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Suraj Gupte

Foreword
Bakul J Parekh

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17 Neonatology

CHAPTER

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INTRODUCTION

First 28 days of life after birth are described as the newborn period. Proper care of the newborn babies forms the foundation for the subsequent life, not only in terms of longevity or survival, but also in terms of qualitative outcome without any mental and physical disabilities.

NOMENCLATURE/DEFINITIONS RELATED TO PERINATAL/NEONATAL PERIOD

Box 17.1 lists the noteworthy definitions concerning the perinatal/neonatal period.

IMPORTANCE OF NEONATAL CARE

Currently, infant mortality rate (IMR) at national level is around 36 per 1,000 live births. Neonatal mortality rate (NMR) and perinatal mortality rate (PMR) are 24 and 20, respectively, per 1,000 live births. Thus, a huge chunk of IMR is contributed by NMR and PMR. As shown in Figure 17.1, etiology of neonatal mortality revolves around:

- ***Prematurity/low birth weight (LBW)/intrauterine growth restriction (IUGR):*** 33%
- ***Infections, including pneumonias and sepsis:*** 33%
- ***Birth asphyxia:*** 20%
- ***Congenital anomalies/malformations:*** 10%
- ***Miscellaneous:*** 4%.

Clearly, a trio of prematurity/LBW/IUGR, serious infections, and birth asphyxia accounts for as high as 85–90% of the neonatal mortality. Congenital malformations are responsible for nearly 10% deaths. Miscellaneous conditions share a meager 4% of the canvas. For achieving further reduction in IMR, it is imperative that we resort to urgent measures for improving the newborn care to bring down NMR.

NEONATAL MORTALITY AND MORBIDITY PATTERN: OVERVIEW

- ***Prematurity and LBW***, responsible for about one-third of neonatal deaths and discussed subsequently in this Chapter.

BOX 17.1: Noteworthy definitions in relation to the neonate.

- ***Neonatal period:*** First 28 days after birth
- ***Early neonatal period:*** First 7 days of life
- ***Late neonatal period:*** More than 7th–28th days of life
- ***Perinatal period:*** From 28th week of gestation (or over 1,000 g of birth weight) to 7th day of postnatal life
- ***Extended perinatal period:*** From 22nd week of gestation (or over 500 g of birth weight) to 7th postnatal day of life
- ***Term baby:*** Neonate born between 37 weeks (completed) and up to 42 weeks (completed) of pregnancy, irrespective of the birth weight
- ***Preterm baby:*** Neonate born before 37 weeks (completed) or less than 259 days irrespective of birth weight
- ***Post term baby:*** Neonate born after 42 weeks (completed) or more than 294 days irrespective of birth weight
- ***LBW:*** Birth weight less than 2,500 g, irrespective of gestational age
- ***VLBW:*** Birth weight less than 1,500 g, irrespective of gestational age
- ***ELBW:*** Birth weight <1,000 g, irrespective of gestational age
- ***SGA :*** Birth weight less than 10th percentile for that period of gestation
- ***LGA :*** Birth weight more than 90th percentile for that period of gestation
- ***AGA:*** Birth weight between 10th and 90th percentile for that period of gestation
- ***Live born:*** Product of conception that shows an evidence of life (breathing, heartbeat, pulsation of umbilical cord, or definite movements of voluntary muscles) after separation from the mother
- ***Stillborn:*** Product of conception that fails to show any evidence of life, (breathing, heartbeat, pulsation of umbilical cord, or definite movements of voluntary muscles), provided that gestational age is 22 weeks or more or weight exceeds 500 g.

(LBW: low birth weight; VLBW: very low birth weight; ELBW: extremely low birth weight; SGA: small for gestational age; LGA: large for gestational age; AGA: appropriate for gestational age)

- ***Serious neonatal infections***, also responsible for around one-third of neonatal deaths, include congenital infections (T)oxoplasmosis, (O)ther agents, (R)ubella, (C)ytomegalovirus, and (H)erpes simplex (TORCH), and acquired infections such as sepsis and pneumonias. These are described in details later in this chapter.
- ***Perinatal asphyxia***, responsible for nearly one-fifth neonatal deaths, is known to cause in the survivors

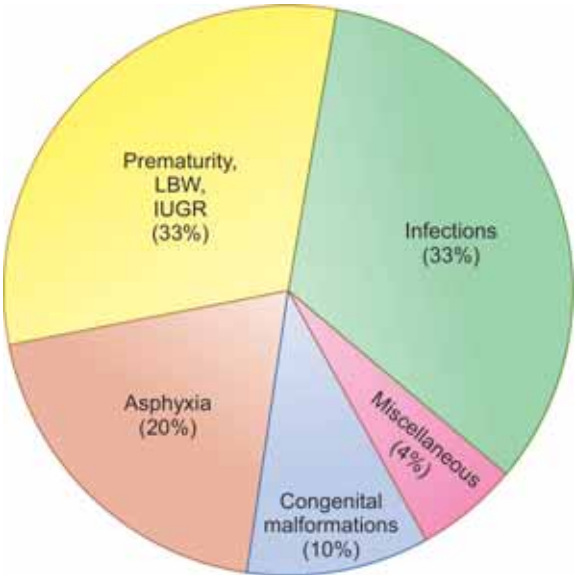

Fig. 17.1: Histogram showing current pattern of neonatal mortality in India. (LBW: low birth weight; IUGR: intrauterine growth restriction)

long-term sequelae such as impaired attention span, hyperactivity, epilepsy, mental retardation, bulbar and pseudobulbar palsies, and auditory deficits. The topic is discussed under hypoxic–ischemic encephalopathy elsewhere in this Chapter.

