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IAP-NNF Textbook of Neonatal Resuscitation

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CHAPTER 2

Preparing for Resuscitation and Familiarizing with the Equipment

US Jagdish Chandra

Lessons to Learn

- Importance of Preparation
- How to anticipate birth asphyxia and identifying risk factors?
- How to prepare personnel for resuscitation?
- Documenting neonatal resuscitation in delivery room
- Description of a newborn corner
- Description of the equipment needed for neonatal resuscitation
- Conducting a post-resuscitation debriefing session
- Behavioral skills required for neonatal resuscitation

IMPORTANCE OF PREPARATION

Nearly 10% of infants need some assistance to begin breathing at birth, with approximately 0.1% of term babies and 15% of preterm babies needing extensive resuscitation and about 0.2–0.3% developing moderate or severe hypoxic-ischemic encephalopathy.[1-3] Newborn infants with birth asphyxia can suffer from short to long-term neurological complications. Severe asphyxia has been linked to cerebral palsy, mental retardation, epilepsy, and learning disorders.[4,5] Mortality in infants with hypoxic-ischemic encephalopathy ranges from 6–30%, and significant morbidity, such as cerebral palsy and long-term disabilities, occurs in 20–30% of survivors. The probability of sequelae is low if a newborn infant is resuscitated promptly and correctly and starts breathing spontaneously within 20 minutes.[6]

The goal of neonatal resuscitation is to prevent the morbidity and mortality associated with hypoxic-ischemic tissue injury to vital organs namely, the brain, heart, kidney and to reestablish adequate spontaneous respiration, and cardiac output.[7-9] The first "*Golden minute*" is crucial for the intact survival of an asphyxiated baby. Global evidence suggests that the risk of neonatal death increases by 16% for every 30 seconds delay in initiating ventilation in the first 6 minutes after birth, and 6% for every minute of delay thereafter.[10] Therefore, it is clear the first minutes after birth are critical to reducing neonatal mortality.

Anticipation, early recognition of the problem, initiation of appropriate resuscitation measures using the correct technique and assessment of the effectiveness of ventilation are critical for successful neonatal resuscitation. The most common causes of failed resuscitation are failure to recognize the problem promptly, not reacting quickly and ineffective ventilation of the lungs due to incorrect technique or nonfunctioning/malfunctioning equipment. Delayed or ineffective action makes resuscitation more difficult and increases the risk of brain damage.

ANTICIPATING BIRTH ASPHYXIA AND IDENTIFYING RISK FACTORS

Most often the transition from intrauterine life to extrauterine life happens without difficulty. However multiple maternal, placental, mechanical, and fetal conditions exist that can jeopardize a smooth transition signaling the need for intervention.

Anticipating a risk requires timely and accurate communication between the obstetric team and the neonatal resuscitation team so that the latter is apprised about the risk status for each delivery. The need for resuscitation should always be anticipated and every birth should be treated as a potential emergency. *A healthy pregnancy, uneventful antenatal period and a normal delivery do not rule out the chances of the baby developing problems and needing resuscitation.* Factors that affect newborn care can be assessed by reviewing the medical record, interacting with the obstetrician and the mother. There are several risk factors in the mother or fetus, which can predispose to asphyxia at birth or need for special care and management in the baby. The number and severity of risk factors are indicative of the magnitude of risk. Prior information and assessment of the risk factors helps in better preparation in terms of personnel required and additional equipment which may be needed and the smooth flow of resuscitation.

Antenatal Assessment of Risk

To assess risk for neonatal resuscitation, the following information should be sought from the obstetrician prebirth:

- What is the expected gestational age?
- Is there a single or are there multiple fetuses?
- Are there any other risk factors?

Table 2.1 lists some of the important perinatal risk factors that are associated with birth asphyxia and increase the risk for the newborn of needing resuscitation at birth.

