

File No	02/1303
Circular No	2002/30
Issued	20 February 2002
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FRAMEWORK FOR AREA HEALTH SERVICES TO DEVELOP POLICY AND PROCEDURES RELATING TO CLINICAL CARE AND RESUSCITATION OF THE NEWLY BORN INFANT

New evidence-based international guidelines for resuscitation of the newly born infant, with recommendations for Basic Life Support (BLS) and Advanced life Support (ALS) have recently been issued by the International Liaison Council On Resuscitation (ILCOR)¹ and **are attached to this Circular.**

Area Health Services should use the attached guidelines to develop clear local policies and procedures for clinical care and resuscitation of the newly born infant. These local policies should establish standards of practice and serve as a foundation for staff education and training programs.

In this context, newly born means the first minutes to hours following birth¹.

As recommended by the NHMRC², local policies and procedures should be prominently displayed in each Birth Unit and should be otherwise made readily accessible to all medical, midwifery, nursing and paramedical staff attending routine and emergency births. This includes home birth attendants, flight nurses and Ambulance Service Officers of all grades.

To provide Area Health Services with a tool to assist in the development of local policies and procedures based on the attached international guidelines, this Framework has been developed by the NSW Pregnancy and Newborn Services Network (NSW PSN). The Framework has been endorsed by the NSW Maternal and Perinatal Committee and is now issued as policy by NSW Health.

Introduction

Transition from fetal to extrauterine life presents unique physiological challenges for the newly born infant. Therefore resuscitation presents a different set of challenges from resuscitation of the adult or even the older infant or child. Although most babies achieve this transition from fetal to extrauterine life without difficulty, a minority (<10%) require some degree of active resuscitation at birth.

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In accordance with the provisions incorporated in the Accounts and Audit Determination, the Board of Directors, Chief Executive Officers and their equivalents, within a public health organisation, shall be held responsible for ensuring the observance of Departmental policy (including circulars and procedure manuals) as issued by the Minister and the Director-General of the Department of Health.

While the need for resuscitation of the newly born infant can often be predicted, the need may also arise suddenly and in any birth setting (including facilities that do not provide neonatal intensive care). It is therefore essential that all staff who may be called upon to provide birthing services possess the necessary knowledge and skills to initiate appropriate resuscitative techniques.

Policies and procedures for resuscitation of the newly born infant which establish evidence-based standards of clinical practice and underpin staff education and training programs play an important role in reducing perinatal morbidity and producing quality neonatal outcomes.

RECOMMENDATIONS

Local AHS policies and procedures should incorporate:

1. Mechanisms to anticipate the need for assistance in establishing respiration and the need for possible active resuscitation of the newly born infant. These should include:
 - Evaluation of every birthing woman for antepartum and intrapartum conditions associated with risk to the newly born infant as per Table 1 (page 5) of the attached International Guidelines for Neonatal Resuscitation;
 - Policies on ethical issues, such as circumstances where non-initiation or discontinuation of resuscitation in the delivery room may be appropriate. These policies should be consistent with the hospital's Role Delineation³, local resources and outcome data and should emphasise the need to include parents in the process of decision-making⁴;
 - Policies covering special resuscitation circumstances such as preterm birth (<37 weeks), multiple birth, meconium–staining of the amniotic fluid and maternity emergencies as per Circular 99/86;
 - Local procedures for implementation of NSW Health Circular 99/71: *Policy for emergency obstetric and neonatal referrals*;
 - Emphasise the need for early consultation and collaboration between parents and all caregivers (general practitioners, midwives, neonatologists, obstetricians and paediatricians) where there may be a need for active resuscitation. This should include information on obtaining advice as outlined in Circular 99/71;
 - Adoption of the NHMRC recommendations⁵ regarding attendance of a staff member skilled in resuscitation at all preterm (<37 weeks) births. If the birth is < 34 weeks, an appropriate staff member skilled in endotracheal intubation, should attend. This would usually be a member of the paediatric or anaesthetic staff;
 - Provisions should also be in place to ensure that staff with skills in advanced life support are readily available to render resuscitation assistance at all births, regardless of gestation;
 - Procedures to ensure equipment is checked frequently for functionality and availability. This should include instructions for use of all equipment, including the radiant warmer;
2. Evaluation of every newly born infant to assess the need for resuscitation. This should include:
 - Visual inspection for meconium on the skin, vigorous cry, respiratory effort, muscle tone, colour and gestation (term, preterm);

If normal: Routine clinical care, with attention to thorough drying for temperature maintenance and prevention of hypothermia.

If abnormal:

- **Airway** - positioning of the infant, use of tactile stimulation, indications for and techniques of suctioning, and management of meconium-stained amniotic fluid;
 - **Breathing** – assessment of colour and respiratory effort, indications for and techniques of oxygen administration, of bag and mask ventilation, and of intubation. Most infants respond to effective bag and mask ventilation and this is indicated by a rise in heart rate, followed by an increase in spontaneous breathing efforts. If there is no response to bag and mask ventilation endotracheal intubation is indicated;
 - **Circulation** – assessment of heart rate and response to above measures, indications for and techniques of cardiac chest compression. Note that the ratio of compressions to breaths for newly born infants is 3:1. This achieves approximately 120 events per minute (90 compressions and 30 breaths);
 - **Drugs**– are rarely indicated in resuscitation of the newly born infant. Medications may be required if bradycardia (HR <60 bpm) persists despite adequate ventilation with 100% oxygen and cardiac chest compressions. Local policies should give clear guidance on indications for and administration of medications (Adrenaline, Naloxone and Sodium Bicarbonate) and volume expanders;
3. Continuing care of the infant and family after resuscitation, including provision of information to the parents as well as supportive care, continuous observation and appropriate diagnostic evaluation of the infant.
4. Procedures for documentation of resuscitation interventions and responses that:
- Contribute to an understanding of the infant’s pathophysiology and possible further treatment;
 - Can be used for audit and peer review purposes to monitor resuscitation outcomes and improve resuscitation performance and training;
5. A staff education and training program that:
- is included in orientation programs for all new staff providing birthing services and working with newborns;
 - is included in annual continuing education and staff development programs;
 - includes theoretical and practical components;
 - includes mechanisms for an annual assessment of competence in resuscitation of the newly born infant

Further information on staff education, training programs and policy development in neonatal resuscitation is available from the NSW Pregnancy and Newborn Services Network on 02 9351 7318.

This Circular is due for revision:

Two years from release date, by the NSW Pregnancy & Newborn Services Network.

This Circular should be read in conjunction with:

- 86/219 *Recommended Code of Safe Practice in Hospital Delivery Suites: Section 10 Neonatal Safety Precautions* (Patient Matters Manual Part 1 Section 17.6)
- 95/72 *Provision of emergency trolleys and resuscitation training* (Patient Matters Manual

Part 1 Section 6.20)

- 95/94 *Resuscitation equipment and training* (Patient Matters Manual Part 1 Section 6.21)
- 95/41 *Administration of Narcotics During Labour* (Patient Matters Manual Part II Section 17.10)
- 97/38 *Guidelines for facilities for the stabilisation of newborns prior to transport* (Patient Matters Manual Part 1, Section 2.23)
- 99/71 *Policy for emergency obstetric and neonatal referrals* (Patient Matters Manual Part 1 Section 6.16)
- 99/86 *Maternity emergencies* (Patient Matters Manual Part 1 Section 6.18)
- 02/6 *Hospital procedures for review and reporting of perinatal deaths* (Patient Matters Manual Part II, Section 17.15)
- *Maternity emergency guidelines for Registered Nurses* 1998. NSW Midwives Association, Module 12, pp1-4.

¹ Niermeyer, S., Kattwinkel, J., Van Reempts, P. Nadkarni, V., Phillips, B. and Zideman, D. (2000) International guidelines for neonatal resuscitation: An excerpt from the guidelines 2000 for cardiopulmonary resuscitation and emergency cardiovascular care: International consensus on science. *Pediatrics*, 106 ,3, 1-16 **Attached to this Circular and available at:** <http://www.pediatrics.org/cgi/content/full/106/3/e29>

² NHMRC (1996) *Clinical practice guidelines. Care around preterm birth*. AGPS: Canberra. p.120-122

³ NSW Health Department (1991). *Guide to the role delineation of Health Services* (currently under review)

⁴ NSW Pregnancy and Newborn Services Network (2000). *Outcomes for premature babies in NSW and ACT: information for parents and prospective parents*. <http://www.usyd.edu.au/cphsr/parents>

⁵ NHMRC (1995) *Perinatal Morbidity*. AGPS: Canberra. p.29

NHMRC (1996) *Clinical practice guidelines. Care around preterm birth*. AGPS: Canberra. p.120-122

Robert McGregor

Acting Director-General

International Guidelines for Neonatal Resuscitation: An Excerpt From the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care: International Consensus on Science

ABSTRACT. The International Guidelines 2000 Conference on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC) formulated new evidence-based recommendations for neonatal resuscitation. These guidelines comprehensively update the last recommendations, published in 1992 after the Fifth National Conference on CPR and ECC.

