SUPPORT OF ADAPTATION AND RESUSCITATION OF THE NEWBORN INFANT

Revised Recommendations of the Swiss Society of Neonatology (2023)

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Introduction

Development and Application of these Recommendations

A working group of the Swiss Society of Neonatology (SSN) first published national recommendations on the care and resuscitation of the newborn infant in 2000. These recommendations have been regularly revised since then, most recently in 2017. The current revision is based on published revised international recommendations (specifically European Resuscitation Council ERC; American Academy of Pediatrics AAP; American Heart Association AHA; International Liaison Committee on Resuscitation ILCOR)[1-3]. Of note, since 2015 the ILCOR (Consensus on Science and Treatment Recommendations for Neonatal Life Support CoSTR) has initiated a process of continuous evaluation of new accumulated evidence on this topic; treatment recommendations are classified using the GRADE system, with evidence for treatments being categorised as high, moderate or weak[4-6]. In addition, a literature review of all topics not covered in the ILCOR CoSTR 2020 was carried out by the ERC NLS Guidelines Group[2]. Finally, published feedback on the 2020 ILCOR recommendations were also taken into account in this revision[7].

These guidelines should be seen as recommendations that can and should be adapted as the individual situation requires.

Aim and Target Audience of these Recommendations

- These recommendations primarily pertain to the care of **neonates with a gestational age (GA) ≥ 34 0/7 weeks (wks)** and with a **birth weight (BW) ≥ 2000 g.**
- They apply to both delivery room care and to the entire neonatal period (the first 28 days of life, respectively up to 44 weeks postmenstrual age).
- They apply to all obstetric units and birthing centres in Switzerland as well as to physicians working in paediatric, neonatal, obstetric and anaesthetic specialties, midwives, emergency, postnatal ward, anaesthetic and neonatal nursing staff.

Compared to the previous version of 2017, the following clarifications and emphases were formulated in the current revision:

- Presence of two professionals for the care of the mother and the newborn baby in case of planned homebirth or in a birthing centre.
- Indications for prenatal transfer.
- Consideration of any intrapartal warning signs present to assess the risk situation of the newborn.
- Adjustment of normal value of umbilical artery pH to ≥ 7.10.
- Changes to target oxygen saturation values (SpO_2) in the first 10 minutes of life.
- Sustained inflation breaths no longer recommended.
- Table "Characteristics of different devices for non-invasive respiratory support of newborns".
- CPAP application in the delivery room.
- Equipment for births in the birth centre.
- Equipment for outpatient care of the newborn in a home postnatal setting.

Organisation

General Aspects

The vast majority of low-risk newborn infants do not need any interventions during the first minutes of life, apart from support to maintain a normal body temperature and ensuring a normal adaptation. Around 85% of newborns breathe normally without requiring support. However, up to 10 % of newborns require simple respiratory support measures for stabilisation purposes in the first minutes of life, such as drying, stimulation and manoeuvres to open the airways; and up to 5% require non-invasive ventilation. More advanced resuscitation measures such as intubation (0.4%), chest compressions (< 0.3%) and adrenaline (0.05%), on the other hand, are very rarely necessary[8-16]. Trained personnel and specific technical equipment for resuscitation must be readily available at every delivery because risk situations cannot always be predicted.

Requirements for Optimal Care of the Newborn Infant:

- Communication between midwives, obstetricians, paediatricians, neonatologists and anaesthetists.
- Sufficient information about the neonatal risk profile must be available, prior to delivery.
- Anticipation of problems that may arise.
- Careful planning and preparation of equipment and briefing of personnel[17].
- Clear and calm lead and assistance of the resuscitation by a competent professional trained in neonatal resuscitation.

Personnel

Ideally, one person is in charge of exclusively caring for the newborn infant after delivery. This person should be able to adequately clinically assess the newly born infant, to ensure normothermia, and if needed, to initiate a resuscitation, i.e. to open the airways and perform mask ventilation. These competencies correspond to the learning objectives of the Swiss Basic Course in neonatal resuscitation (start4neo BSC). Further measures, especially for endotracheal intubation, help from a professional with experience in neonatal resuscitation (neonatologist, paediatrician, anaesthetist) must be requested[18,19]. Even during a supposedly low risk delivery, the neonate may present with unforeseen problems. Therefore, every delivery unit needs to provide a well-functioning resuscitation table with specific equipment *(List 1, 2 and 3)*, and the rapid availability of a person trained in neonatal resuscitation are a prerequisite for every birth attendance. The overall organisational responsibility for the primary care of the newborn lies with the management of the obstetric institution, respectively with the midwife in charge in the case of out-of-hospital births[17]. In individual cases, they may delegate responsibility, preferably to a neonatologist or paediatrician.

In a planned home birth and a birth in a birth centre, two trained professionals should always be present: one person should be responsible for the mother, and another person should be responsible for the newborn and trained in neonatal resuscitation, including mask ventilation and chest compressions. Predefined procedures and contact numbers for difficult situations and unexpected complications should be prepared in advance and available at each birth[2,17,20].

