatal Intensive Care Unit (NICU).
- MAS in newborns has been associated with an increased risk of developing asthma later in life.

Prognosis:
The majority of affected neonates survive. However, MAS can be fatal, particularly in severe cases that lead to prolonged pulmonary hypertension.

4. Congenital Heart Disease (CHD)

Impact on Neonatal Resuscitation:
Structural CHD rarely causes complications during neonatal resuscitation.

Etiology:
CHD is multifactorial, resulting from a combination of environmental risk factors and genetic predisposition.

Antenatal Care and Diagnosis:

- Regular and early antenatal visits with an obstetrician are essential for the health of both the mother and the fetus.
- Major structural CHD should be diagnosed antenatally, typically during the detailed ultrasound scan performed before the start of the second trimester.

Delivery Planning:
Pregnant women whose babies are diagnosed with major CHD should deliver at a tertiary medical center equipped to manage such neonates.

Management of Neonatal Complications Following Maternal Opiate or Anesthesia Exposure

Effects of Maternal Opiates on the Newborn:

- Opiates readily cross the placenta and reach the fetus.
- In the fetus, opiates can depress activity and inhibit the respiratory drive, potentially leading to neonatal respiratory depression.

Management of Neonatal Respiratory Depression Due to Opiates:

- For newborns exhibiting respiratory depression after maternal opiate exposure, the primary management focus is securing the airway and providing respiratory support.
- Initial support involves positive pressure ventilation (PPV).
- If prolonged apnea persists, advanced airway interventions such as insertion of an endotracheal tube or laryngeal mask may be necessary for continued respiratory support.
- **Note on Naloxone:** Although naloxone, an opioid antagonist, has been used in this setting previously, there is currently insufficient evidence to support its safety and efficacy in newborn babies. Its pharmacology in neonates is poorly understood, and animal studies have linked its use to adverse effects like pulmonary edema, cardiac arrest, and seizures.

Considering Other Causes of Neonatal Respiratory Depression:

- If the mother did not receive opiates, general anesthesia, or magnesium sulfate during labor, and the newborn fails to breathe spontaneously, yet PPV successfully normalizes the heart rate and oxygen saturation, other etiologies must be investigated.
- Alternative causes of neonatal respiratory depression include maternal self-administered medications, hypoxia, severe acidosis, a structural brain anomaly, or a neuromuscular disorder.

General Management for Medication-Induced Respiratory Depression:

- Currently, no specific medications are available to reverse the effects of various drugs that can cause neonatal respiratory depression.
- Therefore, the management strategy must prioritize providing airway support, ensuring effective ventilation, and maintaining close observation until the effects of the medication subside.

Managing a Newborn with Myelomeningocele

Myelomeningocele is a type of neural tube defect affecting the spinal cord and vertebrae. It originates during the first few weeks of fetal development when the neural tube fails to close completely, resulting in a fluid-filled sac. This sac, containing nerves and part of the spinal cord, protrudes through an opening in the baby's back (Figure 6.11).

Associated Conditions:

Hydrocephalus and defects in the brainstem and cerebellum (Arnold Chiari malformation) may be associated with myelomeningocele.

.Pre-Delivery Management:

- Antenatal diagnosis is crucial.
- Prior to delivery, comprehensive counseling must be provided to both parents. This should cover the management of labor and delivery, the necessity of surgery, and the potential long-term complications.
- Prepare a "donut" made from a towel before birth. This will be used to protect the sac if the baby needs to be placed in the supine position, with the defect positioned within the donut hole.

Post-Delivery Care and Positioning:

- **Protecting the Sac:** The sac must be protected from trauma to prevent rupture and subsequent infection.
- **Initial Positioning:** After birth, place the baby in the prone position (on their side).
- **Supine Positioning:** If the baby must be placed supine, use the prepared donut to ensure the defect is suspended in the hole, avoiding any pressure on the sac and its contents.
- **Resuscitation:** Exercise extra caution during initial resuscitation steps to prevent rupture of the sac.
- **Sac Coverage:** Cover the sac immediately with a transparent plastic wrap, if available, or with sterile gauze soaked in warm normal saline.