PREPARATION OF PERSONNEL FOR RESUSCITATION

It is desirable that for every birth of a term newborn infant without any antenatal risk factors, there should be a healthcare provider

TABLE 2.1: Perinatal Risk Factors Associated with Need for Neonatal Resuscitation at Birth

Maternal	*Fetal*	*Intrapartum*
• Antepartum hemorrhage (placental abruption, placenta previa) • Pregnancy-induced hypertension, chronic hypertension • Maternal intrapartum pyrexia • Prolonged rupture of membranes—i.e., >18 hours/ maternal infection • Multiple pregnancy • Diabetes mellitus • Rhesus isoimmunization • Previous fetal/neonatal deaths • Poly/oligohydramnios • Chorioamnionitis • Maternal infection • Chronic illness (e.g., anemia, congenital cyanotic heart disease) • No antenatal care • Maternal age <16 or >35 years	• Preterm/post-term • Intrauterine growth restriction • Antenatally diagnosed congenital abnormalities (e.g., congenital diaphragmatic hernia and congenital heart disease, etc.) • Intrauterine infection • Reduced fetal movement before onset of labor	• Cardiotocographic (CTG) abnormalities • Reduced fetal movements • Abnormal presentation—e.g., breech • Cord prolapse • Meconium-stained liquor • Forceps/vacuum delivery • Emergency cesarean section • Precipitate labor • Prolonged first or second stage of labor • Maternal sedation (within 4 hours) • Maternal general anesthesia

trained to provide positive pressure ventilation (PPV). If a delivery is anticipated where there are risk factors, then the delivery should be attended by a healthcare provider who is trained in advanced neonatal resuscitation (intubation, chest compression, etc.). In cases of an anticipated delivery with risk factors there should be at least two or more personnel trained in advanced neonatal resuscitation available at the time of birth of the baby whose primary responsibility should be management of the newborn.[11]

If the delivery room has only one healthcare provider who is trained and capable of initiating basic resuscitation—assess and support airway, and initiate ventilation and if required be able to assist during chest compressions, they should be able to call for additional help if required. Situations that may demand additional help could include multiple births or a newborn needing resuscitative assistance beyond PPV, e.g., intubation, chest compression, or need for medication. The contact details of personnel for providing additional help when required, should be displayed prominently in the delivery room of such health facilities. Ambulance to transport such babies should be available to shift the baby if the need arises for urgent referral of complicated birth asphyxia cases to higher level healthcare facilities.

Identifying the Team and Team Leader

Neonatal resuscitation requires multiple tasks to be performed as part of the resuscitation process. While individual care providers

TABLE 2.2: Requirements for Effective Team Work

Leader	• Must assess patient status • Assign work to team members • Direct team members for action • Supervise, analyze, and coordinate • Provide feedback to team members • Periodically summarize key information and progress • Invite inputs from the team
Task allotment	• Should be aware of one's role and responsibility • Perform and confirm the task • Coordinate within the team
Communication	• Should be clear, concise, and precise • Address team members directly by name • Recipient should confirm the instruction by feedback
Mutual respect	• Calm, cordial environment • Nonthreatening and nonhurried • Must be supportive and respectful to one another • Knowledge sharing must be encouraged • During communication use words such as "please", "thank you", "sorry", etc.

may have the required skills, no single individual can perform all the tasks required. Hence, it is very crucial to have a team involved in the resuscitation process. However, to have favorable outcomes, the team must work in a coordinated and efficient manner. There is sufficient evidence to suggest that inefficient teams result in unfavorable outcomes. The selected team members must have the skills to provide effective resuscitation and to work as a coordinated team. The team leader selected must have a thorough knowledge of the neonatal resuscitation protocol, be an effective communicator, be able to delegate responsibilities to various team members considering the skill sets, they possess and be able to effectively utilize the resources available to them. He/she should also be able to hand over leadership to another team member if he/she gets involved in a procedure. **Table 2.2** outlines the requirements for effective teamwork.

Predelivery Team Briefing

If risk factors are present, the team should be assembled and tasks assigned by the team leader to the team members as per their expertise and capabilities. The clinical situation should be reviewed and possible outcomes and emergency plan of action discussed. Tasks such as receiving the baby and doing initial assessment, performing PPV, intubation, chest compression, administering medication, and documentation should be assigned to different persons who are briefed and ready. In addition to individual skills each team member must effectively follow the instructions and participate as a team.