A consensus on interdisciplinary cooperation for the safety of expectant mothers and newborns has defined and detailed the perinatal framework and the necessary organisation[17]. This interdisciplinary consensus was approved by the following societies (Swiss Society of Obstetrics and Gynaecology SGGG, Swiss Society of Neonatology SSN; Swiss Society of Paediatrics SSP; Swiss Society for Anaesthesiology and Perioperative Medicine SSAPM; Swiss Association of Obstetric Anaesthesia SAOA, Swiss Federation of Midwives SHV) and is part of this recommendation.

Physicians, midwives, and health care professionals providing primary care for neonates after delivery should attend structured courses in neonatal resuscitation every 2–3 years[21]. Based on this recommendation, “start4neo courses” organised by the SSN are carried out in Switzerland at different regional centres and participating professionals are certified after completion of the course.

Equipment

Checklists with equipment required for deliveries in hospitals, birthing centres or at home are given in the appendix *(Lists 1, 2 and 3)*.

Prenatal Transfer of High-Risk Pregnant Women

In a high-risk pregnancy, the optimal care of the mother and the child at delivery requires specialised knowledge, skills and equipment that cannot be available in every maternity unit for reasons of frequency, experience, and economic costs. A small proportion of pregnant women therefore require a timely transfer to a perinatal centre with a neonatal intensive care unit before the planned or imminent delivery.

Indications for Prenatal Transfer

Intrauterine transfer to an perinatal centre (CANU Level III) is indicated in all situations in which the newborn is likely to need resuscitation and/or intensive care measures[17,22].

Prenatal risk stratification and management (anticipated risk)		
	***Absolute* indications for prenatal transfer**	***Transfer to hospital with neonatal unit, CANU level:***
Fetal factors	**GA:** 34 0/7 wks to 34 6/7 wks	Level ≥ IIA
	GA: 32 0/7 wks to 33 6/7 wks	Level ≥ IIB
	GA < 32 0/7 wks	Level III
	Estimated BW: 1500g to 2000g	Level ≥ IIA
	Estimated BW: 1250g to < 1500g	Level ≥ IIB
	Estimated BW < 1250g	Level III
	Difficult postnatal adaptation expected, likely to require intensive care measures	Level III
	Imminent preterm birth < 32 0/7 wks	Level III
	High grade multiple birth (triplets or higher)	Level ≥ IIB
	Prenatal diagnosis of congenital malformations requiring immediate postnatal management	Level III
	Relative* indications for prenatal transfer	***Transfer to hospital with neonatal unit, CANU level:***
Fetal factors	Intrauterine infection	Level ≥ IIA
	Haemolytic disease of the fetus	Level ≥ IIB
	Fetal disorders of cardiac rhythm	Level ≥ IIB
	Intrauterine growth restriction (estimated fetal weight < 5th percentile)	Level ≥ IIA
	Fetus with lethal malformations for which intensive care measures deemed not to be meaningful, but require comprehensive postnatal palliative	Level ≥ IIA
	Oligo- or polyhydramnios	Level ≥ IIA
Maternal factors	Chronic or unstable maternal disease (high blood pressure, preeclampsia, HELLP syndrome, diabetes mellitus, transplant recipient, autoimmune disease, etc)	Level ≥ IIA
	Maternal substance abuse	Level ≥ IIA

**In uncertain cases and depending on local setup, the perinatal referral centre should be consulted.*
GA: gestational age; wks: weeks of pregnancy; BW: birth weight.

Neonatal Adaptation

Introduction

Transition from intra-uterine to extra-uterine life requires a number of biological adaptive steps that are especially important for the integral functioning of the central nervous system[23]. However, delivery and the first days of life are also an emotional event, profoundly influencing the future parent-infant relationship. Perinatal care needs to consider these adaptive and emotional processes and weigh them appropriately.

To assess the risk situation of the newborn, the presence of intrapartal warning signs, in addition to other factors, may be significant. They can indicate a need for increased care immediately after birth, as well the need for additional postnatal monitoring, independent of the clinical situation[24].

Intrapartal warning signs (modified following SSN 1986)

- Acidosis: fetal pH < 7.20 (fetal capillary blood gas analysis).
- Meconium in the amniotic fluid.
- Pathological fetal heart rate (normal 120–160/min).
- Pathological CTG.
- Umbilical artery pH < 7.10[25], umbilical venous pH < 7.20.

Preparation for Initial Care

1. Anticipation of the expected need for resources

- Discuss the expected care situation.
- Identify the primary care/resuscitation lead.
- Clarify distribution of tasks in the primary care team.
- Clarify available staff resources, request additional staff if needed.

2. Preparation of the equipment

- Workstation for neonatal care: Ensure required equipment is available using checklist or photography, check material function, documentation sheet (assessment of adaptation and measures taken).
- Clearly defined local alerting system must be in place, so that additional staff or the appropriate neonatal transport team can be called out quickly if needed.
- Keep delivery room warm (at least 25°C).
- Switch on radiant heat source and light.
- Read through the mother's medical records and consider whether addition assistance from experienced personnel may be needed to care for the baby.
- Wash hands, wear non-sterile gloves.
- The time of birth is the time when the baby is fully delivered: Start stopwatch/Apgar timer[7,26,27].