- ***Birth trauma (Figs. 17.2 to 17.4)***, more important from the angle of morbidity, may cause fracture of skull, clavicle, and extremities and various paralysis such as Erb paralysis (due to involvement of the fifth and sixth cervical roots), Klumpke paralysis (due to involvement of eighth cervical and first thoracic roots with or without injury to cervical sympathetic plexus), and facial palsy (due to seventh nerve paralysis). Breech extraction may cause fracture of a long bone.
- ***Sternomastoid tumor*** may occur in difficult breech deliveries in particular.
- ***Intracranial hemorrhage*** is a serious condition in which hemorrhage occurs inside the cranial vault. Depending on the site, it may, for example, be intraventricular hemorrhage (IVH), subarachnoid hemorrhage or subdural hemorrhage.
- ***Cephalhematoma*** is rather benign, self-limiting collection of blood under the periostium of the skull and resolves in a few weeks' time. The swelling is non-pulsatile, does not increase in size on crying, and does not cross a suture line (Fig. 17.5). It may take 4–6 weeks to resolve. The most common site is the parietal or occipital bone. It usually needs no treatment.
- ***Caput succedaneum,*** resulting from molding, consists of serosanguinous fluid collection over the presenting part between the pericranium and the scalp tissue. It is present at birth, crosses the suture line, and disappears within 2–3 days (Fig. 17.6).
- ***Congenital malformations and other defects*** (Figs. 17.7 to 17.18) may hamper newborn's survival. These include congenital heart disease, choanal atresia, omphalocele (bowel and other viscera herniating through a defect

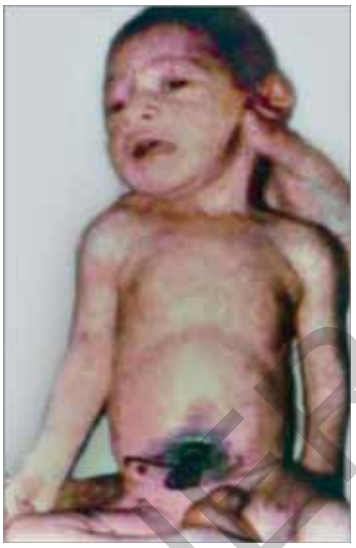

Fig. 17.2: Erb paralysis. Note the characteristic position of the left arm which is adducted and internally rotated with pronation of the forearm. The cause is injury to the fifth and sixth cervical nerves.

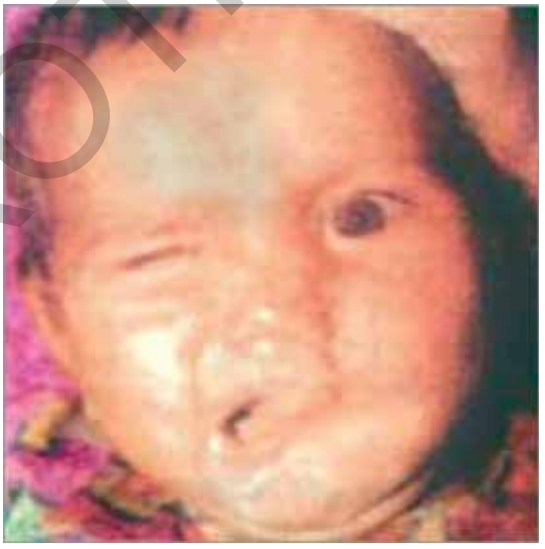

Fig. 17.3: Facial palsy. There was history of birth trauma.

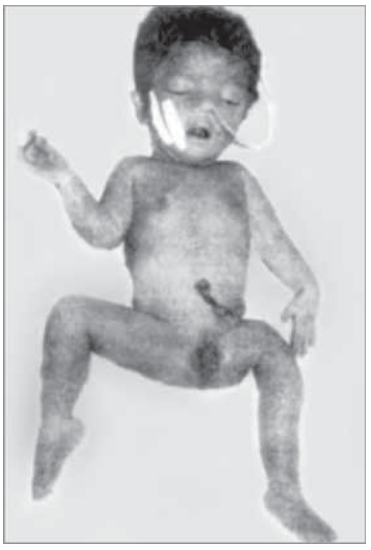

Fig. 17.4: Fracture of the left femur following breech delivery.

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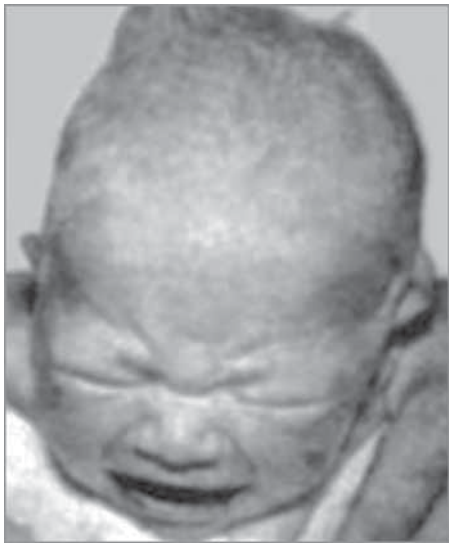

Fig. 17.5: Cephalhematoma. The lesion is soft and fluctuating. Since it is subperiosteal, it does not cross a suture line.