This helps in smooth execution of resuscitation and avoids confusion. Team members should arrange and check all the equipment and supplies required and discuss the emergency measures to be taken like additional expert help or shift to higher facility. The 2020 International Consensus on cardiopulmonary resuscitation concluded that "briefing or debriefing may improve short-term clinical and performance outcomes for infants and staff. The effects of briefing or debriefing on long-term clinical and performance outcomes are uncertain".[11]

Communication

Good communication is key to effective teamwork. Sharing information between team members requires that instructions are heard and understood. Instructions must be directed to the concerned team member by name making direct eye contact and must be spoken clearly. If the recipient of the instruction repeats the instruction given, the sender is assured that the instruction given has been effectively conveyed.

DOCUMENTATION

Documentation of the events is an important and integral part of neonatal resuscitation. Documentation keeps a track of the events, action taken, and time taken by the baby to respond to each of the resuscitation measures thereby making planning easy and executing the resuscitation without confusion. Documentation is also important from the medicolegal aspect. The emergency circumstances of carrying out a resuscitation procedure can make it challenging for accurate recording of events and procedures. A well-designed recording chart which follows the neonatal resuscitation algorithm can make the task of recording events as they occur easier. Retrospective recording of events should be kept to as minimal as possible. Hence it would be desirable that the team member documenting the events should be an experienced healthcare provider and not be entrusted with multitasking.

NEWBORN CARE CORNER

Every delivery room/area must have a designated area for resuscitating a newborn baby which must be at least 3 m^2 with clear floor area. All healthcare providers must be familiar with this area and its upkeep. **Table 2.3** outlines the requirement of a newborn care corner.

EQUIPMENT FOR RESUSCITATION

Table 2.4 provides the list of equipment/supplies/medication that must be available for neonatal resuscitation (*Fig.* **2.1**).

Supplies and equipment required for resuscitation must be readily available and accessible for every birth in an organized area

TABLE 2.3: Newborn Care Corner Requirements

Environment	• Radiant warmer • Well-lit • Draught free area
Equipment	• All equipment/supplies/medication listed in **Table 2.4** • Infant weighing machine • Clearly visible clock (with seconds hand)/timer • All equipment/supplies/medication to be available and functional 24×7 • All supplies/medications checked regularly for their availability by a designated individual using an equipment checklist must
Asepsis	• Hand washing facility (24 hours water supply, elbow/foot operated taps, hand wash detergent, etc.) • Availability of gowns, gloves, and mask • Disposable supplies
Documentation	Standard forms for documenting newborn resuscitation

earmarked for neonatal resuscitation such as the "Newborn Care Corner". This improves the performance of the resuscitation team and would help to minimize delays in the resuscitation process. It is of utmost importance that all equipment be cleaned/disinfected/sterilized before each use, and their function checked periodically and before and after each delivery to ensure that they are ready for use. A brief description regarding some of the important equipment for resuscitation is provided here.

Self-inflating Bag (*Fig.* 2.2)

A neonatal self-inflating resuscitation bag with mask is the most commonly used device for ventilating an asphyxiated newborn who are <5 kg in weight. It is generally made of silicone or similar approved material. It generally has three main components—the bag, pressure release valve, and a face mask. The tidal volume immediately after birth in the newborn infant ranges from 6–7 mL/kg. During resuscitation, it is generally recommended to maintain a tidal volume between 4 and 8 mL/kg and ventilate at a rate of 40–60 breaths/minute. Ventilation with low tidal volume can result in hypercarbia and atelectotrauma. On the other hand, ventilation

FIG. 2.1 Equipment required for newborn resuscitation.