Apgar Score

The Apgar score is a standardised evaluation of postnatal adaptation and of the success of any resuscitation measures[28]. However, the Apgar score is inappropriate for the immediate decision-making regarding the use of therapeutic measures. Individual parameters such as respiration, heart rate and muscle tone, if assessed promptly, can be helpful to identify children who may need resuscitation[2]. However, under no circumstances should the need for resuscitation be delayed until the next routine Apgar score is calculated.

At 1, 5, and 10 minutes after *the infant has been fully developed*, each individual Apgar parameter is evaluated, and the score documented. In case of clinical changes or after therapeutic measures, additional Apgar scores may be carried out during the 10 minutes following birth or even beyond these first 10 minutes of life[29].

Except for ventilation (see Table Apgar Score*), therapeutic measures such as oxygen administration or a support with CPAP do not influence the Apgar score. This means, for instance, that a centrally and peripherally pink infant under additional oxygen receives 2 points for colour.

Cord Clamping

Physiological background[30-44]

One of the features of the fetal circulation is that oxygenated blood is carried from the placenta via the umbilical vein into the inferior vena cava and then via the foramen ovale into the left atrium and left ventricle. This ensures that the most oxygenated blood

	0	1	2
Skin Colour	Body blue or pale	Body pink, extremities blue	Body and extremities pink
Respiration*	None	Insufficient, irregular	Sufficient, strong cry
Muscle Tone	Floppy	Some flexion of arms and legs	Good flexion of arms and legs
Reactivity**	Absent	Slow, grimacing	Vigorous, crying
Heart Rate	0	< 100/min.	> 100/min.

Apgar Score

** In ventilated infants, assess respiratory efforts with a dash (–).*
*** Reactivity = spontaneous motor activity, crying, sneezing, coughing.*

reaches the coronary arteries and the brain. In the case of *immediate or rapid cord clamping*, left ventricular filling is reduced by the now reduced inflow of umbilical venous blood while pulmonary perfusion is still low; this also reduces the stroke volume of this ventricle. However, *delayed cord clamping* (defined as 30 seconds to 2 minutes after full development of the newborn depending on the guidelines) can diminish or completely prevent this effect on the circulation.

Understandably, a so-called *physiological cord clamping* makes the most sense after the lungs have been ventilated, because the associated widening of the pulmonary arteries increases the perfusion of the lungs, and thus guarantees the filling of the left ventricle. Additionally, this improves placento-neonatal blood transfusion[45-47]. The resulting increased haemoglobin levels and better iron stores are further advantages of late cord clamping.

Practical approach

In all preterm and term infants who do not require resuscitation measures (normal spontaneous respiration, heart rate > 100/min), the umbilical cord should not be clamped before 60 seconds but at a maximum of 2 minutes after the infant has been fully delivered, whether by vaginal birth or caesarean section. The newborn should be stimulated during this time to support the onset of respiration to allow for optimal placento-neonatal transfusion and a smooth transition. Cord clamping after 60 seconds should not interfere with early neonatal care (drying, stimulation for first breath, and immediate skin-to-skin contact with the mother) or with the assessment of the 1-minute Apgar score. If at 60 seconds breathing is insufficient or the heart rate is < 100/min, the cord should be clamped and respiratory support should be started.

Concerns about the position of the newborn in relation to the placental level with the umbilical cord still intact appear to be unfounded. The effects of uterine contraction on the one hand and neonatal lung ventilation on the other exert a greater influence on umbilical venous blood flow, and thus on placento-neonatal transfusion than gravity, so that blood transfer from the placenta to the newborn occurs even when the baby is positioned on the mother's abdomen or chest[48].

Delayed cord clamping is contraindicated when gas exchange across the placenta is compromised by placental abruption, umbilical cord prolapse, cord rupture or maternal haemorrhage[2], or in cases of impaired adaptation requiring resuscitation. In these situations, *umbilical cord milking* of the still pulsating umbilical cord may be considered as an alternative in late preterm and term infants[49,50]. In this procedure, the umbilical cord is stroked out three to five times in the direction towards the newborn. After milking, the umbilical cord is clamped and cut, and the newborn can be taken to the resuscitation area.

Delayed cord clamping has become the gold standard in neonatal care. The timing of the cord clamping should be recorded on the documentation sheet[51]. Delayed cord clamping combined with cord milking is not beneficial and is not recommended[2].