As a result of the evidence evaluation process, significant changes occurred in the recommended management routines for:

- **Meconium-stained amniotic fluid:** If the newly born infant has absent or depressed respirations, heart rate <100 beats per minute (bpm), or poor muscle tone, direct tracheal suctioning should be performed to remove meconium from the airway.

- **Preventing heat loss:** Hyperthermia should be avoided.

- **Oxygenation and ventilation:** 100% oxygen is recommended for assisted ventilation; however, if supplemental oxygen is unavailable, positive-pressure ventilation should be initiated with room air. The laryngeal mask airway may serve as an effective alternative for establishing an airway if bag-mask ventilation is ineffective or attempts at intubation have failed. Exhaled CO₂ detection can be useful in the secondary confirmation of endotracheal intubation.

- **Chest compressions:** Compressions should be administered if the heart rate is absent or remains <60 bpm despite adequate assisted ventilation for 30 seconds. The 2-thumb, encircling-hands method of chest compression is preferred, with a depth of compression one third the anterior-posterior diameter of the chest and sufficient to generate a palpable pulse.

- **Medications, volume expansion, and vascular access:** Epinephrine in a dose of 0.01–0.03 mg/kg (0.1–0.3 mL/kg of 1:10,000 solution) should be administered if the heart rate remains <60 bpm after a minimum of 30 seconds of adequate ventilation and chest compressions. Emergency volume expansion may be accomplished with an isotonic crystalloid solution or O-negative red blood cells; albumin-containing solutions are no longer the fluid of choice for initial volume expansion. Intraosseous access can serve as an alternative route for medications/volume expansion if umbilical or other direct venous access is not readily available.

- **Noninitiation and discontinuation of resuscitation:** There are circumstances (relating to gestational age, birth weight, known underlying condition, lack of response to interventions) in which noninitiation or discontinuation of resuscitation in the delivery room may be appropriate. *Pediatrics* 2000;106(3). URL: <http://www.pediatrics.org/cgi/content/full/106/3/e29>

The Neonatal Resuscitation Guidelines, as presented here, constitute only one part of the International Guidelines 2000 for CPR and ECC. Full content of the guidelines, including recommendations for adult, pediatric, and neonatal age groups at both basic and advanced life support levels, appears in a supplement to *Circulation* (2000;102(suppl 1):I-343–I-357).

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[pediatrics.org/cgi/content/full/106/3/e29](http://www.pediatrics.org/cgi/content/full/106/3/e29); *neonatal resuscitation*.

INTRODUCTORY FRAMEWORK FOR NEONATAL RESUSCITATION GUIDELINES

The Neonatal Resuscitation Guidelines present the recommendations of the International Guidelines 2000 Conference on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC). The Guidelines 2000 Conference assembled international experts from many fields, including neonatal resuscitation, to comprehensively update existing guidelines through a process of evidence evaluation.

The Neonatal Resuscitation Program Steering Committee (American Academy of Pediatrics), the Pediatric Working Group of the International Liaison Committee on Resuscitation (ILCOR), and the Pediatric Resuscitation Subcommittee of the Emergency Cardiovascular Care Committee (American Heart Association) worked together for 2 years in a systematic process of evidence evaluation and formulation of new recommendations. In 1999 the Pediatric Working Group of ILCOR developed a consensus advisory statement, "Resuscitation of the newly born infant" (*Pediatrics* 1999;103(4). <http://www.pediatrics.org/cgi/content/full/103/4/e56>). Using questions and controversies identified during the consensus process, members of the participating organizations worked with additional topic experts from various countries to assemble the most current scientific information relating to neonatal resuscitation. A standard worksheet template served as a framework for uniform evaluation of each selected topic. Articles published in peer-reviewed journals were assembled and analyzed individually for relevance to the proposed guideline change and the quality of the evidence presented. Strength of evidence was classified on the basis of the level of evidence, or study design (ie, randomized, controlled trials, prospective observational studies, retrospective observational studies, case series, animal studies, extrapolations, and common sense) and the quality of the methodology (population, techniques, bias, confounders, etc). Integration of evidence at many different levels and of different quality occurred through consensus discussions among experts and formal panel presentation and debate at the Evidence Evaluation Conference (American Heart Association, September 1999). From the integration process emerged a class of recommendation for each proposed guideline, based on the level of evidence and critical assessment of the quality of the studies, as well as the number of studies, consistency of conclusions, outcomes measured, and magnitude of benefit. The proposed guideline

TABLE I. Clinical Interpretation of Classes of Recommendations

Class of Recommendation	Interpretation
Class I	Always acceptable, proven safe, definitely useful
Class IIa	Acceptable, safe, useful (standard of care or intervention of choice)
Class IIb	Acceptable, safe, useful (within the standard of care or an optional or alternative intervention)
Class indeterminate	Preliminary research stage with promising results but insufficient available evidence to support a final class decision
Class III	Unacceptable, no documented benefit, may be harmful

changes, as well as their class of recommendation and level of evidence were presented for final debate and ratification at the Guidelines 2000 Conference (February 2000).

For each new or revised guideline, the class of recommendation, as well as the highest level of evidence (LOE) supporting the recommendation, appears in the text. Table I provides a guide to the clinical interpretation of each class of recommendation. Previous guideline recommendations not originally formulated through evidence-based review remain in place unless there existed a lack of evidence to confirm effectiveness, new evidence to suggest harm or ineffectiveness, or evidence that superior approaches had become available. Although the International Guidelines 2000 present the consensus of experts in the field of resuscitation, use of the guidelines is not mandated or imposed upon an individual or organization. The guidelines represent the most effective practices for resuscitation of the newly born infant, based upon current research, knowledge, and experience. As such they are intended to serve as the foundation for educational programs and national, regional, and local processes which establish standards of practice.

MAJOR GUIDELINES CHANGES

The Pediatric Working Group of the International Liaison Committee on Resuscitation (ILCOR) developed an advisory statement published in 1999. This statement listed the following principles of resuscitation of the newly born:

- Personnel capable of initiating resuscitation should attend every delivery. A minority (fewer than 10%) of newly born infants require active resuscitative interventions to establish a vigorous cry or regular respirations, maintain a heart rate >100 beats per minute (bpm), and achieve good color and tone.
- When meconium is observed in the amniotic fluid, deliver the head, and suction meconium from the hypopharynx on delivery of the head. If the newly born infant has absent or depressed respirations, heart rate <100 bpm, or poor muscle tone, carry out direct tracheal suctioning to remove meconium from the airway.
- Establishment of adequate ventilation should be of primary concern. Provide assisted ventilation with

attention to oxygen delivery, inspiratory time, and effectiveness as judged by chest rise if stimulation does not achieve prompt onset of spontaneous respirations or the heart rate is <100 bpm.

- Provide chest compressions if the heart rate is absent or remains <60 bpm despite adequate assisted ventilation for 30 seconds. Coordinate chest compressions with ventilations at a ratio of 3:1 and a rate of 120 events per minute to achieve approximately 90 compressions and 30 breaths per minute.
- Administer epinephrine if the heart rate remains <60 bpm despite 30 seconds of effective assisted ventilation and circulation (chest compressions).

At the Guidelines 2000 Conference, we made the following recommendations:

Temperature

- Cerebral hypothermia; avoidance of perinatal hyperthermia
 - Avoid hyperthermia (Class III).
 - Although several recent animal and human studies have suggested that selective cerebral hypothermia may protect against brain injury in the asphyxiated infant, we cannot recommend routine implementation of this therapy until appropriate controlled human studies have been performed (Class Indeterminate).

Oxygenation and Ventilation

- Room air versus 100% oxygen during positive-pressure ventilation
 - 100% oxygen has been used traditionally for rapid reversal of hypoxia. Although biochemical and preliminary clinical evidence suggests that lower inspired oxygen concentrations may be useful in some settings, data is insufficient to justify a change from the recommendation that 100% oxygen be used if assisted ventilation is required.
 - If supplemental oxygen is unavailable and positive-pressure ventilation is required, use room air (Class Indeterminate).
- Laryngeal mask as an alternative method of establishing an airway
 - When used by appropriately trained providers, the laryngeal mask airway may be an effective alternative for establishing an airway during resuscitation of the newly born infant, particularly if bag-mask ventilation is ineffective or attempts at tracheal intubation have failed (Class Indeterminate).
- Confirmation of tracheal tube placement by exhaled CO₂ detection
 - Exhaled CO₂ detection can be useful in the secondary confirmation of tracheal intubation in the newly born, particularly when clinical assessment is equivocal (Class Indeterminate).