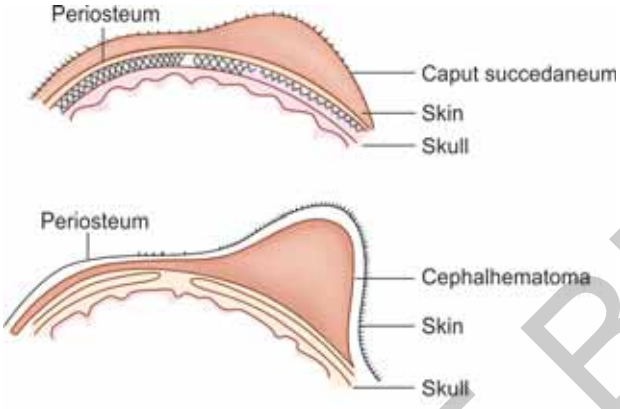

Fig. 17.6: Development of caput succedaneum and cephalhematoma. Caput succedaneum: serosanguinous fluid collection in the soft tissue, not limited by suture lines, disappears speedily. Cephalhematoma: collection of blood between skull bone and overlying periosteum, limited by suture line; disappears slowly in a few weeks.

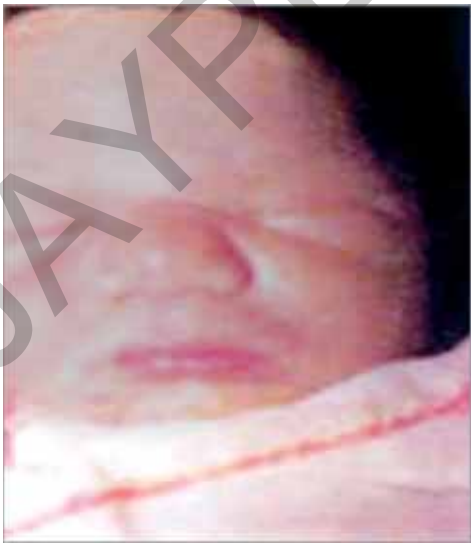

Fig. 17.7: Dysmorphic facies. Note the remarkably depressed bridge of nose.

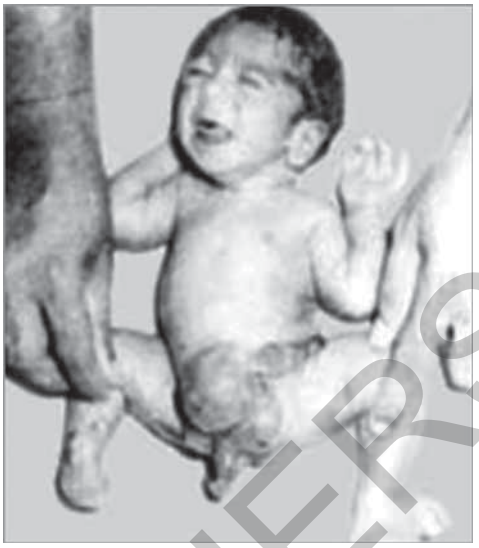

Fig. 17.8: Extroversion of cloaca.

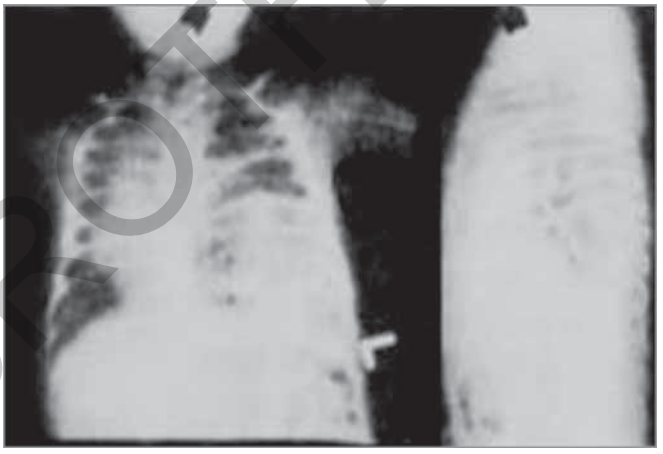

Fig. 17.9: Congenital diaphragmatic hernia. Note the abdominal contents herniated into thorax.

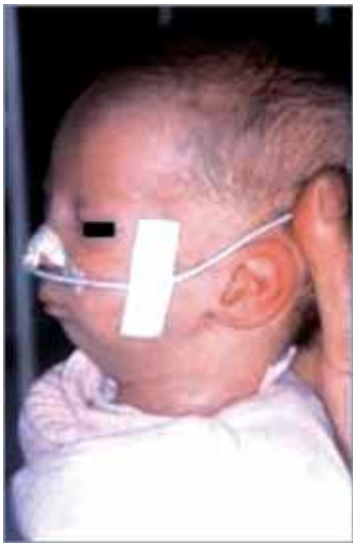

Fig. 17.10: Pierre Robin syndrome. Note the shrewlike facies due to hypoplastic mandible (micrognathia), glossoptosis, and high-arched cleft palate.

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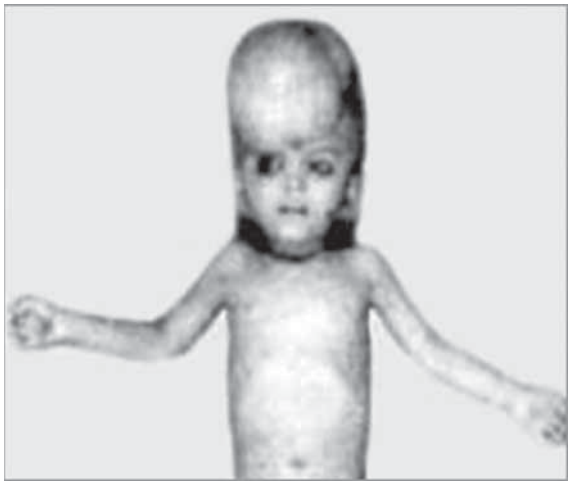

Fig. 17.11: Frontal encephalocele. The sac contains both meninges and brain in about two-thirds of patients with encephalocele. There is accompanying hydrocephalus that may be detected by ultrasonography or CT scan.