Clinical Assessment of Adaptation

The following 4 criteria: respiration, heart rate, muscle tone and skin colour, are assessed before cord clamping. They guide the application of any measures to support the adaptation or resuscitation, as well as the decision regarding the appropriateness and duration of delayed cord clamping. Respiration and heart rate are the central criteria for initiating measures; muscle tone and skin colour are additional criteria to optimise the initial care *(see Algorithm)*:

- **Breathing:** Present or absent? Sufficient, insufficient? Gasping (gasping breaths with pauses in breathing following severe oxygen deprivation)? Usually, a healthy neonate will begin to breathe or cry spontaneously or in response to tactile stimulation within 30–60 seconds following delivery[10].
- **Heart rate:** Preferably determined via auscultation using a stethoscope over the apex of the heart. In the first minutes of life and if a pulsation is palpable, this can be done by palpation at the base of the umbilical cord. As this method is not always reliable, the stethoscope should be used if possible. Is the heart rate above 60/min or above 100/min? Palpation of peripheral pulses is not suitable for determining heart rate[29].
- **Tone:** A neonate presenting with very low muscle tone will very likely require respiratory support[29].
- **Skin colour:** Is the infant centrally pinking up (assess the colour of the tongue)? Most neonates are initially pale to cyanotic as fetal oxygen saturation is around 40–60% and skin perfusion is still diminished. After a few minutes, skin colour changes to a generalised pink. Assessing oxygenation by skin colour is unreliable[2,52]. Especially in the presence of anaemia, central cyanosis is only visible at low levels of oxygen saturation. If a neonate remains clinically cyanotic, oxygen saturation should be measured using pulse oximetry at 5 minutes of life at the latest[29]. On the other hand, a very pale skin colour can be an indicator of anaemia or acidosis requiring treatment[29].

Procedures during Normal Adaptation

Rapid evaluation of respiration, heart rate, muscle tone and skin colour is used to document the baseline situation, to determine the need for support or resuscitation, and to determine the indication and duration of delayed cord clamping[2]. In case of a normal adaptation, neonates breathe spontaneously after delivery, have a heart rate above 100 beats/min, present with a good muscle tone, and become pink within 5 to 10 minutes following birth[53,54]. Maintaining a nor-

mal body temperature and facilitating the initiation of spontaneous sufficient breathing are the main goals.

- This newborn infant is immediately dried with prewarmed blankets and placed on the mother's abdomen or chest. The head, except for the face, is covered with a hat and the body covered with a warm dry cloth to prevent thermal losses. The body temperature is checked regularly by the midwife.

- The opening of the airways is ensured by correctly positioning of the infant. If the baby is lying on the mother's abdomen or chest, the baby should be positioned in such a way that the airways remain open and that the infant is always visible.

- Suctioning is only required when specifically indicated. If a healthy term newborn infant regularly breathes within the first 60 seconds of life, has a heart rate > 100/min and develops good muscle tone, then suctioning of the mouth, pharynx and nose should be avoided. Suctioning is uncomfortable for the infant, it can cause mucosal lesions and, in the case of deep suctioning, can lead to reflex bradycardia, apnoea and laryngospasm.

- Stimulation to initiate regular breathing is achieved primarily through the initial handling of the newborn, such as drying and positioning. If the baby requires more stimulation, this can be done by gently rubbing the sole of the foot or the back. More aggressive stimulation methods should not be used[2].

Ideally, mother and infant should be allowed 2 hours of continuous skin-to-skin contact after birth; but at least until after the first breastfeeding. Within the first hours of life, newborns who are bonding with their mothers are at increased risk of sudden unexpected postnatal collapse (SUPC)[55,56]. During this time, the midwife/nurse must therefore regularly check the well-being of the newborn[57]. Routine procedures and further care of the infant should be performed at around 2 hours after birth, or at the earliest after the first breastfeed[58]. These procedures include a first examination of the neonate by the midwife, obstetrician, paediatrician, or neonatologist. This exam should be carried out under a radiant warmer in good lighting conditions.

The purpose of this first exam is to assess the further adaptation based on the vital parameters and the body measurements, as well as to exclude potential malformations:

- **Thermoregulation:** Target temperature range for newborn infants without need of therapeutic hypothermia is 36,5–37,5°C, extremities should be warm.

- **Respiration:** Respiratory rate (normal range 30–60 breaths/minute), signs of respiratory distress (retractions, grunting, nasal flaring, cyanosis, tachypnea)?

- **Circulation:** Heart rate (normal range 100–160 beats/minute), periphery well perfused?

- **Malformations:** Extremities, genitalia, back, palate. Placement of a gastric tube to exclude oesophageal atresia or an upper intestinal obstruction is only indicated in case of polyhydramnios or foamy secretions. Routine probing of nasal airways to rule out choanal atresia must be avoided.

- The skin is cleaned of blood and meconium without completely wiping off the vernix.

- **Body measurements:** Weight, length, head circumference (plot values on percentile curves)[59]. Ideally, these measurements should be taken after the bonding phase.

- All observations and measures must be recorded on the newborn's flow chart.

- Vitamin K prophylaxis and, if indicated, the active and passive hepatitis B vaccination are performed according to current guidelines[60,61].