TABLE 2.4: Equipment Required for Neonatal Resuscitation

	Term neonates	***Additional requirements for preterm neonates***
For temperature maintenance	• Radiant warmer (preheated) • Pair of clean prewarmed sheet • Room thermometer • Clinical (digital) thermometer	• Plastic wrap (<32 weeks) • Cap • Thermal mattress (<32 weeks)
For airway clearance	• Suction device set at 80–100 mm Hg (central, electric) • Suction catheters (size,10F,12F) • Mucous extractor • Oropharyngeal airway (size 0, 1) • Shoulder roll	• Oropharyngeal airway (size 00)
For ventilation and oxygenation	• T-piece resuscitator or self-inflating bag (250 mL; 200–320 mL) or flow inflating bag • Face mask (size 0, 1/50–60 mm outer diameter) • Flow meter (up to at least 10 L/min) • Oxygen source • Oxygen blender/oxygen-air mix (set to 21%) • Pulse oximeter with neonatal probe • Feeding tube (size 8F) • Laryngoscope with batteries and straight blade (size 0,1) • ET tubes (size 2.5, 3, 3.5, 4 mm) • Stylet (optional) • Scissors • Laryngeal mask (size 1) (optional) • End-tidal CO_2 detector (optional)	• Face mask (Size 00, 0/35–50 mm outer diameter) • Oxygen blender/oxygen-air mix (set to 21–30%) • Feeding tube (size 5F, 6F) • Laryngoscope straight blade (size 0, 00)
Circulation	• Syringes (1 mL, 2 mL, 5 mL, 10 mL, 20 mL, and 50 mL) • Umbilical catheterization set (umbilical catheters 3.5, 4.0, and 5.0, sterile blade, gloves, cord ties, mosquito forceps, alcohol sponges, povidone iodine, 3-way stopcock) • Adhesive tape • Sterile gauze • Needles—25, 21, and 18-gauge • Stethoscope • Electronic cardiac monitor and ECG leads	
Drugs	• Epinephrine (1:10,000) • Normal saline (0.9%)	
Miscellaneous	• Gloves • Timer • Extra laryngoscope bulb • Extra laryngoscope batteries • Cord scissors • Cord clamp, tie • Measuring tape	Transport incubator

with high tidal volume can result in volutrauma. Therefore, it is recommended that the volume of neonatal resuscitation bags should be around 250 mL (200–320 mL).[12] The bag also has a patient nonbreathing valve with a pressure limiting valve so that it does not exceed an airway pressure of 45 cmH_2O and can generate an airway pressure of at least 30 cmH_2O. The face mask is generally translucent and made of silicone or similar approved material. It is generally round and available in 2 sizes—size 1 (for term babies) with an outer diameter of 50–60 mm, and size 0 (for preterm and low birth weight babies) with an outer diameter of 35–50 mm (*Fig.* **2.3**). The inlet valve of the compressible bag may have a nipple for connecting an oxygen tube.

In contrast to a self-inflating bag, the ***flow-inflating bag*** (anesthesia bag) only inflates when compressed gas flows into the bag (*Fig.* **2.4**).

T-piece Resuscitator (*Fig.* 2.5)

It is a flow-controlled pressure limited ventilator device. Compressed gas is delivered at one port of T-piece. A preset peak inspiratory pressure (PIP) and positive end-expiratory pressure (PEEP) is set. It has a maximum pressure relief control, which is a safety feature like the pressure relief valve in a self-inflating resuscitation bag. With a T-piece device, gas flows into a face mask or endotracheal tube through a "patient supply line". Inflation is achieved by interrupting the escape of gas through an outlet hole on the T-piece using a thumb so that the pressure rises and is displayed by a manometer.

Suction Devices

DeeLee mucus extractor is usually made of plastic with two tubes—one goes into mouth of healthcare provider and other (usually 8F/10F size) into the baby's mouth (*Fig.* **2.6**). Suction can also be provided by an *electric suction machine or a central vacuum system or a foot operated suction device.* The maximum vacuum should not be >100 mm Hg. They usually have one or two suction jars of 1 L capacity and a

FIG. 2.2 Self-inflating bag, reservoirs, and masks.

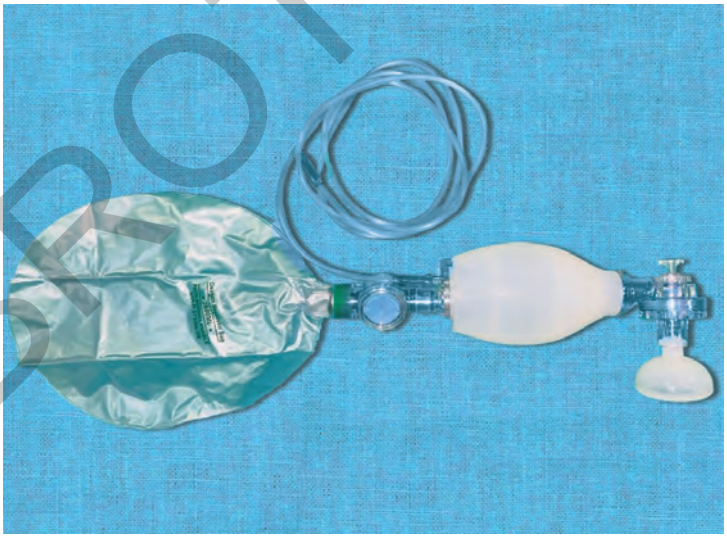


FIG. 2.3 Self-inflating bag with reservoir.
Source: Sweta Kumari, Piyush Gupta.