Chest Compressions

- Preferred technique for chest compressions
 - Two thumb-encircling hands chest compression is the preferred technique for chest com-

pressions in newly born infants and older infants when size permits (Class IIb).

- For chest compressions, we recommend a relative depth of compression (one third of the anterior-posterior diameter of the chest) rather than an absolute depth. Chest compressions should be sufficiently deep to generate a palpable pulse.

Medications, Volume Expansion, and Vascular Access

- Epinephrine dose
 - Administer epinephrine if the heart rate remains <60 bpm after a minimum of 30 seconds of adequate ventilation and chest compressions (Class I).
 - Epinephrine administration is particularly indicated in the presence of asystole.
- Choice of fluid for acute volume expansion
 - Emergency volume expansion may be accomplished by an isotonic crystalloid solution such as normal saline or Ringer's lactate. O-negative red blood cells may be used if the need for blood replacement is anticipated before birth (Class IIb).
 - Albumin-containing solutions are no longer the fluid of choice for initial volume expansion because their availability is limited, they introduce a risk of infectious disease, and an association with increased mortality has been observed.
- Alternative routes for vascular access
 - Intraosseous access can be used as an alternative route for medications/volume expansion if umbilical or other direct venous access is not readily available (Class IIb).

Ethics

- Noninitiation and discontinuation of resuscitation
 - There are circumstances (relating to gestational age, birth weight, known underlying condition, lack of response to interventions) in which noninitiation or discontinuation of resuscitation in the delivery room may be appropriate (Class IIb).

INTRODUCTION

Resuscitation of the newly born infant presents a different set of challenges than resuscitation of the adult or even the older infant or child. The transition from placental gas exchange in a liquid-filled intrauterine environment to spontaneous breathing of air requires dramatic physiological changes in the infant within the first minutes to hours after birth.

Approximately 5% to 10% of the newly born population require some degree of active resuscitation at birth (eg, stimulation to breathe),¹ and approximately 1% to 10% born in the hospital are reported to require assisted ventilation.² More than 5 million neonatal deaths occur worldwide each year. It has been estimated that birth asphyxia accounts for 19% of these deaths, suggesting that the outcome might be improved for more than 1 million infants per year through implementation of simple resuscitative techniques.³ Although the need for resuscitation of the newly born infant often can be predicted, such cir-

cumstances may arise suddenly and may occur in facilities that do not routinely provide neonatal intensive care. Thus, it is essential that the knowledge and skills required for resuscitation be taught to all providers of neonatal care.

With adequate anticipation, it is possible to optimize the delivery setting with appropriately prepared equipment and trained personnel who are capable of functioning as a team during neonatal resuscitation. At least 1 person skilled in initiating neonatal resuscitation should be present at every delivery. An additional skilled person capable of performing a complete resuscitation should be immediately available.

Neonatal resuscitation can be divided into 4 categories of action:

- Basic steps, including rapid assessment and initial steps in stabilization
- Ventilation, including bag-mask or bag-tube ventilation
- Chest compressions
- Administration of medications or fluids

Tracheal intubation may be required during any of these steps. All newly born infants require rapid assessment, including examination for the presence of meconium in the amniotic fluid or on the skin; evaluation of breathing, muscle tone, and color; and classification of gestational age as term or preterm. Newly born infants with a normal rapid assessment require only routine care (warmth, clearing the airway, drying). All others receive the initial steps, including warmth, clearing the airway, drying, positioning, stimulation to initiate or improve respirations, and oxygen as necessary.

Subsequent evaluation and intervention are based on a triad of characteristics: (1) respirations, (2) heart rate, and (3) color. Most newly born infants require only the basic steps, but for those who require further intervention, the most crucial action is establishment of adequate ventilation. Only a very small percentage will need chest compressions and medications.⁴

Certain special circumstances have unique implications for resuscitation of the newly born infant. Care of the infant after resuscitation includes not only supportive care but also ongoing monitoring and appropriate diagnostic evaluation. In certain clinical circumstances, noninitiation or discontinuation of resuscitation in the delivery room may be appropriate. Finally, it is important to document resuscitation interventions and responses in order to understand an individual infant's pathophysiology as well as to improve resuscitation performance and study resuscitation outcomes.⁵⁻⁸

BACKGROUND

Changes in Neonatal Resuscitation Guidelines, 1992 to 2000

The ILCOR Pediatric Working Group consists of representatives from the American Heart Association (AHA), European Resuscitation Council (ERC), Heart and Stroke Foundation of Canada (HSFC),

Australian Resuscitation Council (ARC), New Zealand Resuscitation Council (NZRC), Resuscitation Council of Southern Africa (RCSA), and Council of Latin America for Resuscitation (CLAR). Members of the Neonatal Resuscitation Program (NRP) Steering Committee of the American Academy of Pediatrics (AAP) and representatives of the World Health Organization (WHO) joined the ILCOR Pediatric Working Group to extend existing advisory recommendations for pediatric and neonatal basic life support⁹ to comprehensive basic and advanced resuscitation for the newly born.¹⁰ Careful review of the guidelines of constituent organizations^{11–17} and current international literature formed the basis for the 1999 ILCOR advisory statement.¹⁰ We have included consensus recommendations from that statement at the beginning of this document.

Using questions and controversies identified during the ILCOR process, the Neonatal Resuscitation Program Steering Committee (AAP), the Pediatric Working Group (ILCOR), and the Pediatric Resuscitation Subcommittee of the Emergency Cardiovascular Care Committee (AHA) carried out further evidence evaluation. At the Evidence Evaluation Conference and International Guidelines 2000 Conference on CPR and ECC, these groups and panels of international experts and participants developed additional recommendations. The International Guidelines 2000 recommendations form the basis of this document.

Definition of “Newly Born,” “Neonate,” and “Infant”

Although the guidelines for neonatal resuscitation focus on newly born infants, most of the principles are applicable throughout the neonatal period and early infancy. The term “newly born” refers specifically to the infant in *the first minutes to hours after birth*. The term “neonate” is generally defined as an infant during the first 28 days of life. Infancy includes the neonatal period and extends through 12 months of age.

Unique Physiology of the Newly Born

The transition from fetal to extrauterine life is characterized by a series of unique physiological events: the lungs change from fluid-filled to air-filled, pulmonary blood flow increases dramatically, and intracardiac and extracardiac shunts (foramen ovale and ductus arteriosus) initially reverse direction and subsequently close. Such physiological considerations affect resuscitative interventions in the newly born.

For initial lung expansion, fluid-filled aveoli may require higher ventilation pressures than are commonly used in rescue breathing during infancy.^{18,19} Physical expansion of the lungs, with establishment of functional residual capacity and increase in alveolar oxygen tension, both mediate the critical decrease in pulmonary vascular resistance and result in an increase in pulmonary blood flow after birth. Failure to normalize pulmonary vascular resistance may result in persistence of right-to-left intracardiac and extracardiac shunts (persistent pulmonary hypertension). Failure to adequately expand alveolar spaces may result in intrapulmonary shunting of

blood with resultant hypoxemia. In addition to disordered cardiopulmonary transition, disruption of the fetoplacental circulation also may render the newly born at risk for resuscitation because of acute blood loss.

Developmental considerations at various gestational ages also influence pulmonary pathology and resuscitation physiology in the newly born. Surfactant deficiency in the premature infant alters lung compliance and resistance.²⁰ Meconium passed into the amniotic fluid may be aspirated, leading to airway obstruction. Complications of meconium aspiration are particularly likely in infants small for gestational age and those born post term or with significant perinatal compromise.²¹

Although certain physiological features are unique to the newly born, others pertain to infants throughout the neonatal period and into the first months of life. Severe illness due to a wide variety of conditions continues to manifest as disturbances in respiratory function (cyanosis, apnea, respiratory failure). Convalescing preterm infants with chronic lung disease often require significant ventilatory support regardless of the etiology of their need for resuscitation. Persistent pulmonary hypertension, persistent patency of the ductus arteriosus, and intracardiac shunts may produce symptoms during the neonatal period or even into infancy. Thus, many of the considerations and interventions that apply to the newly born may remain important for days, weeks, or months after birth.

The point at which neonatal resuscitation guidelines should be replaced by pediatric resuscitation protocols varies for individual patients. Objective data is lacking on optimal compression-ventilation ratios by age and disease state. However, infants with acute or chronic lung disease may benefit from a lower compression-ventilation ratio well into infancy. For these infants, continued use of some aspects of the neonatal guidelines is reasonable. Conversely, a neonate with a cardiac arrhythmia resulting in poor perfusion requires use of protocols more fully detailed in pediatric advanced life support. Factors of age, pathophysiology, and caregiver training should be evaluated for each patient and the most appropriate resuscitation routines and care setting identified.