Procedures in Case of Impaired Adaptation

Resuscitation algorithm

If the clinical assessment shows no regular or insufficient breathing or a heart rate below 100/min, further measures are added to those performed during normal adaptation, namely *thermoregulation* (**T**), opening airways (**A**, *airway*) and further measures depending on the condition of the infant. Opening, respectively maintaining the airways open (**A**) and enabling the aeration of the lungs (**B**, *breathing*) are the two most important measures in neonatal resuscitation. In most cases, these measures are sufficient to stabilise a neonate. Further, more complex interventions, however, are ineffective until these initial measures have been carried out correctly[2]. The potential steps and their respective indications are summarised in the *Algorithm*.

Commentary on the Individual Steps

T – Thermoregulation

- Regardless of gestational age, there is a clear association of hypothermia with mortality and morbidity[20,62-64].
- Resuscitation should be performed in a warm room (at least 25°C). Draughts are avoided; windows and doors should be closed.
- The radiant warmer is switched on 10–15 minutes before birth.
- The infant is quickly dried and transferred in warm blankets to the resuscitation table under a radiant warmer; wet blankets are replaced by dry and preheated blankets. A non-heatable pad draws warmth away from the newborn infant; such a pad should therefore be covered with warm blankets.
- Further possible measures: Head cover (cap or hat), switching on the heating pad or mattress, warm blankets.

A – Opening the airways

1. Correct Positioning

- A correct horizontal supine placement of the infant, with the head in neutral position with slight extension (sniffing position), is important to maintain optimal airway patency (*see Figure 1*). Hyperextension or flexion of the head must be avoided, as this may lead to narrowing of the airways.
- Raising the lower jaw (jaw thrust) can help to open and keep the airway open, as well as reduce mask leaks[2].
- A small rolled towel under the shoulders (not under the occiput/neck) can help maintain airway patency.
- Breathing should be described as sufficient, insufficient, pathological in breathing pattern or absent with regard to breathing rate, depth and effort.

2. Suctioning

- Suctioning is only necessary if amniotic fluid, vernix, mucus, meconium or blood obstruct the airways.
- Use a 10 Ch (Charrière) gauge catheter without side holes. Use oral suction bulb or mechanical device with trap (suction approx. –2 m water column, corresponding to –200 mbar = –150 mm Hg = –20 kPa = –0.2 atm).
- Suction the mouth and, if necessary, both nostrils.
- Do not insert the catheter into the nose because of risk of injury and swelling of the nasal mucosa. Newborn infants are preferential nose breathers.
- Repeated suctioning of longer duration impedes the initiation of spontaneous breathing. Touching the posterior pharyngeal wall can lead to a vagal reflex with bradycardia.
- Any suctioning manoeuvre should not last longer than 5 seconds. Suctioning of the stomach should only be performed when adequate oxygenation and stable respiration are achieved, and under the following circumstances
  - > In case of polyhydramnios, or when foamy saliva is present.
  - > During or after mask ventilation or before transport.
- If the suction catheter cannot be advanced into the stomach, oesophageal atresia should be suspected. In that case, the infant should be placed in prone position due to risk of aspiration, and mouth and pharynx are gently and repeatedly suctioned with an open gastric tube.
- Suctioning of more than 20 ml of gastric fluid is suggestive of upper gastrointestinal obstruction. In this situation, a gastric tube should be put in place and left open and suctioned every 10 minutes.
- *Meconium stained amniotic fluid:* Intrapartum oropharyngeal suctioning in the presence of meconium stained amniotic fluid has no influence on the outcome of the neonate[65-67]; this procedure is therefore no longer recommended as routine measure[68].
- The management of the newborn infant with meconium stained amniotic fluid follows the same principles as for infants with clear amniotic fluid. Vigorous newborn infants with normal breathing pattern and with a good muscle tone can remain with their mothers. Intratracheal suctioning should not be routinely performed in case of thick meconium stained amniotic fluid and depressed respiration, as this does not prevent meconium aspiration syndrome[69,70]. The main focus should rather be on rapidly initiating the normal resuscitation measures to support respiration while ensuring normothermia.
- If no chest movements can be achieved under mask ventilation and, after ruling out insufficient inspiratory pressure or a mask leak, an obstruction of the trachea by, for example, meconium, blood, mucus, etc. is suspected, then a person experienced in intubation can perform intratracheal intubation and suction this material with a meconium aspiration adapter connected to a vacuum. This suctioning procedure with insertion and removal of the whole tube can be repeated if the heart rate remains normal. Otherwise, efficient mask ventilation should be started, especially if bradycardia persists[18,19].