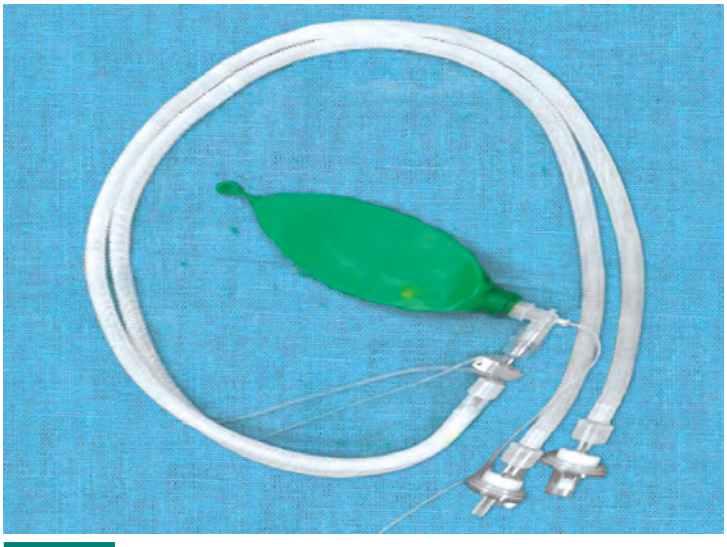


FIG. 2.4 Flow-inflating bag.

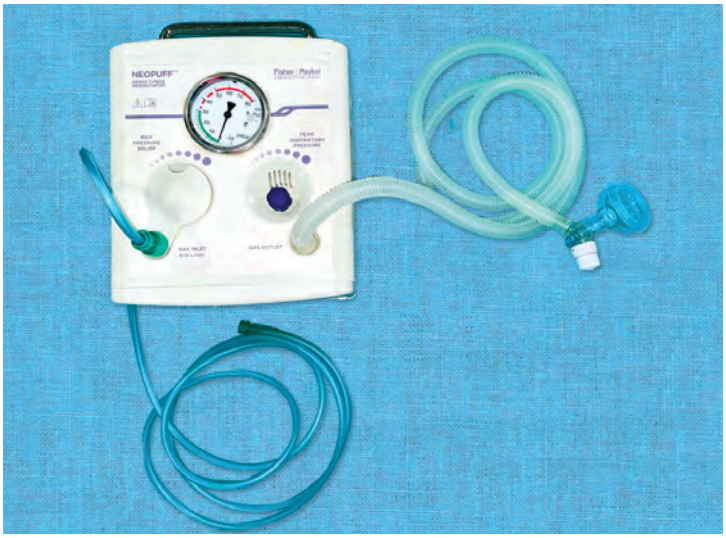


FIG. 2.5 T-piece resuscitator.
Source: Sweta Kumari, Piyush Gupta.

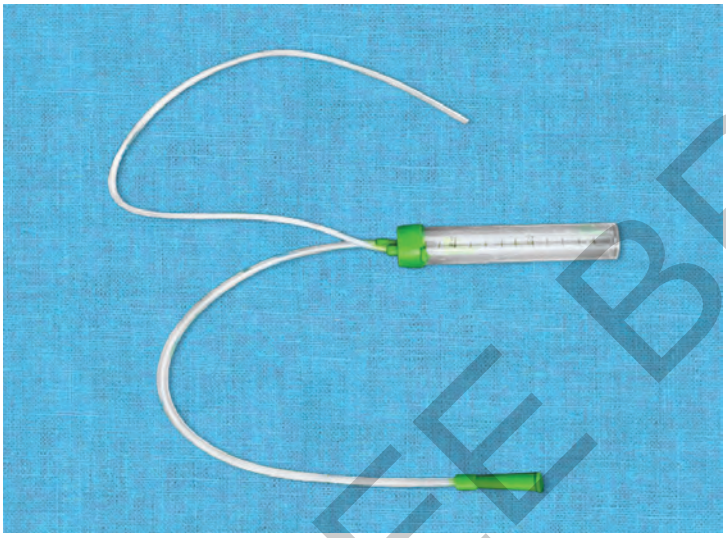


FIG. 2.6 DeeLee's mucous extractor.