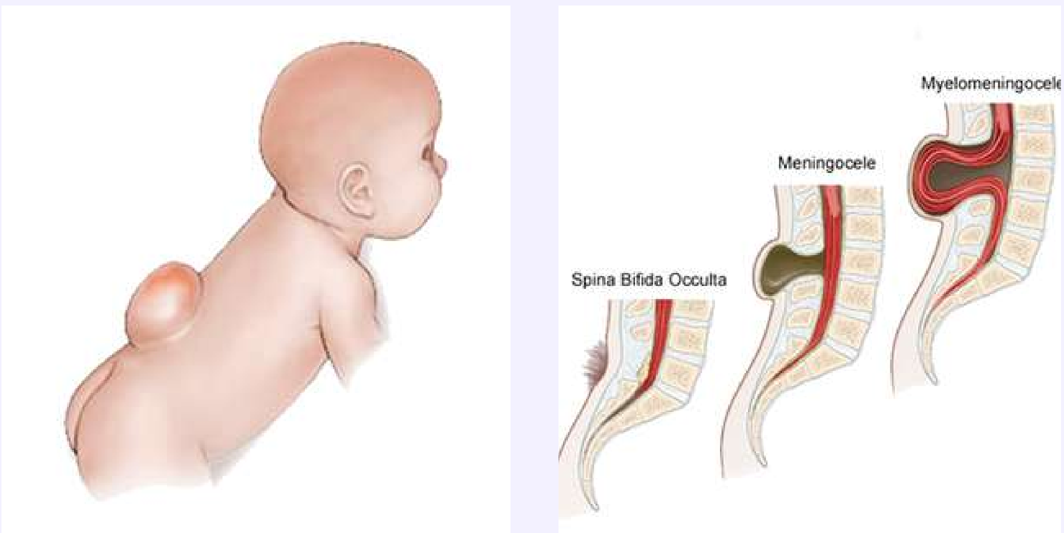

Figure 6.11 Newborn with spina bifida and its different types including Myelomeningocele.

Management of Newborns with Abdominal Wall Defects

Key Considerations:

- Abdominal wall defects, most commonly Gastroschisis and Omphalocele, must be diagnosed antenatally.
- Delivery should be planned in a higher-level center due to the need for specialized care.

Defining the Defects:

- **Gastroschisis:** A defect in the abdominal wall, typically to the right of a normal-appearing umbilicus, through which the baby's bowel protrudes.
  - Usually occurs as an isolated anomaly (without other congenital defects).

- **Omphalocele:** A defect that includes the umbilical cord, covered by a membranous sac containing the abdominal organs.
  - The sac may rupture before or after birth, exposing the contents.
  - Often associated with other congenital anomalies or genetic syndromes.

Immediate Post-Delivery Management:

1. **Protect the Defect:** Place the baby and the defect within a clear, sterile plastic bag and secure it to minimize contamination and fluid/heat loss.
2. **Positioning:** Position the baby on the right side to optimize perfusion.
3. **Ventilation:** Avoid prolonged face-mask ventilation. If assisted ventilation is required, consider endotracheal intubation to prevent air from distending the bowel.
4. **Handle with Care:** Handle the defect gently, frequently assessing the color and perfusion of the exposed contents.
5. **Fluid and Temperature Management:** The exposed defect significantly increases heat and fluid losses, necessitating careful temperature control and fluid administration.

Umbilical Cord Management:

- Gastroschisis: Ask the obstetrician to cut the umbilical cord 10-20 cm from the body, as the cord may be needed for surgical repair or emergency access.
- Omphalocele: Clamp and cut the cord well above the defect. The cord cannot be used for emergency access; an intraosseous needle should be used if vascular access is urgently required.

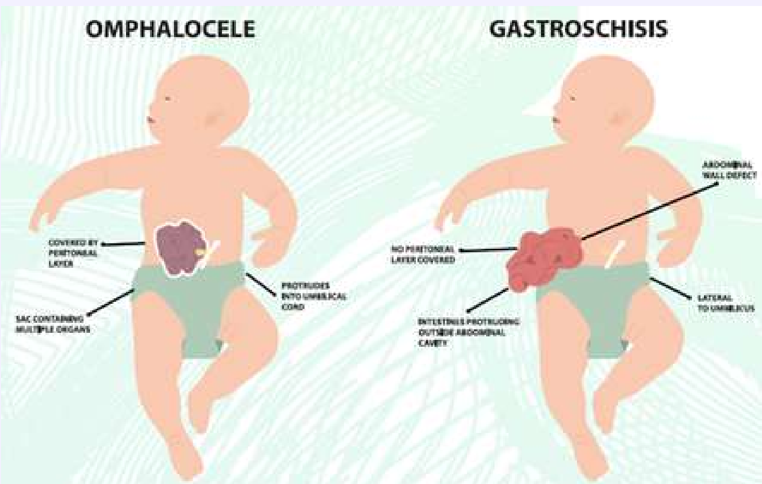

Figure 6.12 Newborn with Omphalocele and Gastroschisis

Chapter 7

Post-Resuscitation Care

CHAPTER OBJECTIVES :

Upon completion of this chapter, you will be able to:

- Describe the immediate actions required following successful neonatal resuscitation.
- Identify potential medical conditions that may arise after neonatal resuscitation.
- Explain the role of therapeutic hypothermia in the post-resuscitation management of neonates.
- Outline considerations for the ongoing management of a neonate after resuscitation.