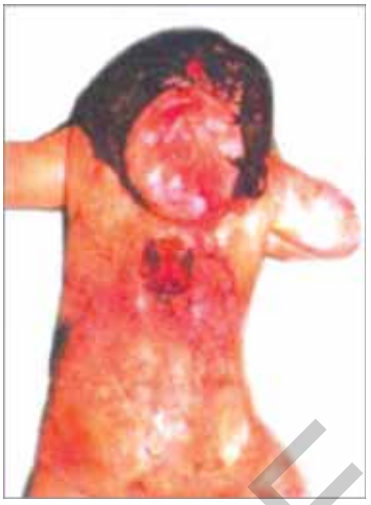

Fig. 17.12: Occipital encephalocele. The swelling fluctuates in size with coughing or crying which alter the intracranial pressure. Note that this stillborn baby also had anencephaly and hemicrania, the defects that are known to be incompatible with life.

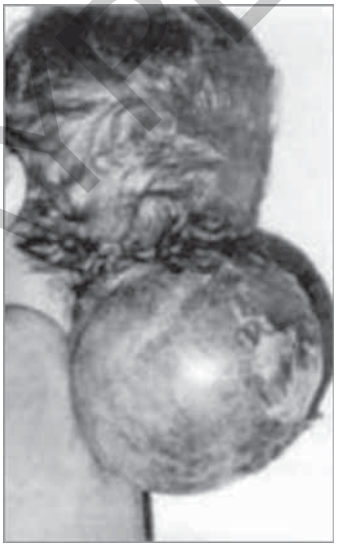

Fig. 17.13: Occipital encephalocele. It needs to be differentiated from cranial meningocele by palpation, transillumination, and, if needed, CT scan.

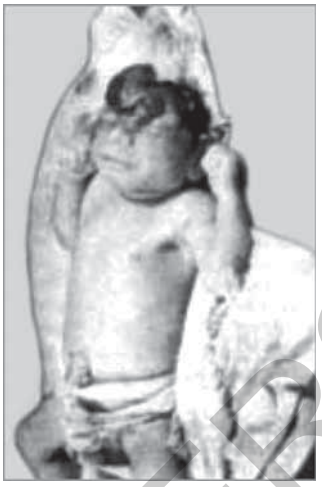

Fig. 17.14: Microcephaly with herniation of brain tissue.

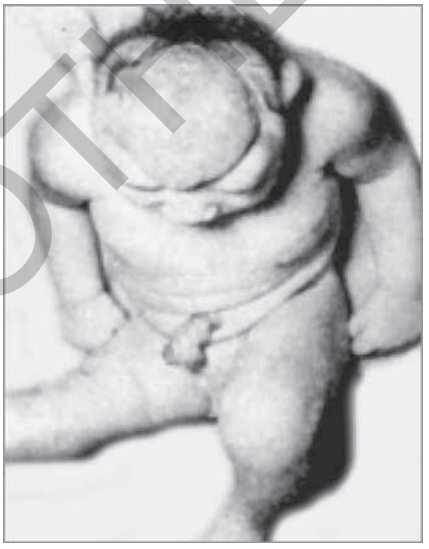

Fig. 17.15: Anencephaly. In this infant, who died within 24 hours of birth, membranous skull and cerebral hemisphere were absent.

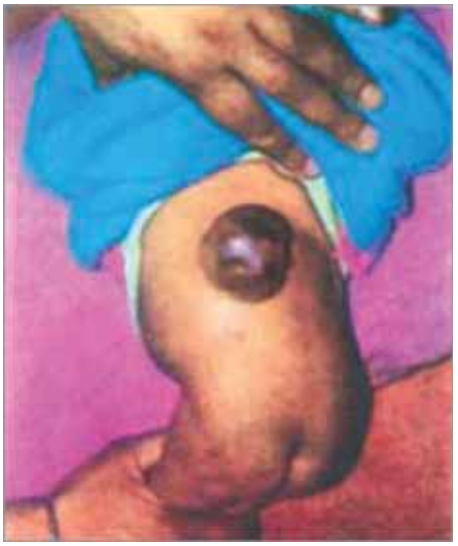

Fig. 17.16: Meningocele. The swelling, containing primarily meningeal tissue, shows good transillumination and no significant functional disability. In order to safeguard against infection and perforation, surgical excision is recommended.

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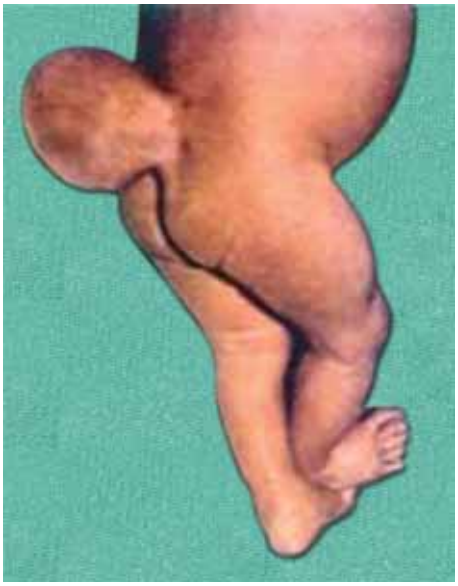

Fig. 17.17: Meningomyelocele. A relatively higher site, poor transillumination, and neurologic deficit are the hallmarks of this anomaly.