FIG. 2.7 Air-oxygen blender.

connecting tube of noncollapsible material to which an 8F or 10F size suction catheter can be connected.

Oxygen Blender (*Fig.* **2.7**)

An oxygen blender can regulate the delivered inspired oxygen concentrations ranging from 21–100% oxygen. In the absence of a blender, an air-oxygen mix can be used to deliver oxygen concentration to neonates needing resuscitation. **Tables 2.5 and 2.6** provide the oxygen and air flows at a total flow of 8 L/min and 10 L/min respectively, to provide different inspired oxygen concentrations (FiO_2).

Pulse Oximeter

Pulse oximeter is a device to noninvasively measure the oxygen saturation of hemoglobin. The visible red part and the invisible infrared part of the spectrum are specifically absorbed by the oxygenated hemoglobin and reduced hemoglobin fraction respectively. The relative proportional presence of these two fractions is calculated as the percentage of the oxyhemoglobin fraction to the total hemoglobin and is displayed as oxygen saturation percentage on the monitor (*Fig.* **2.8**).

Medication and Supplies

All supplies and medications should be checked for their date of expiry and those which have crossed their expiry date should be discarded.

POSTRESUSCITATION DEBRIEFING

A quick debriefing should be conducted immediately after resuscitation with the team members to review and introspect the actions taken. It provides an opportunity to give inputs and identify areas which could be improved. This helps in better coordination among the team members. The process involves discussion on the following points—need for preparing for resuscitation, asking for the risk factors, and analyzing the information available, how was the preparation and was it done well, whether

TABLE 2.5: Oxygen Air Flows at 8 L/min to Provide Inspired Oxygen Concentrations between 21 and 100%

Approximate oxygen (%)	*Oxygen flowmeter (L/min)*	*Air flowmeter (L/min)*
21	0	8
30	1	7
40	2	6
50	3	5
60	4	4
70	5	3
80	6	2
90	7	1
100	8	0

TABLE 2.6: Oxygen Air Flows at 10 L/min to Provide Inspired Oxygen Concentrations between 21 and 100%

Approximate oxygen (%)	*Oxygen flowmeter (L/min)*	*Air flowmeter (L/min)*
21	0	10
30	1	9
40	2	8
50	4	6
60	5	5
70	6	4
80	7.5	2.5
90	9	1
100	10	0

anything was missed or done improperly, could it have been improved and if so how, rating their team's performance, steps for improving individual team member's performance and what were the learning points.