POST-RESUSCITATION CARE IN NEONATES

The transition from intrauterine to extrauterine life continues for several hours after birth. Even when vital signs appear normal after initial resuscitation, the process itself can disrupt this delicate transition. Therefore, close monitoring is essential.

Monitoring and Management

Following successful resuscitation, newborns require immediate and close monitoring of:

- Vital signs
- Oxygen saturation
- Blood glucose
- Serum electrolytes
- Urine output
- Neurologic status

These newborns are typically transferred to the neonatal intensive care unit (NICU). Appropriate monitoring facilitates the anticipation and prompt management of potential post-resuscitation medical complications, which can affect multiple organ systems.

MEDICAL CONDITIONS THAT MAY OCCUR POST-RESUSCITATION

1. Temperature Instability

- Babies may experience hypothermia (low temperature) or hyperthermia (high temperature) after resuscitation.
- Hypothermia is a particular concern in premature babies and is associated with increased mortality.

  Techniques for maintaining normal body temperature , especially in premature newborns, are detailed in previous lessons.
- Overheating must be avoided.
- Therapeutic Hypothermia: If indicated, therapeutic hypothermia must be initiated. Studies show that in term and late preterm babies with moderate to severe Hypoxic-Ischemic Encephalopathy (HIE), therapeutic hypothermia reduces the risk of death and/or neurodevelopmental delay.
  - Each institution must establish its own guidelines for initiating this treatment.
  - If therapeutic hypothermia is unavailable at your hospital, the newborn must be referred to the nearest facility offering this option within a maximum window of six hours.

2. Hypotension

Low blood pressure can occur after resuscitation due to:

- Decreased cardiac contractility and blood vessel tone from low oxygen levels.
- Hypovolemia (low blood volume) if there was significant blood loss.
- Peripheral vasodilation (widening of blood vessels) secondary to sepsis.

Management :

- Closely monitor blood pressure.
- If a significant history of hypovolemia exists, volume expanders (crystalloid solution or blood transfusion) may be necessary.
- The routine use of volume expanders without evidence of hypovolemia in the immediate post-resuscitation period is not recommended and may be harmful.
- Some newborns may require medications (e.g., dopamine, dobutamine, or epinephrine) to improve cardiac output and systemic blood flow.

3. Persistent Pulmonary Hypertension of the Newborn (PPHN)

Normally, pulmonary blood vessels relax after birth, allowing increased blood flow to the lungs. If they remain constricted, the resulting high pulmonary blood pressure is PPHN.

- The pulmonary vascular bed is very labile (unstable) post-resuscitation.
- Factors that can induce PPHN include hypothermia, hypoxemia, excessive stimulation, and acidosis.
- While hypoxia can cause PPHN, hyperoxia (excessive oxygen) can be harmful and offers no benefit.

Diagnosis and Management:

- Diagnosis is aided by a history of resuscitation, pre- and post-ductal oxygen saturation differences, arterial blood air analysis, and echocardiography.
- Treatment options include oxygen, conventional mechanical ventilation, High-Frequency Oscillatory Ventilation (HFOV), inhaled nitric oxide, and ExtraCorporeal Membrane Oxygenation (ECMO).

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4. Hypoglycemia

Glucose is vital for brain metabolism; prolonged low blood sugar in neonates can cause severe brain injury.

- Anaerobic metabolism during resuscitation increases glucose consumption.
- Perinatal stress requiring resuscitation can rapidly deplete glucose stores.

Management:

- Blood glucose levels must be monitored soon after resuscitation and at regular intervals until stable.
- Intravenous glucose infusion may be necessary to maintain normal levels.

5. Metabolic Acidosis

- Insufficient oxygenation during resuscitation leads to the production and accumulation of acids.
- Metabolic acidosis impairs heart function and worsens pulmonary hypertension.