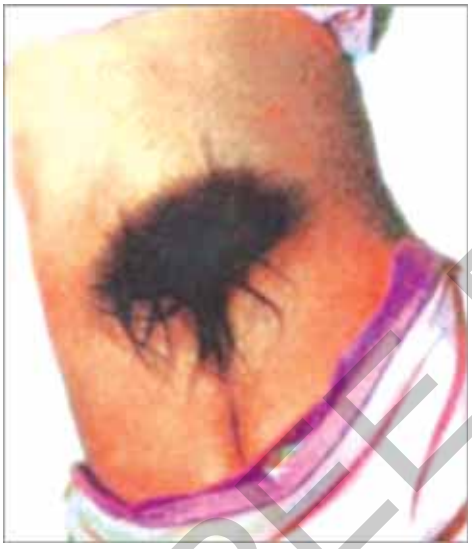

Fig. 17.18: Spina bifida occulta. Abnormal tuft of hair in an infant with radiologically proven underlying spina bifida occulta. Besides hair tuft, other conditions that should arouse suspicion of spina bifida occulta include telangiectasia and subcutaneous lipoma. The anomaly is most common at L5 and S1, but it may involve any portion of the vertebral column.

in the abdominal wall), congenital diaphragmatic hernia (CDH), tracheoesophageal fistula (TOF), intestinal obstruction, anorectal anomalies, Pierre Robin syndrome (micrognathia, i.e. a small mandible, cleft palate, and posterior displacement of tongue), and neural tube defects (NTDs) such as meningomyelocele (spina bifida with herniation of meninges, nerve roots, and spinal cord). Immediate recognition of such anomalies is important. These conditions are discussed elsewhere in different chapters.

A careful examination may also help early recognition of diseases such as congenital hypothyroidism, Cushing syndrome, Down syndrome, and Turner syndrome.

NEONATAL RESUSCITATION PROGRAM

Around 10% newborns need some resuscitation at birth. Understandably, neonatal resuscitation is a real emergency, requiring participation of everyone in the labor/delivery room. The fact that 70% of the babies with absent heart beat can be resuscitated shows how rewarding the maneuver is. Often a good antenatal check-up indicates whether resuscitation is likely to be needed. A weak fetal heart rate of less than 100 beats/minute or its irregularity during the late stage of labor is a sign of progressive asphyxia that will need resuscitative measures.

Currently, globally, the trend is to follow the Neonatal Resuscitation Program (NRP) based on the American Heart Association (AHA) and American Academy of Pediatrics (AAP) Guidelines which are duly endorsed by the International Liaison Committee on Resuscitation. In India, the National Neonatology Forum (NNF) and the Indian Academy of Pediatrics are aggressively propagating these guidelines through Neonatal Advanced Life Support (NALS) Course workshops across the country. Though 2010 guidelines are in vogue, updates from 2015 guidelines (given toward the end of the description on NRP) need to be incorporated in practice.

High-risk Situation

- ***Maternal:*** The situations in relation to ***high-risk pregnancy*** in which the mother is suffering from an adverse factor, e.g. maternal malnutrition, bad obstetrical history, hypertension, rhesus (Rh) isoimmunization, toxemias, etc.
- ***Fetal:*** Preterm birth, LBW infants, multiple pregnancies, fetal malformations (identified on ultrasonography), IUGR, fetal distress manifested by certain signs [meconium-stained liquor amnii, abnormal variation in fetal heart rate or rhythm, electrocardiogram (ECG)] changes in fetal monitoring records, changes in fetal blood pH, and gases on fetal blood samples.

Golden Minute Concept

According to this concept, if by the end of 1 minute of initial steps directed at stabilization, satisfactory outcome is not forthcoming, assisted ventilation becomes mandatory. Once positive pressure ventilation or supplementary oxygen administration is begun, assessment should consist of simultaneous evaluation of three vital characteristics, namely, ***heart rate, respiration,*** and ***the state of oxygenation*** rather than the color (earlier criterion). Oxygenation is optimally determined by pulse oximeter.

Initial Rapid Assessment: Whether Resuscitation Needed or Not?

As per new guidelines, the following three questions need to be answered in the initial assessment:

1. Is this a term gestation?
2. Is the infant crying and breathing?
3. Does the infant have good muscle tone?

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BOX 17.2: Checklist of neonatal resuscitation equipment and supplies.

- ***For suction:*** Mucus aspirator, meconium aspirator, mechanical suction, suction catheters 10 F or 12 F, feeding tube 6 F, 20 mL syringe.
- ***For bag and mask ventilation:*** Neonatal resuscitation bag, face masks (full-term and preterm sizes), oxygen with flowmeter, and tubing.
- ***For endotracheal intubation:*** Endotracheal tubes 2.5, 3.0, 3.5, 4.0, and 1 D, laryngoscope with straight blades of size 0 (preterm) and 1 (term) with extra-batteries and bulbs for laryngoscopy, stylet, scissors.
- ***Medications:*** Epinephrine, normal saline, sodium bicarbonate, naloxone, and sterile water.
- ***Miscellaneous:*** Radiant warmer, umbilical catheters, watch with seconds hand, linen and shoulder roll, stethoscope, adhesive tape, syringes 1–50 mL, gauze, and three-way stopcock gloves.

The previous guidelines included the question "*Is the amniotic fluid clear of meconium and evidence of infection*?" which stands deleted in the new guidelines.