Assessing Heart Rate

- Reliably assessing the heart rate (HR) is of vital importance in neonatal resuscitation since, on the one hand, the HR will determine changes or the escalation of resuscitation measures; on the other hand, an increase or persistence of HR > 100/min is the most important parameter of effective ventilation and oxygenation[71-73]. A bradycardic HR, on the other hand, indicates persisting insufficient oxygenation (hypoxia), and often also inadequate ventilation[2].
- Initially, the HR is most easily assessed with a stethoscope placed over the apex of the heart; this method allows an acceptably precise assessment of HR and is therefore still considered the preferred initial clinical documentation of HR[1].
- Palpating the base of the umbilical cord should be used only as an auxiliary measure. It can be performed quickly but is less reliable as it is associated with significant underestimation of the real HR[74,75].
- Both of the above methods can lead to an underestimation of the HR[74,75] and thus possibly lead to unnecessary measures.
- Using pulse oximetry to determine the HR is more precise, but requires around 1 minute to establish an accurate reading[76]. Pulse oximetry often underestimates the HR during the first 2 minutes of life[77].
- Use of ECG to determine the HR is precise and reliable within the first minutes of life[77-82]. Despite these advantages, ECG cannot replace pulse oximetry, but only complement it because, unlike pulse oximetry, ECG does not assess oxygenation or perfusion. In the extremely rare

situation of so-called pulseless electrical activity (PEA or electromechanical uncoupling), the ECG, unlike the pulse oximeter, can detect a HR despite the absence of a heartbeat[77-82]. The installation of ECG should neither delay clinical assessment nor the initiation of resuscitative measures.

B – Breathing / Ventilation *(Figures 2, 3 and 4; Appendix)*

Mask ventilation: In the case of insufficient or absent spontaneous breathing or gasping, or with a HR < 100/min, mask ventilation should be performed using a **bag-mask system** (*see Figure 3*) or a **T-piece-mask system** (*see Figure 4*).

For ventilation to be carried out correctly, the following points must be observed:

- The head should be held in a midline, slightly extended position with the mouth kept slightly open (*see Figure 1*).
- In term neonates, ventilation should be started with room air[18,19]. The inspiratory pressure is adapted on the basis of the thoracic excursions and measured with a manometer on the bag; an inspiratory pressure between 25–30 cmH_2O is often sufficient. Occasionally, however, this pressure must be increased to 30–40cmH_2O in term babies. If pressure monitoring is not possible, the inspiratory pressure should be gradually increased to achieve visible chest movements and an increase in HR[18,19].
- Following this, ventilation is performed with a pressure adapted to the infant's needs (visible chest movement) and with a frequency between 40–60/min.
- Visible thoracic excursions indicate open airways and sufficiently high respiratory volumes (target 5–8 ml/kg body weight). Conversely, if the thorax does not move, airway obstruction or low inspiratory pressure resulting in insufficient tidal volumes must be suspected, so that ventilation of the lungs is not adequate[2].

The value of *prolonged initial breaths* (so-called "sustained inflations" with > 1 second inspiration time) has been questioned due to new findings indicating potential harm[83]. In infants > 34 weeks gestation, there are no robust data to justify a recommendation for or against, so that the routine use of prolonged inspiratory breaths does not seem to be indicated at present[84].

Ventilation with a T-piece system *(e.g. Perivent®, Neopuff®; see Figure 4):*
In contrast to a bag-and-mask system[85-90], the use of a T-piece system allows a more reliable and stable application of a PEEP pressure; likewise, inspiratory pressure and time can be better controlled. In contrast to the self-expanding bag, the T-piece system can be used to provide CPAP as respiratory support (*see Figure 5*). When using a T-piece system, a bag and mask should always be available as a backup.

Figure 1: *A – airway: Correct positioning to keep the airway open: sniffing position*

Figure 1: *A – airway: Incorrect positioning: flexion*

Figure 1: *A – airway: Incorrect positioning: hyperextension of the head*

Positive end-expiratory pressure
Although no neonatal clinical studies have specifically investigated the use of supplemental positive end-expiratory pressure (PEEP) with positive pressure ventilation to build functional residual capacity immediately after birth, it can be assumed that the use of PEEP is beneficial for gas exchange, and particularly for oxygenation, and thus should be used insofar the necessary material is available. Generally, an initial PEEP of 5 cmH_2O is used. When using a self-expanding ventilation bag, a PEEP valve must also be attached[2,18].

CPAP in the delivery room *(Continuous Positive Airway Pressure; Figure 5; Appendix)*
CPAP is a non-invasive respiratory support that provides continuous positive end-expiratory pressure (PEEP) to spontaneously breathing neonates throughout the respiratory cycle without additional inspiratory pressure support[91]. CPAP application opens both the alveoli and the upper airways and prevents their collapse during expiration (preserving functional residual capacity), which is associated with a decrease in intrapulmonary right-to-left shunt. It also increases lung distensibility, decreases work of breathing and improves oxygen uptake. Currently, the quality of data is poor and the evidence weak to recommend for or against routine CPAP application in term and late preterm infants with a gestational age ≥ 34 weeks in the delivery room who either develop or are at increased risk of respiratory distress syndrome[92]. CPAP is indicated for respiratory distress syndrome with increased work of breathing and an oxygen requirement of ≥ 30% to achieve a preductal SpO_2 between ≥ 90% and ≤ 95%[93], or for persistent tachypnoea with expiratory grunting. For a correct indication, it is also important that the neonate is breathing spontaneously and adequately, as no ventilatory breaths are delivered with CPAP. An apnoeic or insufficiently breathing newborn who does not respond to simple measures needs ventilation; CPAP support alone is not adequate in these situations. In the delivery room, CPAP is usually administered by mask using a T-piece system (*see Figure 5*). Generally, the initial PEEP pressure is set at 5 cmH_2O.