Management:

- Metabolic acidosis typically resolves once respiratory and cardiac functions are restored; administering base is usually unnecessary. The priority is correcting the underlying cause.
- If acidosis persists despite restored cardio-respiratory function, investigate other causes (e.g., sepsis, inborn errors of metabolism).

6. Electrolyte Disturbances

- Hyponatremia (low sodium) and hypocalcemia (low calcium) are common post-resuscitation.
- Serum electrolytes should be checked, and disturbances treated with intravenous supplementation.

7. Central Nervous System (CNS) Abnormalities

- **Hypoxic-Ischemic Encephalopathy (HIE)** is a brain dysfunction linked to hypotension, hypoxemia, and acidosis.
- Initial signs include **hypotonia, lethargy, poor respiratory effort, or apnea.** Seizures may appear a few hours later.
- A thorough neurological assessment is crucial.
- Other causes of lethargy, apnea, and seizures must be ruled out (e.g., maternal narcotics exposure, electrolyte imbalance, infection, inborn errors of metabolism).

8. Respiratory Problems

- **Neonatal pneumonia and aspiration** may present similarly to respiratory distress syndrome, with tachypnea, nasal flaring, hypoxia, grunting, and retractions.
- **Mechanical complications** can occur, such as endotracheal tube obstruction, dislodgement, displacement, or pneumothorax development.

9. Renal Failure

- Hypoxia, acidosis, and hypotension during resuscitation can decrease renal blood flow.
- Acute Tubular Necrosis (ATN), a temporary form of renal failure, can follow aggressive resuscitation, leading to fluid retention, low urine output, and electrolyte imbalance.

Management:

- Restoration of respiratory and cardiac function, fluid restriction, and avoidance of nephrotoxic medications usually suffice for ATN.
- In the recovery phase, the baby may have very high urine output and require additional fluids.

10. Feeding Problems

- Hypoxia, decreased intestinal blood flow, acidosis, and hypotension can affect the gastrointestinal tract, causing vomiting, feeding intolerance, reduced motility, bleeding, or even intestinal perforation.
- The coordination of sucking, swallowing, and breathing may also be impaired, depending on the degree of CNS injury.
- Enteral feeding is delayed until the newborn is ready, necessitating alternative nutritional support during this interval.

Management:

- Blood glucose levels must be monitored soon after resuscitation and at regular intervals until stable.
- Intravenous glucose infusion may be necessary to maintain normal levels.

Ethics and End-of-Life Care

The ethical principles guiding neonatal resuscitation align with those for older children and adults.

Decision-Making

- Parents are typically the decision-makers and must be provided with complete, relevant, and up-to-date information.
- "What is best for the newborn" must be the guiding principle when discussing treatment options.
- Discussions regarding major decisions should be well-planned and ideally started antenatally once the medical team has sufficient information.
- Allowing sufficient time for parents to reach a decision, possibly over multiple interviews, is recommended.
- Informed consent should be obtained from parents in most cases; however, in life-threatening emergencies, procedures should proceed without delay.

When to Withhold Resuscitation

- If the most responsible physician determines there is **no chance for survival** (e.g., non-viable fetus, complex lethal congenital anomalies), resuscitation should not be offered to parents.
- It is ethical not to initiate resuscitation in cases of **extreme prematurity (less than the point of viability), lethal anomalies, and severe congenital anomalies**.

Managing Uncertainty

- In cases of high risk of mortality or significant morbidity, treatment options, including initiation or withholding of resuscitation, should be discussed with parents, respecting their wishes.
- When the extent of congenital anomalies, gestational age, or likelihood of survival is uncertain, initial decisions may be made based on current knowledge. It is acceptable to reevaluate the baby's condition post-delivery with new information, and the initial decision may change according to the baby's best interest.
- When the medical team is in doubt about the baby's outcome, all resuscitative measures should be employed pending further assessment and a final decision.

Ongoing and End-of-Life Care

- The ethical obligation to continue life-sustaining therapies ceases once the baby has been resuscitated.
- For a dying baby, the priority is to minimize suffering by providing humane and compassionate care.
- Humane, compassionate, and culturally sensitive palliative care should be provided for all babies for whom resuscitation was unsuccessful or not initiated.
- Family members and staff involved in the care of the baby require emotional support.
- "Do Not Resuscitate" (DNR) orders and the withholding of life support are medical decisions, and parents must be informed.

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Online/Web Resources:

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- https://www.msdmanuals.com/professional/pediatrics/perinatal-problems/neonatal-resuscitation