In case answer to all these three questions is *yes*, the infant is not in need of any resuscitation. If it is *no* to any of the questions, the infant is in need of initial steps in stabilization which too are a part of resuscitation.

Resuscitation Equipment

It should be obligatory on the part of each and every delivery room to maintain an easily accessible neonatal resuscitation tray which is cross-checked and replenished from time to time (Box 17.2).

Adequate Preparation for Resuscitation

Every delivery warrants availability of:

- A radiant warmer ready for use
- All resuscitation equipment immediately available and in good working order
- At least one trained person (preferably two) skilled in neonatal resuscitation.

TABC of Resuscitation: Initial Steps in Stabilization

- ***T—Temperature:*** Maintenance of warmth is achieved by:
  - Placing the neonate under a preheated radiant warmer or alternatively, overhead 200 watt bulb/room heater.
  - Drying the neonate as soon as he is placed under the warmer using a prewarmed towel.
  - Removing the wet towel and replacing it with a dry and prewarmed one.

Over and above the maintenance of temperature, the major steps in neonatal resuscitation follow the time-honored ABC (Airway, Breathing, Circulation) pattern and should be completed as far as possible within 15 seconds of birth.

- ***A—Airway:*** Anticipate and establish an open airwayby:
  - Positioning of the neonate.
  - Suction of mouth, nose, and, at times trachea.
  - Performing endotracheal intubation and aspiration.
- ***B—Breathing:*** Tactile stimulation such as slapping the foot, rubbing the back, etc., or positive pressure ventilation (PPV) with a bag and mask or through an endotracheal tube.
- ***C—Circulation:*** Maintain the circulation with:
  - Chest compression
  - Medications, if needed.

Opening the Airway

- ***Positioning***: The neonate should be placed on his back/side with the neck slightly extended to straighten the airway and head kept slightly down to prevent aspiration with a shoulder roll made out of a towel or a blanket.
- ***Suction:*** If no meconium is present, first the mouth and oropharynx and then the nose and nasopharynx should be gently suctioned. If there is meconium-stained amniotic fluid, suction should be done when head is delivered but shoulders are yet to be out. This is termed ***intrapartum suctioning***. After the delivery of the infant, residual meconium in the hypopharynx should be suctioned out under direct vision laryngoscopy.

Initiating Breathing

- ***Tactile stimulation:*** If the depressed baby fails to have respiration despite drying and suctioning, additional tactile stimulation may be provided by slapping or flicking the soles of the feet and rubbing the back firmly once or twice.
- ***Positive pressure ventilation (PPV):*** If the baby is still depressed (apnea, heart rate <100/minute), he should be given bag and mask ventilation as per Box 17.3 and Figure 17.19. If it fails, endotracheal intubation should be performed.
- ***Endotracheal intubation:*** It is done after the baby is delivered to remove secretions from the lower airway. It is indicated in all babies who are apneic with meconium aspiration (Box 17.4, Figs. 17.20 and 17.21).

Maintaining Circulation

Chest compression (external cardiac massage) is given if heart rate remains less than 60/minutes. It consists of rhythmic compressions (120/minute; ratio 3:1) of lower third of the sternum that compress the heart against the spine, raise the intrathoracic pressure, and circulate blood to the vital organs (Figs. 17.22A and B). Details are given in Box 17.5.

Medication is only rarely needed. Depressed neonates with heart rate less than 60/minutes despite adequate ventilation with 100% oxygen, air-oxygen mixture, or room air (the last two may be preferred) and chest compressions are candidates for receiving medication in the form of epinephrine, volume expanders, sodium bicarbonate, and dopamine. There is no place for dexamethasone, atropine, mannitol, calcium, dextrose, and naloxone in resuscitation in the delivery room.

- ***Epinephrine A:*** 1 in 10,000, 0.1–0.3 mL/kg intravenous (IV). Intratracheal (IT) is given rapidly. The same dose may be repeated every 5 minutes.

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- ***Volume expanders:*** Normal saline, whole blood, 5% albumin, or Ringer lactate is indicated in the event of an acute bleeding with signs of hypovolemia.
- ***Sodium bicarbonate:*** 1–2 mEq/kg/minute of 4.2% solution slowly over 2-minute period after effective

BOX 17.3: Bag and mask ventilation.

Indications
- Apnea/gasping
- Heart rate less than 100/minute.

Equipment
- Resuscitation bag (self-inflating, capacity 240–750 mL) (Fig. 17.21)
- Oxygen (90–100%)
- Masks (well fitting, cushioned)
- Oxygen equipment (source, flow meter, tubing, etc.).

Procedure

The baby's neck should be slightly extended to ensure an open airway while he lies on his back. An appropriate-sized bag and mask is selected.
- The mask is placed in position so that it covers the mouth and the nose, but not the eyes. Then, bagging is started at a rate of 40–60/minute for 15–30 seconds, using enough pressure to cause chest movements.

Evaluation
- If heart rate is more than 100/minute and infant having spontaneous breathing, stop bagging (ventilation)
- If heart rate more than 100, but infant yet not having spontaneous breathing or is gasping, continue ventilation
- If heart rate 60–100/minute and not increasing, continue ventilation and check for adequacy of ventilation from chest elevation
- If heart rate 60–100/minute and increasing, continue ventilation
- If heart rate less than 60/minute, continue to ventilate, start chest compressions and consider intubation.

Signs of improvement
- Rising heart rate
- Spontaneous breathing
- Improving color.