ANTICIPATION OF RESUSCITATION NEED

Anticipation, adequate preparation, accurate evaluation, and prompt initiation of support are the critical steps to successful neonatal resuscitation.

Communication

Appropriate preparation for an anticipated high-risk delivery requires communication between the person(s) caring for the mother and those responsible for resuscitation of the newly born. Communication among caregivers should include details of antepartum and intrapartum maternal medical conditions and treatment as well as specific indicators of fetal condition (fetal heart rate monitoring, lung maturity, ultrasonography). Table 1 lists examples of the

TABLE 1. Conditions Associated With Risk to Newborns**Antepartum risk factors**

Maternal diabetes
 Pregnancy-induced hypertension
 Chronic hypertension
 Chronic maternal illness
 Cardiovascular
 Thyroid
 Neurological
 Pulmonary
 Renal
 Anemia or isoimmunization
 Previous fetal or neonatal death
 Bleeding in second or third trimester
 Maternal infection
 Polyhydramnios
 Oligohydramnios
 Premature rupture of membranes
 Post-term gestation
 Multiple gestation
 Size-dates discrepancy
 Drug therapy, eg,
 Lithium carbonate
 Magnesium
 Adrenergic-blocking drugs
 Maternal substance abuse
 Fetal malformation
 Diminished fetal activity
 No prenatal care
 Age <16 or >35 years

Intrapartum risk factors

Emergency cesarean section
 Forceps or vacuum-assisted delivery
 Breech or other abnormal presentation
 Premature labor
 Precipitous labor
 Chorioamnionitis
 Prolonged rupture of membranes (>18 hours before delivery)
 Prolonged labor (>24 hours)
 Prolonged second stage of labor (>2 hours)
 Fetal bradycardia
 Non-reassuring fetal heart rate patterns
 Use of general anesthesia
 Uterine tetany
 Narcotics administered to mother within 4 hours of delivery
 Meconium-stained amniotic fluid
 Prolapsed cord
 Abruptio placentae
 Placenta previa

antepartum and intrapartum circumstances that place the newly born infant at risk.

PREPARATION FOR DELIVERY**Personnel**

Personnel capable of initiating resuscitation should attend every delivery. At least 1 such person should be responsible solely for care of the infant. A person capable of carrying out a complete resuscitation should be immediately available for normal low-risk deliveries and in attendance for all deliveries considered high risk. More than 1 experienced person should attend an anticipated high-risk delivery. Resuscitation of a severely depressed newly born infant requires at least 2 persons, 1 to ventilate and intubate if necessary and another to monitor heart rate and perform chest compressions if required. A team of 3 or more persons with designated roles is highly desirable during an extensive resuscitation including medication administration. A separate team should be present for each infant of a

multiple gestation. Each resuscitation team should have an identified leader, and all team members should have specifically defined roles.

Equipment

Although the need for resuscitation at birth often can be predicted by risk factors, for many infants resuscitation cannot be anticipated.²² Therefore, a clean and warm environment with a complete inventory of resuscitation equipment and drugs should be maintained at hand and in fully operational condition wherever deliveries occur. Table 2 presents a list of suggested neonatal supplies, medications, and equipment.

Standard precautions should be followed carefully in delivery areas, where exposure to blood and body fluids is likely. All fluids from patients should be treated as potentially infectious. Personnel should wear gloves and other appropriate protective barriers when handling newly born infants or contaminated equipment. Techniques involving mouth suction by the healthcare provider should not be used.

EVALUATION

Determination of the need for resuscitative efforts should begin immediately after birth and proceed throughout the resuscitation process. An initial complex of signs (meconium in the amniotic fluid or on the skin, cry or respirations, muscle tone, color, term or preterm gestation) should be evaluated rapidly and simultaneously by visual inspection. Actions are dictated by integrated evaluation rather than by evaluation of a single vital sign, followed by action on the result, and then evaluation of the next sign (sequential action). Evaluation and intervention for the newly born are often simultaneous processes, especially when >1 trained provider is present. To enhance educational retention, this process is often taught as a sequence of distinct steps. The appropriate response to abnormal findings also depends on the time elapsed since birth and how the infant has responded to previous resuscitative interventions.

Response to Extrauterine Environment

Most newly born infants will respond to the stimulation of the extrauterine environment with strong inspiratory efforts, a vigorous cry, and movement of all extremities. If these responses are intact, color improves steadily from cyanotic or dusky to pink, and heart rate can be assumed to be adequate. The infant who responds vigorously to the extrauterine environment and who is term can remain with the mother to receive routine care (warmth, clearing the airway, drying). Indications for further assessment under a radiant warmer and possible intervention include

- Meconium in the amniotic fluid or on the skin
- Absent or weak responses
- Persistent cyanosis
- Preterm birth

Further assessment of the newly born infant is based on the triad of respiration, heart rate, and color.

TABLE 2. Neonatal Resuscitation Supplies and Equipment

Suction equipment
Bulb syringe
Mechanical suction and tubing
Suction catheters, 5F or 6F, 8F, and 10F or 12F
8F feeding tube and 20-mL syringe
Meconium aspiration device
Bag-and-mask equipment
Neonatal resuscitation bag with a pressure-release valve or pressure manometer (the bag must be capable of delivering 90% to 100% oxygen)
Face masks, newborn and premature sizes (masks with cushioned rim preferred)
Oxygen with flowmeter (flow rate up to 10 L/min) and tubing (including portable oxygen cylinders)
Intubation equipment
Laryngoscope with straight blades, No. 0 (preterm) and No. 1 (term)
Extra bulbs and batteries for laryngoscope
Tracheal tubes, 2.5, 3.0, 3.5, and 4.0 mm ID
Stylet (optional)
Scissors
Tape or securing device for tracheal tube
Alcohol sponges
CO ₂ detector (optional)
Laryngeal mask airway (optional)
Medications
Epinephrine 1:10 000 (0.1 mg/mL)—3-mL or 10-mL ampules
Isotonic crystalloid (normal saline or Ringer's lactate) for volume expansion—100 or 250 mL
Sodium bicarbonate 4.2% (5 mEq/10 mL)—10-mL ampules
Naloxone hydrochloride 0.4 mg/mL—1-mL ampules; or 1.0 mg/mL—2-mL ampules
Normal saline, 30 mL
Dextrose 10%, 250 mL
Normal saline “fish” or “bullet” (optional)
Feeding tube, 5F (optional)
Umbilical vessel catheterization supplies
Sterile gloves
Scalpel or scissors
Povidone-iodine solution
Umbilical tape
Umbilical catheters, 3.5F, 5F
Three-way stopcock
Syringes, 1, 3, 5, 10, 20, and 50 mL
Needles, 25-, 21-, and 18-gauge or puncture device for needleless system
Miscellaneous
Gloves and appropriate personal protection
Radiant warmer or other heat source
Firm, padded resuscitation surface
Clock (timer optional)
Warmed linens
Stethoscope
Tape, ½ or ¾ inch
Cardiac monitor and electrodes and/or pulse oximeter with probe (optional for delivery room)
Oropharyngeal airways

Respiration

After initial respiratory efforts, the newly born infant should be able to establish regular respirations sufficient to improve color and maintain a heart rate >100 bpm. Gasping and apnea are signs that indicate the need for assisted ventilation.²³

Heart Rate

Heart rate is determined by listening to the precordium with a stethoscope or feeling pulsations at the base of the umbilical cord. Central and peripheral pulses in the neck and extremities are often difficult to feel in infants,^{24,25} but the umbilical pulse is readily accessible in the newly born and permits assessment of heart rate without interruption of ventilation for auscultation. If pulsations cannot be felt at the base of the cord, auscultation of the precordium should be performed. Heart rate should be consistently >100 bpm in an uncompromised newly born infant. An increasing