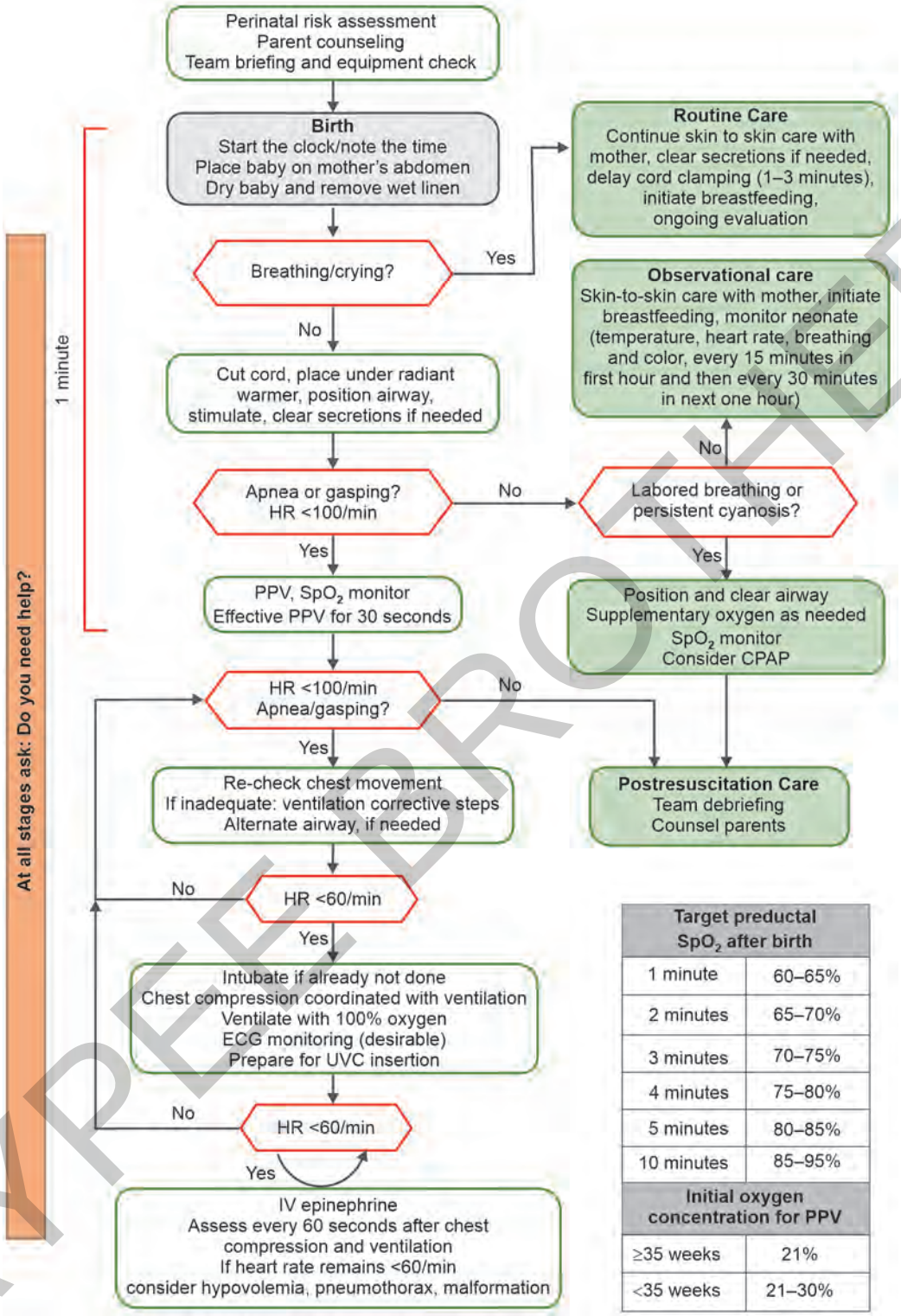
FIG. 2.8 Pulse oximeter with neonatal sensor.

BEHAVIOR SKILLS

There are important behavior skills that must be there in all healthcare providers trained for neonatal resuscitation. These key skills are summarized here:[7]

- Knowing one's environment (using equipment checklist, aware of where the equipment are, etc.)
- Using available information
- Anticipating problems and planning for it
- Clearly identifying a team leader
- Be able to communicate effectively
- Be able to delegate workload optimally.
- Be able to assess the clinical situation continuously and monitor the skills of personnel to ensure patient safety
- Be able to use available resources effectively
- Call for additional help when needed (know when to call whom to call and how to call)
- Maintain professional behavior.

These skills need constant and frequent reiteration and practice.



Target preductal SpO_2 after birth	
1 minute	60–65%
2 minutes	65–70%
3 minutes	70–75%
4 minutes	75–80%
5 minutes	80–85%
10 minutes	85–95%
Initial oxygen concentration for PPV	
≥35 weeks	21%
<35 weeks	21–30%

FIG. 2.9 Neonatal resuscitation algorithm.

COUNSELING PARENTS

If time permits the healthcare providers should introduce themselves to the parents before birth. They should inform and discuss relevant issues related to the anticipated problems, proposed plan of care and possibility of transfer to neonatal intensive care unit (NICU) if the newborn is high-risk. Parents and/or decision makers in the family should be involved in decision making about extent of resuscitation especially in cases of extreme preterm infants and in those with major malformations.

NEONATAL RESUSCITATION ALGORITHM

Figure **2.9** is the flow for the neonatal resuscitation algorithm. All healthcare providers who would be involved in neonatal resuscitation should be familiar with this algorithm. The details of individual sections of the algorithm are being dealt with in subsequent chapters of this book. **Box 2.1** provides an illustrative case of how one prepares for delivery room resuscitation of a newborn infant.