Risks

Abdominal distention because of gastric distention from entry of air into stomach during ventilation exceeding 2 minutes.

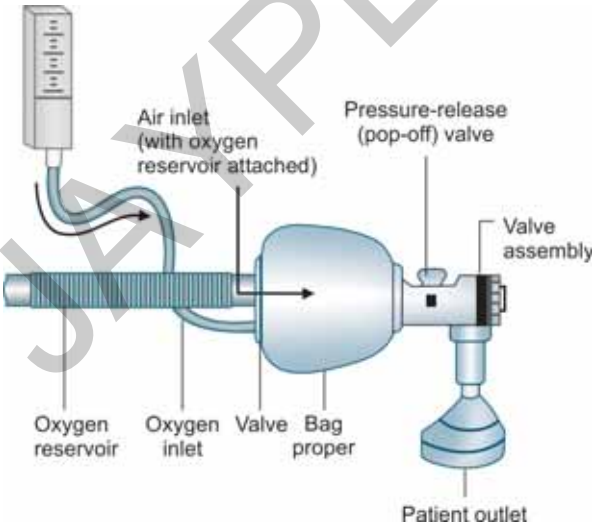

Fig. 17.19: Self-inflating bag. A 250–750 mL size bag comprising four major components (inlet, bag proper, patient outlet, and O_2 reservoir) is appropriate for a neonate. The most often employed gadget is ambulatory/artificial manual breathing unit (AMBU).

BOX 17.4: Endotracheal intubation (Figs. 17.20 to 17.22).

Indications:
- Failure of bag and mask ventilation as well as medication
- When PPV is needed.
- When tracheal suction, especially for aspiration of meconium, is needed.
- Diaphragmatic hernia.

Equipment

Endotracheal tube of appropriate size, neonatal laryngoscope with straight blades of size 0 for preterms and 1 for term babies.

Procedure
- The newborn is placed on a resuscitation table (high enough and with flat surface) in a supine position with fully extended. It is good to place folded towel or blanket beneath the shoulders to facilitate this position
- The operator sits on a stool at the head end. As he opens the infant's mouth with the index finger and the thumb of the right hand, his left hand introduces the lighted laryngoscope (infant size) into the pharynx up to the epiglottis
- The glottis is cleared by gentle suction. This makes it easier to clearly see the epiglottis and the surrounding structures. When the glottis is visible, a curved endotracheal tube is gently inserted through the larynx. Make sure that it is not pushed too far to prevent its entry into the right bronchus. The laryngoscope is now withdrawn
- The IPPR is given through the tube with a bag or mechanical respirator
- As soon as respiration gets established, the tube should be withdrawn. If the response is poor, still efforts have got to be continued as long as the heart beat exists or brain death is diagnosed.

Precautions during intubation

In order to prevent hypoxia during intubation, provide free flow oxygen, limit intubation attempt to 20 seconds and avoid excessive flexion of neck.

Precautions during extubation
- Give free-flow oxygen through the lid of the endotracheal tube for a few seconds
- Always take help of a laryngoscope during extubation.
- Continue bag and mask ventilation for 15 seconds after extubation.

(IPPR: intermittent positive pressure respiration; PPV: positive pressure ventilation)

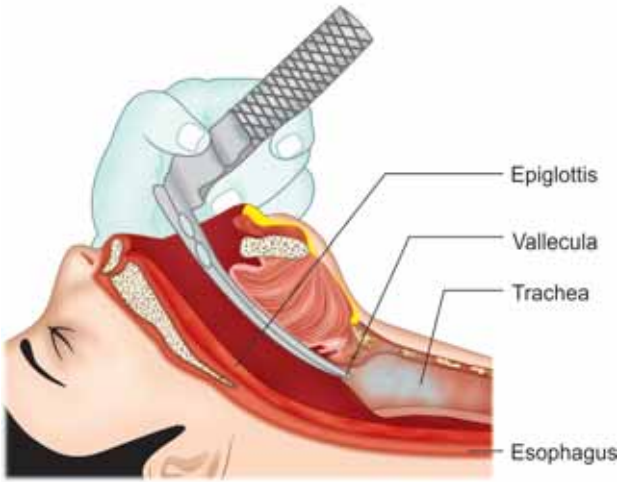

Fig. 17.20: Endotracheal intubation technique. Note the endotracheal tube in position. It is inserted up to 2.5 cm beyond the vocal cord.