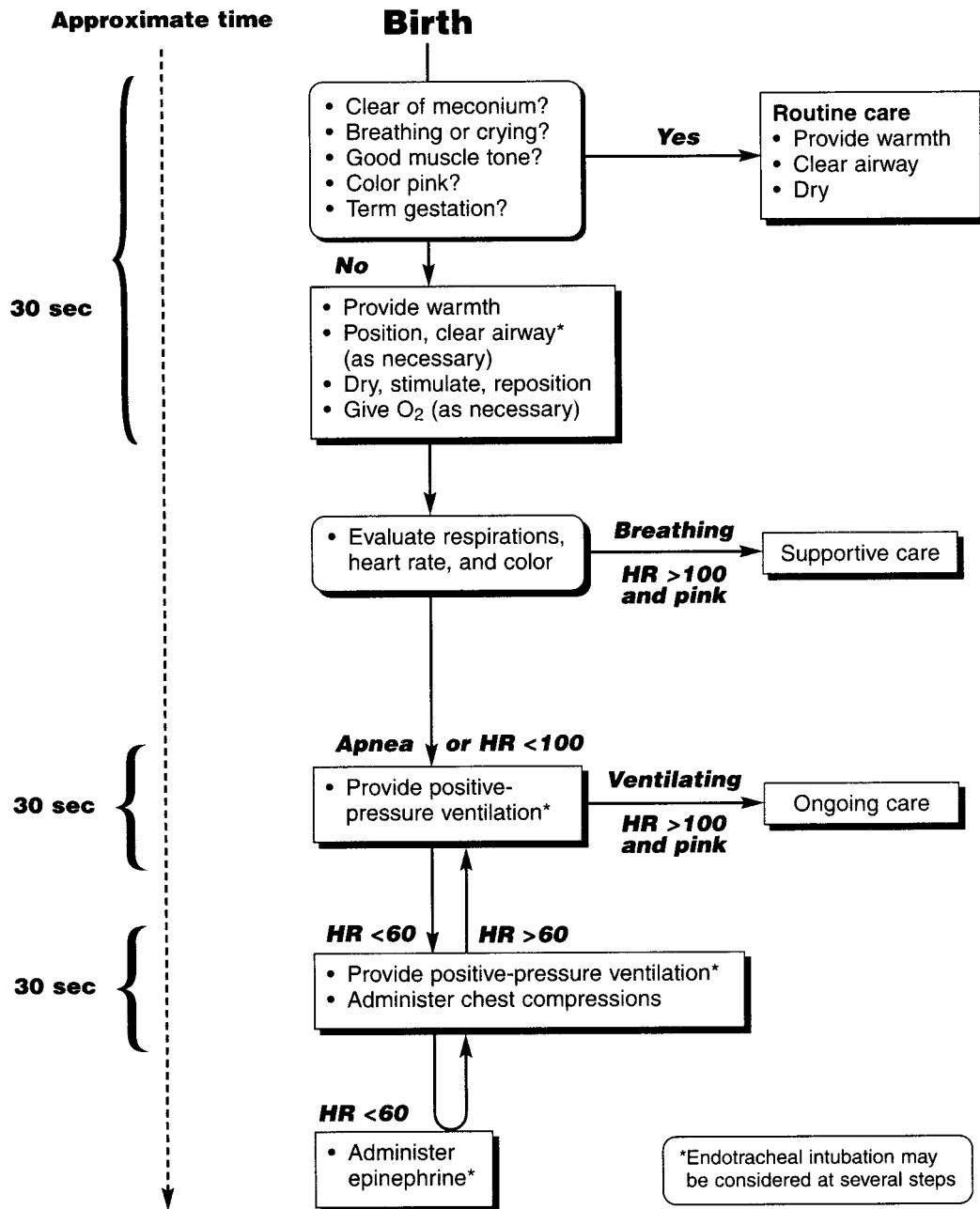
or decreasing heart rate also can provide evidence of improvement or deterioration.

Color

An uncompromised newly born infant will be able to maintain a pink color of the mucous membranes without supplemental oxygen. Central cyanosis is determined by examining the face, trunk, and mucous membranes. Acrocyanosis is usually a normal finding at birth and is not a reliable indicator of hypoxemia, but it may indicate other conditions, such as cold stress. Pallor may be a sign of decreased cardiac output, severe anemia, hypovolemia, hypothermia, or acidosis.

TECHNIQUES OF RESUSCITATION

The techniques of neonatal resuscitation are discussed below and are outlined in the algorithm (see Figure).



Algorithm for resuscitation of the newly born infant.

Basic Steps

Warmth

Preventing heat loss in the newly born is vital because cold stress can increase oxygen consumption and impede effective resuscitation.^{26,27} Hyperthermia should be avoided, however, because it is associated with perinatal respiratory depression^{28,29} (Class III, level of evidence [LOE] 3). Whenever possible, deliver the infant in a warm, draft-free area. Placing the infant under a radiant warmer, rapidly drying the skin, removing wet linen immediately, and wrapping the infant in prewarmed blankets will reduce heat loss. Another strategy for reducing heat loss is placing the dried infant skin-to-skin on the mother's chest or abdomen to use her body as a heat source.

Recent animal and human studies have suggested that selective (cerebral) hypothermia of the asphyxiated infant may protect against brain injury.^{30–32} Although this is a promising area of research, we cannot recommend routine implementation until appropriate controlled studies in humans have been performed (Class Indeterminate, LOE 2).

Clearing the Airway

The infant's airway is cleared by positioning of the infant and removal of secretions if needed.

Positioning

The newly born infant should be placed supine or lying on its side, with the head in a neutral or slightly extended position. If respiratory efforts are present

but not producing effective tidal ventilation, often the airway is obstructed; immediate efforts must be made to correct overextension or flexion or to remove secretions. A blanket or towel placed under the shoulders may be helpful in maintaining proper head position.

Suctioning

If time permits, the person assisting delivery of the infant should suction the infant's nose and mouth with a bulb syringe after delivery of the shoulders but before delivery of the chest. Healthy, vigorous, newly born infants generally do not require suctioning after delivery.³³ Secretions may be wiped from the nose and mouth with gauze or a towel. If suctioning is necessary, clear secretions first from the mouth and then the nose with a bulb syringe or suction catheter (8F or 10F). Aggressive pharyngeal suction can cause laryngeal spasm and vagal bradycardia³⁴ and delay the onset of spontaneous breathing. In the absence of meconium or blood, limit mechanical suction with a catheter in depth and duration. Negative pressure of the suction apparatus should not exceed 100 mm Hg (13.3 kPa or 136 cm H₂O). If copious secretions are present, the infant's head may be turned to the side, and suctioning may help clear the airway.

Clearing the Airway of Meconium

Approximately 12% of deliveries are complicated by the presence of meconium in the amniotic fluid.³⁵ When the amniotic fluid is meconium-stained, suction the mouth, pharynx, and nose as soon as the head is delivered (intrapartum suctioning) regardless of whether the meconium is thin or thick.³⁶ Either a large-bore suction catheter (12F to 14F) or bulb syringe can be used.³⁷ Thorough suctioning of the nose, mouth, and posterior pharynx before delivery of the body appears to decrease the risk of meconium-aspiration syndrome.³⁶ Nevertheless, a significant number (20% to 30%) of meconium-stained infants will have meconium in the trachea despite such suctioning and in the absence of spontaneous respirations.^{38,39} This suggests the occurrence of in utero aspiration and the need for tracheal suctioning after delivery in *depressed* infants.

If the fluid contains meconium and the infant has absent or depressed respirations, decreased muscle tone, or heart rate <100 bpm, perform direct laryngoscopy immediately after birth for suctioning of residual meconium from the hypopharynx (under direct vision) and intubation/suction of the trachea.^{40,41} There is evidence that tracheal suctioning of the vigorous infant with meconium-stained fluid does not improve outcome and may cause complications (Class I, LOE 1).^{42,43} Warmth can be provided by a radiant heater; however, drying and stimulation generally should be delayed in such infants. Accomplish tracheal suctioning by applying suction directly to a tracheal tube as it is withdrawn from the airway. Repeat intubation and suctioning until little additional meconium is recovered or until the heart rate indicates that resuscitation must proceed without delay. If the infant's heart rate or respiration is se-

verely depressed, it may be necessary to institute positive-pressure ventilation despite the presence of some meconium in the airway. Suction catheters inserted through the tracheal tube may be too small to accomplish initial removal of particulate meconium; subsequent use of suction catheters inserted through a tracheal tube may be adequate to continue removal of meconium. Delay gastric suctioning to prevent aspiration of swallowed meconium until initial resuscitation is complete. Meconium-stained infants who develop apnea or respiratory distress should receive tracheal suctioning before positive-pressure ventilation, even if they are initially vigorous.