Isolated tachypnoea in the newborn is usually self-limiting and is not an indication for routine CPAP support[94,95]. Similarly, routine CPAP application is not appropriate in all term and late preterm infants after caesarean section. An incorrect indication for CPAP increases the risk of transfer to a neonatal unit, and thus of mother-child separation. Also, if the lung volume is well recruited with normal functional residual capacity, CPAP application may decrease the tidal volume and thus lead to CO_2 retention.

During CPAP therapy, the clinical course of the respiratory distress syndrome should be documented regularly and the preductal SpO_2 measured continuously. Care should be taken to ensure that the upper airway is clear and that secretions are removed regularly. A capillary blood gas analysis (pH, pCO_2) should be performed after 30–60 minutes at the latest. Possible complications may include gastric distention or pneumothorax. If the respiratory distress syndrome worsens under CPAP, the neonatal referral centre should be notified to discuss the further management.

The success of ventilation is assessed on the basis of the following criteria:
- Thoracic excursions are visible.
- The most important sign of success is that HR increases or remains > 100/min.
- Normalisation of the SpO_2.
- Skin colour changes to pink.

Under ventilation, the HR is continuously monitored using pulse oximetry (or ECG) and respiration should be evaluated regularly, at least every 30 seconds. Ventilation is continued until the neonate has established regular and sufficient breathing and the HR is > 100/min. In the case of prolonged mask ventilation, a gastric tube should be inserted to evacuate air that has distended the stomach[96].

The **laryngeal mask** has shown efficacy in term newborn infants and in preterm infants born ≥34 weeks GA and >2000 g birth weight[97-100]. Thus, the laryngeal mask can be considered an alternative for trained personnel to ventilate term infants, especially in situations where mask ventilation or intubation cannot be successfully performed[18,19,29,101]. However, correctly performed mask ventilation leads to success in most situations; it is also easier to learn.

An **oropharyngeal tube** *(Guedel tube,* insertion without rotation) may be helpful in situations where, despite jaw-lifting manoeuvres, breathing is obstructed by upper airway obstruction in the presence of micrognathia, Pierre-Robin sequence or choanal atresia. Similarly, a **nasopharyngeal tube** *(Wendl tube;* or *endotracheal tube ID 3.0/3.5: nasal insertion depth 3–4 cm)* may be considered if keeping the airway open proves difficult and mask ventilation does not result in adequate ventilation[2].

The Role of Oxygen in Neonatal Resuscitation

Based on several studies, pure oxygen (100% O_2) should no longer be primarily used in neonatal resuscitation, as lower oxygen concentrations or room air (21% O_2) are just as efficient as oxygen in high concentrations in most newborns after birth[102-105]. There is concern about the potential effects of using 100% oxygen on respiration, on cerebral blood flow, and on potential cellular damage from toxic oxygen radicals. This is of particular concern when high concentrations of oxygen are applied following hypoxic cell and tissue damage. Generally speaking, oxygen should be regarded as a medication and thus strictly indicated and dosed. The vast majority of newborns do not need supplementary oxygen immediately after birth. Isolated peripheral cyanosis in a vigorous newborn with a normal heart rate and sufficient respiration is not an indication for oxygen administration.

Skin colour is not very helpful in assessing oxygenation; at most, in good light conditions, the colour of the tongue can give an indication of oxygena-

tion of the myocardium and brain. On the other hand, cyanosis is sometimes difficult to recognise clinically. In the delivery room, for situations with disturbed adaptation, a pulse oximeter adequate for newborns to assess oxygenation and an oxygen/compressed air blender for the titration of oxygen therapy must be available[2]. Data show that preductal transcutaneous oxygen saturation during normal transition in room air in healthy term neonates rises from 40–60% prenatally to > 90% within 10 minutes after birth. As a pragmatic memory aid, the following preductal SpO_2 target values are formulated (*Algorithm*):

- 3 minutes of life ≥ 70%
- 5 minutes of life ≥ 80%
- 10 minutes of life ≥ 90%

Not reaching the SpO_2 target of ≥ 80% at 5 minutes of life has been associated with increased morbidity and mortality[112].

When oxygen is administered, it must always be monitored and dosed using transcutaneous preductal oxygen saturation (SpO_2, at the right wrist/hand). The target preductal SpO_2 under oxygen application should be between 90–95% after the 10th minute of life (increase O_2 concentration if SpO_2 < 90%; decrease O_2 concentration if SpO_2 > 95%).

Neonates not requiring resuscitation

If a newborn infant has central cyanosis after 5 minutes of life with regular breathing and normal heart rate, a preductal transcutaneous saturation is measured. If the oxygen saturation is too low (*see Algorithm,* preductal SpO_2 target values), oxygen should be administered to the infant (flow 4–5 L/min, initial FiO_2 30%). Oxygen concentration is adjusted in 10% increments every 30 seconds until oxygen saturation is normalised.