BOX 2.1: Illustrative Case—Preparing for Delivery Room Neonatal Resuscitation

A woman is admitted to the delivery room in labor. As the period of pregnancy is 30 weeks, the delivery room informs the neonatal team about the impending delivery. On reaching the delivery room the neonatal team checks with the obstetrician for the number of fetuses and additional risk factors. They are informed that there is a single fetus, and the mother has been leaking per vaginum for over 24 hours and has fever suggesting chorioamnionitis. The team leader ensures that there are at least two members who are trained in advanced neonatal resuscitation. The team leader discusses the anticipated problems and line of action with the team members. Tasks such as receiving the baby and doing initial assessment, performing PPV, intubation, chest compression, administering medication, and documentation are assigned to different persons after confirming their expertise. One team member discusses with the family the possible outcomes and counsels the family about the possible need for resuscitation and subsequent transfer to NICU for care.

*Another team member checks that the windows and fans near the newborn corner are shut, turns on the radiant warmer, and checks it is functioning. Also checks for clean sheets and plastic wrap (as the expected gestation is <32 weeks). They also run a checklist for all the equipment and supplies that may be needed for resuscitation (see **Table 2.4**). The central suction is set to a negative pressure of 80 mm Hg. They assemble and check the function of the self-inflating bag (250 mL). As a T-piece resuscitator is also available, its function is also checked. The flow meter in the central oxygen source is set to 10 L/minute and the oxygen concentration on the blender is set to 30%. The pulse oximeter and its sensor are checked. Equipment for intubation (laryngoscope with straight blades size 0 and 00, endotracheal tubes of 2.5 mm and 3.0 mm ID) are checked. The team also checks for equipment and supplies for umbilical venous cannulation and availability of medication (epinephrine, normal saline).*

All team members have washed their hands following the hand washing protocol, wear gloves and wait for the delivery of the baby.

(NICU: neonatal intensive care unit; PPV: positive pressure ventilation).

KEY POINTS

1. Majority, but not all newborn, who will require resuscitation can be identified by the presence of perinatal risk factors.
2. Neonatal resuscitation is a team effort, not an individual one.
3. Anticipation and preparation are key to successful resuscitation of newborn.
4. Every delivery room should have a checklist for equipment, supplies and medication required for neonatal resuscitation. All equipment should be functional.
5. All deliveries should be attended by skilled personnel who are solely responsible for the newborn and can perform initial steps, initiate ventilation, and assist in chest compressions.
6. If a high-risk delivery is anticipated, at least two skilled personnel should be present. A team of personnel skilled in advanced resuscitation—intubation, vascular access, and medications, should be readily available if the need arises for all deliveries.
7. Resuscitation is a time bound intervention and demands coordinated teamwork consistently, with high reliability and adaptability.
8. Clear and acknowledged communication is the most basic vital function of a good team and is the one function that fails most frequently.

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IAP-NNF Textbook of Neonatal Resuscitation

Salient Features

- The first official IAP-NNF textbook on neonatal resuscitation; shared vision of IAP and NNF
- Presents the resuscitation guidelines for the country from the best available evidence
- Blend of a workbook for training (each chapter having practical practice guidelines and a self-assessment section) and a standard textbook providing information beyond the objectives of skill transfer of a training course
- Consisting of 9 Sections and 24 Chapters; other than core topics, also includes chapters on ethical issues in neonatal resuscitation, end-of-life care, evolution of international guidelines, the current evidence for resuscitation practices, research priorities, and quality considerations
- Presents for the first-time chapters on resuscitation in low-resource settings and in the presence of new emerging infections such as SARS-CoV2
- Key elements of each chapter include learning objectives, case scenarios, and key points; all color coded for easy accessibility and visualization
- Has numerous flowcharts, figures, tables, and highlighted boxes that make the reading easy and enjoyable
- 7 Performance checklists to provide a step-by-step outline of the procedure for use during the practice phase of the lesson; followed by a Performance Evaluation Test checklist for evaluating the learner's performance
- Meets the needs of all healthcare providers involved in newborn care and provide the policymakers with a national technical consensus guideline.

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