Tactile Stimulation

Drying and suctioning produce enough stimulation to initiate effective respirations in most newly born infants. If an infant fails to establish spontaneous and effective respirations after drying with a towel or gentle rubbing of the back, flicking the soles of the feet may initiate spontaneous respirations. Avoid more vigorous methods of stimulation. Tactile stimulation may initiate spontaneous respirations in newly born infants who are experiencing primary apnea. If these efforts do not result in prompt onset of effective ventilation, discontinue them because the infant is in secondary apnea and positive-pressure ventilation will be required.²³

Oxygen Administration

Hypoxia is nearly always present in a newly born infant who requires resuscitation. Therefore, if cyanosis, bradycardia, or other signs of distress are noted in a breathing newborn during stabilization, administration of 100% oxygen is indicated while determining the need for additional intervention. Free-flow oxygen can be delivered through a face mask and flow-inflating bag, an oxygen mask, or a hand cupped around oxygen tubing. The oxygen source should deliver at least 5 L/min, and the oxygen should be held close to the face to maximize the inhaled concentration. Many self-inflating bags will not passively deliver sufficient oxygen flow (ie, when not being squeezed). The goal of supplemental oxygen use should be normoxia; sufficient oxygen should be administered to achieve pink color in the mucous membranes. If cyanosis returns when supplemental oxygen is withdrawn, post-resuscitation care should include monitoring of administered oxygen concentration and arterial oxygen saturation.

Ventilation

Most newly born infants who require positive-pressure ventilation can be adequately ventilated with a bag and mask. Indications for positive-pressure ventilation include apnea or gasping respirations, heart rate <100 bpm, and persistent central cyanosis despite 100% oxygen.

Although the pressure required for establishment of air breathing is variable and unpredictable, higher inflation pressures (30 to 40 cm H₂O or higher) and longer inflation times may be required for the first several breaths than for subsequent breaths.^{18,19} Vis-

ible chest expansion is a more reliable sign of appropriate inflation pressures than any specific manometer reading. The assisted ventilation rate should be 40 to 60 breaths per minute (30 breaths per minute when chest compressions are also being delivered). Signs of adequate ventilation include bilateral expansion of the lungs, as assessed by chest wall movement and breath sounds, and improvement in heart rate and color. If ventilation is inadequate, check the seal between mask and face, clear any airway obstruction (adjust head position, clear secretions, open the infant's mouth), and finally increase inflation pressure. Prolonged bag-mask ventilation may produce gastric inflation; this should be relieved by insertion of an 8F orogastric tube that is aspirated with a syringe and left open to air. If such maneuvers do not result in adequate ventilation, endotracheal intubation should follow.

After 30 seconds of adequate ventilation with 100% oxygen, spontaneous breathing and heart rate should be checked. If spontaneous respirations are present and the heart rate is ≥ 100 bpm, positive-pressure ventilation may be gradually reduced and discontinued. Gentle tactile stimulation may help maintain and improve spontaneous respirations while free-flow oxygen is administered. If spontaneous respirations are inadequate or if heart rate remains below 100 bpm, assisted ventilation must continue with bag and mask or tracheal tube. If the heart rate is < 60 bpm, continue assisted ventilation, begin chest compressions, and consider endotracheal intubation.

The key to successful neonatal resuscitation is establishment of adequate ventilation. Reversal of hypoxia, acidosis, and bradycardia depends on adequate inflation of fluid-filled lungs with air or oxygen.^{44,45} Although 100% oxygen has been used traditionally for rapid reversal of hypoxia, there is biochemical evidence and preliminary clinical evidence to argue for resuscitation with lower oxygen concentrations.⁴⁶⁻⁴⁸ Current clinical data, however, is insufficient to justify adopting this as routine practice. If assisted ventilation is required, deliver 100% oxygen by positive-pressure ventilation. If supplemental oxygen is unavailable, initiate resuscitation of the newly born infant with positive-pressure ventilation and room air (Class Indeterminate, LOE 2).

Ventilation Bags

Resuscitation bags used for neonates should be no larger than 750 mL; larger bag volumes make it difficult to judge delivery of the small tidal volumes (5 to 8 mL/kg) that newly born infants require. Bags for neonatal resuscitation can be either self-inflating or flow-inflating.

Self-Inflating Bags

The self-inflating bag refills independently of gas flow because of the recoil of the bag. To permit rapid reinflation, most bags of this type have an intake valve at one end that pulls in room air, diluting the oxygen flowing into the bag at a fixed rate. Delivery of high concentrations of oxygen (90% to 100%) with a self-inflating bag requires an attached oxygen reservoir.

To maintain inflation pressure for at least 1 second,

a minimum bag volume of 450 to 500 mL may be necessary. If the device contains a pressure-release valve, it should release at approximately 30 to 35 cm H₂O pressure and should have an override feature to permit delivery of higher pressures if necessary to achieve good chest expansion. Self-inflating bags that are not pressure-limited or that have a device to bypass the pressure-release valve should be equipped with an in-line manometer. Do not use self-inflating bags to deliver oxygen passively through the mask because the flow of oxygen is unreliable unless the bag is being squeezed.

Flow-Inflating Bags

The flow-inflating (anesthesia) bag inflates only when compressed gas is flowing into it and the patient outlet is at least partially occluded. Proper use requires adjustment of the flow of gas into the gas inlet, adjustment of the flow of gas out through the flow-control valve, and creation of a tight seal between the mask and face. Because a flow-inflating bag is capable of delivering very high pressures, a manometer should be connected to the bag to monitor peak and end-expiratory pressures. More training is required for proper use of the flow-inflating bag than the self-inflating bag,⁴⁹ but the flow-inflating bag can provide a greater range of peak inspiratory pressures and more reliable control of oxygen concentration. High concentrations of oxygen may be delivered passively through the mask of a flow-inflating bag.

Face Masks

Masks should be of appropriate size to seal around the mouth and nose but not cover the eyes or overlap the chin. A range of sizes should be available. A round mask can seal effectively on the face of a small infant; anatomically shaped masks better fit the contours of a large term infant's face. Masks should be designed to have low dead space (< 5 mL). A mask with a cushioned rim is preferable to one without because the cushioned rim facilitates creation of a tight seal without exerting excessive pressure on the face.⁵⁰

Laryngeal Mask Airway Ventilation

Masks that fit over the laryngeal inlet have been shown to be effective for ventilating newly born full-term infants.⁵¹ There is limited data on the use of these devices in small preterm infants,⁵² however, and their use in the setting of meconium-stained amniotic fluid has not been studied. The laryngeal mask airway, when used by appropriately trained providers, may be an effective alternative for establishing an airway in resuscitation of the newly born infant, especially in the case of ineffective bag-mask ventilation or failed endotracheal intubation (Class Indeterminate, LOE 5). However, we cannot recommend routine use of the laryngeal mask airway at this time, and the device cannot replace endotracheal intubation for meconium suctioning.

Endotracheal Intubation

Endotracheal intubation may be indicated at several points during neonatal resuscitation:

- When tracheal suctioning for meconium is required
- If bag-mask ventilation is ineffective or prolonged
- When chest compressions are performed
- When tracheal administration of medications is desired
- Special resuscitation circumstances, such as congenital diaphragmatic hernia or extremely low birth weight

The timing of endotracheal intubation may also depend on the skill and experience of the resuscitator.

Keep the supplies and equipment for endotracheal intubation together and readily available in each delivery room, nursery, and Emergency Department. Preferred tracheal tubes have a uniform diameter (without a shoulder) and have a natural curve, a radiopaque indicator line, and markings to indicate the appropriate depth of insertion. If a stylet is used, it must not protrude beyond the tip of the tube. Table 3 provides a guideline for selection of tracheal tube sizes and depths of insertion. Positioning the vocal cord guide (a line proximal to the tip of the tube) at the level of the vocal cords should position the tip of the tube above the carina. Proper depth of insertion can also be estimated by calculating the depth at the lips according to the following formula:

$$\begin{aligned} & \text{weight in kilograms} + 6 \text{ cm} \\ & = \text{insertion depth at lip in cm} \end{aligned}$$

Perform endotracheal intubation orally, using a laryngoscope with a straight blade (size 0 for premature infants, size 1 for term infants). Insert the tip of the laryngoscope into the vallecula or onto the epiglottis and elevate gently to reveal the vocal cords. Cricoid pressure may be helpful. Insert the tube to an appropriate depth through the vocal cords as indicated by the vocal cord guide line and check its position by the centimeter marking at the upper lip. Record and maintain this depth of insertion. Variation in head position will alter the depth of insertion and may predispose to unintentional extubation or endobronchial intubation.^{53,54}

After endotracheal intubation, confirm the position of the tube by the following:

- Observing symmetrical chest-wall motion
- Listening for equal breath sounds, especially in the axillae, and for absence of breath sounds over the stomach

TABLE 3. Suggested Tracheal Tube Size and Depth of Insertion According to Weight and Gestational Age

Weight, g	Gestational Age, wk	Tube Size, mm (ID)	Depth of Insertion From Upper Lip, cm
<1000	<28	2.5	6.5–7
1000–2000	28–34	3.0	7–8
2000–3000	34–38	3.5	8–9
>3000	>38	3.5–4.0	>9

ID indicates inner diameter.