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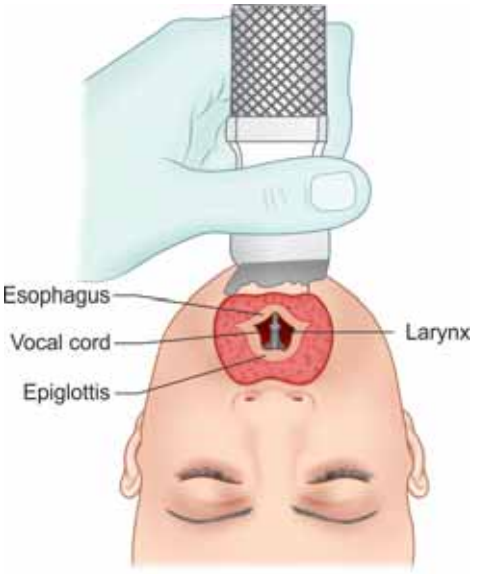
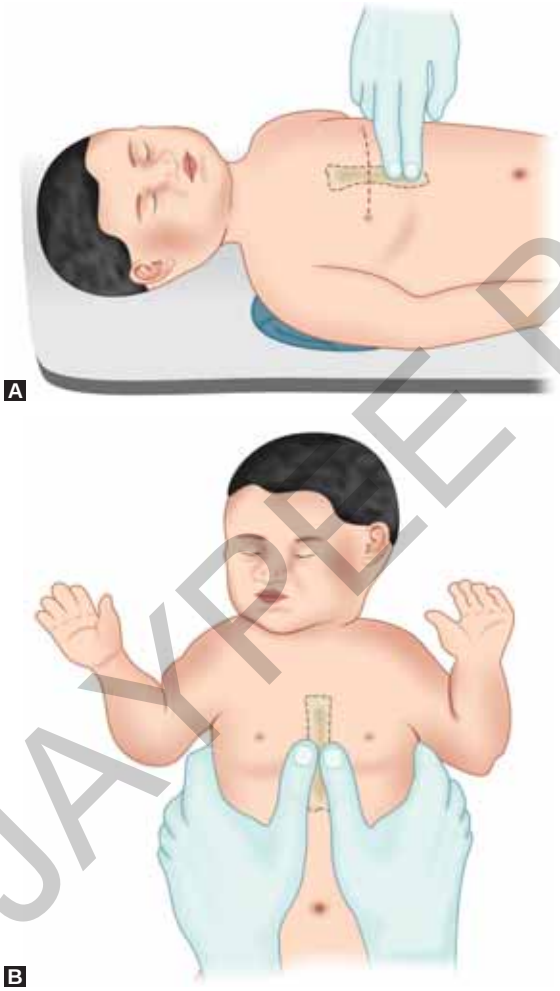


Fig. 17.21: Endotracheal intubation technique. The glottis (triangular opening formed by vocal cords and arytenoid cartilage) as viewed through laryngoscope.



Figs. 17.22A and B: Chest compression. It consists of rhythmic compressions (120/min; ratio 3:1 with ventilation) of lower third of the sternum if heart rate remains <60/minute. (A) Two-finger technique in which tips of the middle finger and an adjoining finger of a hand are employed to depress the lower one-third of the sternum; (B) Thumb technique in which thumbs of both hands are employed to depress the lower one-third of the sternum.

BOX 17.5: Chest compression.

Indications
If after 15–30 seconds of positive pressure ventilation (PPV) with 100% oxygen, heart rate remains <60/minute or it is 60–80/minute, but not increasing.

Site
Lower third of the sternum below the imaginary line drawn between two nipples.

Procedure
In the thumb technique, thumbs are employed to compress the sternum while the fingers support the back and the hand encircles the torso. In the two-finger technique, the finger tips (middle finger with index finger or ring finger), one hand are employed to compress the sternum. The other hand supports the neonate's back. The rate of chest compressions should be 120 beats/minute and depth 1–2 cm. During the procedure, fingers and thumbs must never be taken off the sternum in between compressions.

Evaluation
Thirty seconds of chest compression should be followed by rechecking of the heart rate. If it is below 80 beats/minute, the procedure should continue along with bag and mask ventilation with 100% oxygen, plus medication (vide text). If heart rate is more than 80/minute, stop chest compression but continue ventilation until heart rate crosses 100 beats/minute and the baby is breathing spontaneously.

Complications
Trauma to the chest in the form of fractures, pneumothorax, and laceration of liver.

ventilation has been established. It is indicated only in the event of documented metabolic acidosis. Else, there is risk of such a therapy producing respiratory acidosis.

- ***Dopamine:*** 5–20 mg/kg/minute as a continuous IV infusion in poor peripheral perfusion, weak pulses, hypotension, tachycardia persisting after the initial resuscitative efforts.

In earlier guidelines, naloxone 0.01 mg/kg [IV, subcutaneous (SC), intramuscular OIM), IT] was recommended in case of history of maternal narcotic drug administration. New guidelines do not recommend naloxone.

Pulse Oximetry

The new guidelines have emphasized the use of pulse oximetry rather than the color of the baby (Box 17.6).

Supplementary Oxygen

The new guidelines stress the need for employing room air providing 21% oxygen (rather than using 100% oxygen) in

BOX 17.6: Pulse oximetry.

Pulse oximetry should be employed:
- When resuscitation is anticipated
- When positive pressure is administered for more than few breaths
- When cyanosis is persistent
- When supplementary oxygen is administered.

The probe should be attached to a preductal location, i.e. right upper extremity, usually wrist or medial surface of palm. Attaching the probe to the infant before connecting the probe to the instrument facilitates the most rapid acquisition of signal.

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Suraj Gupte MD FIAP FSAMS (Sweden) FRSTMH (London) hails from the alumni of India's prestigious, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh. At present, he is Professor and Head (Emeritus), Postgraduate Department of Pediatrics, Mamata Medical College/Mamata General and Superspeciality Hospitals, Khammam, Telangana, India.

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Over and above The Short Textbook of Pediatrics, he has edited/authored international series, Recent Advances in Pediatrics, and scores of other world class child health books of high esteem and published/presented over 260 papers in national and international journals/forums. He has been on several academic task forces and editorial boards of reputed pediatric periodicals, both national and international, as an adviser, editor, member and peer-reviewer.

In the Indian Academy of Pediatrics and its subspecialty chapters, he has held several important positions, including Founder and Vice-President of the Child Nutrition Chapter and Founder and Secretary of the Child Neurology Chapter. He remained National Executive Member for several terms. At the International Nestle Nutrition Workshop held in Taiwan in 1989, he was the solo official representative of the IAP. He was Adviser, 8th International Congress of Tropical Pediatrics and National Executive Member, 8th Asian Congress of Pediatrics.

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