- Confirming absence of gastric inflation
- Watching for a fog of moisture in the tube during exhalation
- Noting improvement in heart rate, color, and activity of the infant

An exhaled-CO₂ monitor may be used to verify tracheal tube placement.⁵⁵ These devices are associated with some false-negative but few false-positive results.⁵⁶ Monitoring of exhaled CO₂ can be useful in the secondary confirmation of tracheal intubation in the newly born, particularly when clinical assessment is equivocal (Class Indeterminate, LOE 5). Data about sensitivity and specificity of exhaled CO₂ detectors in reflecting tracheal tube position is limited in newly born infants. Extrapolation of data from other age groups is problematic because conditions common to the newborn period, including inadequate pulmonary expansion, decreased pulmonary blood flow, and small tidal volumes, may influence the interpretation of the exhaled CO₂ concentration.

Chest Compressions

Asphyxia causes peripheral vasoconstriction, tissue hypoxia, acidosis, poor myocardial contractility, bradycardia, and eventually cardiac arrest. Establishment of adequate ventilation and oxygenation will restore vital signs in the vast majority of newly born infants. In deciding when to initiate chest compressions, consider the heart rate, the change of heart rate, and the time elapsed after initiation of resuscitative measures. Because chest compressions may diminish the effectiveness of ventilation, do not initiate them until lung inflation and ventilation have been established.

The general indication for initiation of chest compressions is a heart rate <60 bpm despite adequate ventilation with 100% oxygen for 30 seconds. Although it has been common practice to give compressions if the heart rate is 60 to 80 bpm and the heart rate is not rising, ventilation should be the priority in resuscitation of the newly born. Provision of chest compressions is likely to compete with provision of effective ventilation. Because no scientific data suggests an evidence-based resolution, the ILCOR Working Group recommends that compressions be initiated for a heart rate of <60 bpm based on construct validity (ease of teaching and skill retention).

Compression Technique

Compressions should be delivered on the lower third of the sternum.^{57,58} Acceptable techniques are (1) 2 thumbs on the sternum, superimposed or adjacent to each other according to the size of the infant, with fingers encircling the chest and supporting the back (the 2 thumb–encircling hands technique), and (2) 2 fingers placed on the sternum at right angles to the chest with the other hand supporting the back.^{59–61} Data suggests that the 2 thumb–encircling hands technique may offer some advantages in generating peak systolic and coronary perfusion pressure and that providers prefer this technique to the 2-finger technique.^{59–63} For this reason, we prefer the

2 thumb-encircling hands technique for healthcare providers performing chest compressions in newly born infants and older infants whose size permits its use (Class IIb, LOE 5).

Consensus of the ILCOR Working Group supports a relative rather than absolute depth of compression (ie, compress to approximately one third of the anterior-posterior diameter of the chest) to generate a palpable pulse. The pediatric basic life support guidelines recommend a relative compression depth of one third to one half of the anterior-posterior dimension of the chest. In the absence of specific data about ideal compression depth, these guidelines recommend compression to approximately one third the depth of the chest, but the compression depth must be adequate to produce a palpable pulse. Deliver compressions smoothly. A compression to relaxation ratio with a slightly shorter compression than relaxation phase offers theoretical advantages for blood flow in the very young infant.⁶⁴ Keep the thumbs or fingers on the sternum during the relaxation phase.

Coordinate compressions and ventilations to avoid simultaneous delivery.⁶⁵ There should be a 3:1 ratio of compressions to ventilations, with 90 compressions and 30 breaths to achieve approximately 120 events per minute. Thus, each event will be allotted approximately 1/2 second, with exhalation occurring during the first compression following each ventilation. Reassess the heart rate approximately every 30 seconds. Continue chest compressions until the spontaneous heart rate is ≥ 60 bpm.

MEDICATIONS

Drugs are rarely indicated in resuscitation of the newly born infant.⁶⁶ Bradycardia in the newly born infant is usually the result of inadequate lung inflation or profound hypoxia, and adequate ventilation is the most important step in correcting bradycardia. Administer medications if, despite adequate ventilation with 100% oxygen and chest compressions, the heart rate remains <60 bpm.

Medications and Volume Expansion

Epinephrine

Administration of epinephrine is indicated when the heart rate remains <60 bpm after a minimum of 30 seconds of adequate ventilation and chest compressions (Class I). Epinephrine is particularly indicated in the presence of asystole.

Epinephrine has both α - and β -adrenergic-stimulating properties; however, in cardiac arrest, α -adrenergic-mediated vasoconstriction may be the more important action.⁶⁷ Vasoconstriction elevates the perfusion pressure during chest compression, enhancing delivery of oxygen to the heart and brain.⁶⁸ Epinephrine also enhances the contractile state of the heart, stimulates spontaneous contractions, and increases heart rate.

The recommended intravenous or endotracheal dose is 0.1 to 0.3 mL/kg of a 1:10 000 solution (0.01 to 0.03 mg/kg), repeated every 3 to 5 minutes as indicated. The data regarding effects of high-dose epi-

nephrine for resuscitation of newly born infants is inadequate to support routine use of higher doses of epinephrine (Class Indeterminate, LOE 4). Higher doses have been associated with exaggerated hypertension but lower cardiac output in animals.^{69,70} The sequence of hypotension followed by hypertension likely increases the risk of intracranial hemorrhage, especially in preterm infants.⁷¹

Volume Expanders

Volume expanders may be necessary to resuscitate a newly born infant who is hypovolemic. Suspect hypovolemia in any infant who fails to respond to resuscitation. Consider volume expansion when there has been suspected blood loss or the infant appears to be in shock (pale, poor perfusion, weak pulse) and has not responded adequately to other resuscitative measures (Class I). The fluid of choice for volume expansion is an isotonic crystalloid solution such as normal saline or Ringer's lactate (Class IIb, LOE 7). Administration of O-negative red blood cells may be indicated for replacement of large-volume blood loss (Class IIb, LOE 7). Albumin-containing solutions are less frequently used for initial volume expansion because of limited availability, risk of infectious disease, and an observed association with increased mortality.⁷²

The initial dose of volume expander is 10 mL/kg given by slow intravenous push over 5 to 10 minutes. The dose may be repeated after further clinical assessment and observation of response. Higher bolus volumes have been recommended for resuscitation of older infants. However, volume overload or complications such as intracranial hemorrhage may result from inappropriate intravascular volume expansion in asphyxiated newly born infants as well as in preterm infants.^{73,74}

Bicarbonate

There is insufficient data to recommend routine use of bicarbonate in resuscitation of the newly born. In fact, the hyperosmolarity and CO₂-generating properties of sodium bicarbonate may be detrimental to myocardial or cerebral function.⁷⁵⁻⁷⁷ Use of sodium bicarbonate is discouraged during brief CPR. If it is used during prolonged arrests unresponsive to other therapy, it should be given only after establishment of adequate ventilation and circulation.⁷⁸ Later use of bicarbonate for treatment of persistent metabolic acidosis or hyperkalemia should be directed by arterial blood gas levels or serum chemistries, among other evaluations. A dose of 1 to 2 mEq/kg of a 0.5 mEq/mL solution may be given by slow intravenous push (over at least 2 minutes) after adequate ventilation and perfusion have been established.

Naloxone

Naloxone hydrochloride is a narcotic antagonist without respiratory-depressant activity. It is specifically indicated for reversal of respiratory depression in a newly born infant whose mother received narcotics within 4 hours of delivery. Always establish and maintain adequate ventilation before administration of naloxone. Do not administer naloxone to

newly born infants whose mothers are suspected of having recently abused narcotic drugs because it may precipitate abrupt withdrawal signs in such infants.

The recommended dose of naloxone is 0.1 mg/kg of a 0.4 mg/mL or 1.0 mg/mL solution given intravenously, endotracheally, or—if perfusion is adequate—intramuscularly or subcutaneously. Because the duration of action of narcotics may exceed that of naloxone, continued monitoring of respiratory function is essential, and repeated naloxone doses may be necessary to prevent recurrent apnea.

Routes of Medication Administration

The tracheal route is generally the most rapidly accessible route for drug administration during resuscitation. It may be used for administration of epinephrine and naloxone, but it should not be used during resuscitation for administration of caustic agents such as sodium bicarbonate. The tracheal route of administration may result in a more variable response to epinephrine than the intravenous route^{79–81}; however, neonatal data is insufficient to recommend a higher dose of epinephrine for tracheal administration.

Attempt to establish intravenous access in neonates who fail to respond to tracheally administered epinephrine. The umbilical vein is the most rapidly accessible venous route; it may be used for epinephrine or naloxone administration as well as for administration of volume expanders and bicarbonate. Insert a 3.5F or 5F radiopaque catheter so that the tip is just below skin level and a free flow of blood returns on aspiration. Deep insertion poses the risk of infusion of hypertonic and vasoactive medications into the liver. Take care to avoid introduction of air emboli into the umbilical vein.

Peripheral sites for venous access (scalp or peripheral vein) may be adequate but are usually more difficult to cannulate. Naloxone may be given intramuscularly or subcutaneously but only after effective

assisted ventilation has been established and only if the infant's peripheral circulation is adequate. We do not recommend administration of resuscitation drugs through the umbilical artery because the artery is often not rapidly accessible and complications may result if vasoactive or hypertonic drugs (eg, epinephrine or bicarbonate) are given by this route.

Intraosseous lines are not commonly used in newly born infants because the umbilical vein is more accessible, the small bones are fragile, and the intraosseous space is small in a premature infant. Intraosseous access has been shown to be useful in the neonate and older infant when vascular access is difficult to achieve.⁸² Intraosseous access can be used as an alternative route for medication/volume expansion if umbilical or other direct venous access is not readily attainable (Class IIb, LOE 5).

SPECIAL RESUSCITATION CIRCUMSTANCES

Several circumstances have unique implications for resuscitation of the newly born infant. Prenatal diagnosis and certain features of the perinatal history and clinical course may alert the resuscitation team to these special circumstances. Meconium aspiration (see above), multiple birth, and prematurity are common conditions with immediate implications for the resuscitation team at delivery. Other circumstances that may affect opening of the airway, timing of endotracheal intubation, and selection and administration of volume expanders are presented in Table 4.

Prematurity

The incidence of perinatal depression is markedly increased among preterm neonates because of the complications associated with preterm labor and the physiological immaturity and lability of the preterm infant.⁸³ Diminished lung compliance, respiratory musculature, and respiratory drive may contribute to the need for assisted ventilation.

Some experts recommend early elective intubation of extremely preterm infants (eg, <28 weeks of ges-

TABLE 4. Special Circumstances in Resuscitation of the Newly Born Infant

Condition	History/Clinical Signs	Actions
Mechanical blockage of the airway		
Meconium or mucus blockage	Meconium-stained amniotic fluid Poor chest wall movement	Intubation for suctioning/ventilation
Choanal atresia	Pink when crying, cyanotic when quiet	Oral airway Endotracheal intubation
Pharyngeal airway malformation	Persistent retractions, poor air entry	Prone positioning, posterior nasopharyngeal tube
Impaired lung function		
Pneumothorax	Asymmetrical breath sounds Persistent cyanosis/bradycardia	Needle thoracentesis
Pleural effusions/ascites	Diminished air movement Persistent cyanosis/bradycardia	Immediate intubation Needle thoracentesis, paracentesis Possible volume expansion
Congenital diaphragmatic hernia	Asymmetrical breath sounds Persistent cyanosis/bradycardia Scaphoid abdomen	Endotracheal intubation Placement of orogastric catheter
Pneumonia/sepsis	Diminished air movement Persistent cyanosis/bradycardia	Endotracheal intubation Possible volume expansion
Impaired cardiac function		
Congenital heart disease	Persistent cyanosis/bradycardia	Diagnostic evaluation
Fetal/maternal hemorrhage	Pallor; poor response to resuscitation	Volume expansion, possibly including red blood cells

tation) to help establish an air-fluid interface,⁸⁴ while others recommend that this be accomplished with oxygen administration via mask or nasal prongs.⁸⁵ Many infants younger than 30 to 31 weeks will undergo intubation for surfactant administration after the initial stages of resuscitation have been successful.⁸⁶

A number of factors can complicate resuscitation of the premature infant. Because premature infants have low body fat and a high ratio of surface area to body mass, they are also more difficult to keep warm. Their immature brains and the presence of a fragile germinal matrix predispose them to development of intracranial hemorrhage after episodes of hypoxia or rapid changes in vascular pressure and osmolarity.^{77,87,88} For this reason, avoid rapid boluses of volume expanders or hyperosmolar solutions.

Multiple Births

Multiple births are more frequently associated with a need for resuscitation because of abnormalities of placentation, compromise of cord blood flow, or mechanical complications during delivery. Monozygotic multiple fetuses may also have abnormalities of blood volume resulting from interfetal vascular anastomoses.

POSTRESUSCITATION ISSUES

Continuing Care of the Newly Born Infant After Resuscitation

Supportive or ongoing care, monitoring, and appropriate diagnostic evaluation are required after resuscitation. Once adequate ventilation and circulation have been established, the infant is still at risk and should be maintained in or transferred to an environment in which close monitoring and anticipatory care can be provided. Postresuscitation monitoring should include monitoring of heart rate, respiratory rate, administered oxygen concentration, and arterial oxygen saturation, with blood gas analysis as indicated. Document blood pressure and check the blood glucose level during stabilization after resuscitation. Consider ongoing blood glucose screening and documentation of calcium. A chest radiograph may help elucidate underlying causes of the arrest or detect complications, such as pneumothorax. Additional postresuscitation care may include treatment of hypotension with volume expanders or pressors, treatment of possible infection or seizures, initiation of appropriate fluid therapy, and documentation of observations and actions.

TABLE 5. Apgar Scoring

Sign	Score		
	0	1	2
Heart rate	Absent	Slow (<100 bpm)	≥100 bpm
Respirations	Absent	Slow, irregular	Good, crying
Muscle tone	Limp	Some flexion	Active motion
Reflex irritability (catheter in nares, tactile stimulation)	No response	Grimace	Cough, sneeze, cry
Color	Blue or pale	Pink body, blue extremities	Completely pink

bpm indicates beats per minute.

Documentation of Resuscitation

Thorough documentation of assessments and resuscitative actions is essential for good clinical care, for communication, and for medicolegal concerns. The Apgar scores quantify and summarize the response of the newly born infant to the extrauterine environment and to resuscitation (Table 5).^{89,90} Assign Apgar scores at 1 and 5 minutes after birth and then sequentially every 5 minutes until vital signs have stabilized. The Apgar scores should not dictate appropriate resuscitative actions, nor should interventions for depressed infants be delayed until the 1-minute assessment. Complete documentation must also include a narrative description of interventions performed and their timing.

Continuing Care of the Family

When time permits, the team responsible for care of the newly born should introduce themselves to the mother and family before delivery. They should outline the proposed plan of care and solicit the family's questions. Especially in cases of potentially lethal fetal malformations or extreme prematurity, the family should be asked to articulate their beliefs and desires about the extent of resuscitation, and the team should outline its planned approach (see below).

After delivery the mother continues to be a patient herself, with physical and emotional needs. The team caring for the newly born infant should inform the parents of the infant's condition at the earliest opportunity. If resuscitation is necessary, inform the parents of the procedures undertaken and their indications. Encourage the parents to ask questions, and answer their questions as frankly and honestly as possible. Make every effort to enable the parents to have contact with the newly born infant.

ETHICS

There are circumstances in which noninitiation or discontinuation of resuscitation in the delivery room may be appropriate. However, national and local protocols should dictate the procedures to be followed. Changes in resuscitation and intensive care practices and neonatal outcome make it imperative that all such protocols be reviewed regularly and modified as necessary.

Noninitiation of Resuscitation

The delivery of extremely immature infants and infants with severe congenital anomalies raises questions about initiation of resuscitation.⁹¹⁻⁹³ Noninitia-

tion of resuscitation in the delivery room is appropriate for infants with confirmed gestation <23 weeks or birth weight <400 g, anencephaly, or confirmed trisomy 13 or 18. Current data suggests that resuscitation of these newly born infants is very unlikely to result in survival or survival without severe disability (Class IIb, LOE 5).^{94,95} However, antenatal information may be incomplete or unreliable. In cases of uncertain prognosis, including uncertain gestational age, resuscitation options include a trial of therapy and noninitiation or discontinuation of resuscitation after assessment of the infant. In such cases, initiation of resuscitation at delivery does not mandate continued support.

Noninitiation of support and later withdrawal of support are generally considered to be ethically equivalent; however, the latter approach allows time to gather more complete clinical information and to provide counseling to the family. Ongoing evaluation and discussion with the parents and the healthcare team should guide continuation versus withdrawal of support. In general, there is no advantage to delayed, graded, or partial support; if the infant survives, outcome may be worsened as a result of this approach.

Discontinuation of Resuscitation

Discontinuation of resuscitative efforts may be appropriate if resuscitation of an infant with cardiorespiratory arrest does not result in spontaneous circulation in 15 minutes. Resuscitation of newly born infants after 10 minutes of asystole is very unlikely to result in survival or survival without severe disability (Class IIb, LOE 5).^{96–99} We recommend local discussions to formulate guidelines consistent with local resources and outcome data.

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