Neonates requiring resuscitation

Term infants should be ventilated primarily with room air. If a neonate shows insufficient breathing but has a normal heart rate, the indication for supplemental oxygen is based on the transcutaneous oxygen saturation values (measured by preductal pulse oximetry). If the heart rate is normal and cyanosis persists, supplemental oxygen should be titrated such that oxygen saturation values increase normally (*see Algorithm*) [a,b][18,19]. Conversely, if the heart rate remains between 60–100/min despite ventilation with room air for 30 seconds, the oxygen supply should be immediately increased to 100% and help should be called.

a) Based on animal experimental data, newborn infants with pulmonary arterial hypertension or with malformations such as pulmonary hypoplasia (oligohydramnios, diaphragmatic hernia) seem to benefit from higher oxygen concentrations. Data, however, are too scarce to make more precise statements on this[110].

b) Hyperoxaemia is harmful for preterm infants and can occur at oxygen saturation values >95%. For this reason, the postnatal oxygen saturation increase in preterm infants should not exceed that of term infants. Although the data

Figure 2: *Correct placement of the mask for ventilation. The anatomically shaped mask with air cushion covers both the nose and the open mouth.*

Figure 3: *Ventilation with bag and mask. Correct position of the head and mask; the mouth is slightly open. Thumb and index finger form the so-called C-grip, the middle finger is placed on the lower jaw; no pressure should be applied to the floor of the mouth.*

Figure 4: *Ventilation with T-piece system; inspiration above, expiration below.*

Figure 5: *CPAP with T-piece system. Correct position of the head and mask, mouth slightly open.*

are not fully clear yet, additional oxygen immediately after birth may be necessary and beneficial in preterm infants[113-115], this should also be precisely titrated.
The use of a pulse oximeter should be considered at every birth when it can be expected that the newborn will have a disturbed adaptation, need for respiratory support or for resuscitation[29]. Modern devices allow a reliable and continuous assessment of the oxygen saturation and heart rate from the first minutes of life[116]. The sensor is applied to the right hand or wrist, thereby allowing a measurement of the preductal oxygen saturation[108,111]. A somewhat faster signal acquisition can be achieved by first connecting the sensor to the monitor and only then attaching it to the infant; in most cases, a reliable measurement can be achieved within 60 seconds[76].

C – Circulation and Chest Compressions
(Figure 6, Table)

Ventilation is the most important measure in neonatal resuscitation to supply the heart muscle and brain with oxygen. If ventilation is not correctly performed, chest compressions will also remain ineffective[19]. Chest compressions should not be started before ventilation with 100% oxygen has been performed in the specified steps (*see Algorithm*); similarly, chest compressions should not be performed without reliably obtaining a HR < 60/minute.

Indications for performing chest compressions after mask ventilation with 100% O_2 for 30 seconds and continuing:

- asystole[c].
- bradycardia less than 60/min.

Technique[117]

Both thumbs are positioned one above the other over the sternum and below a virtual line connecting both nipples (*see Figure 6*), the other fingers encircling the thorax. It may be difficult, especially for small hands, to fully encircle the thorax; in this case, the thorax is then only partially grasped so that the thumbs can be placed correctly. The depth of compression should be at least 1/3 of the antero-posterior diameter of the thorax (*see Figure 6*). Chest compressions can impede effective ventilation; therefore, both actions should be coordinated so that they do not coincide[18,19]. They should be performed for the neonatal period (up to 4 weeks after the calculated date of birth) in a compression to ventilation ratio of 3:1, so that there are 3 compressions and 1 ventilation per 2 seconds (= 1 cycle, corresponding to 90 compressions and 30 breaths per minute). As compromised gas exchange with hypoxaemia is usually the primary cause of cardiovascular collapse in this age group, this ratio allows more ventilatory breaths to be given to treat hypoxia[16,118]. This ratio should also be continued in a coordinated manner after intubation. Ventilation should always be carried out with 100% oxygen during chest compression.

Figure 6: *Chest compressions synchronised with ventilation 3:1 – compression phase. Two-handed wrap-around technique with thumbs superimposed below a connecting line between both nipples, compression depth 1/3 of the antero-posterior diameter.*

Evaluation and re-evaluation:

After 30 seconds of chest compressions, the HR should be re-evaluated, as well as every 30 seconds thereafter. Only chest compressions are stopped to measure the infant's spontaneous HR; ventilation is continued without interruption during this time. Chest compressions should be stopped as soon as the spontaneous HR is > 60/min[19]. Ventilation is continued until the HR is > 100/min and the infant is breathing adequately; the FiO_2 should now be adjusted to the adequate target SpO_2[2].

Step-by-Step Course of Action and Timeline for Bradycardia *(Algorithm, Table)*

1. *HR < 100/min:* start mask ventilation with 21% O_2
2. *HR remains < 100/min after 30 seconds of mask ventilation with 21% O_2:* continue mask ventilation, immediately increase oxygen concentration to 100% and call for help.
3. *HR decreases/remains < 60/min after 30 seconds of mask ventilation with 100% O_2:* start chest compressions (CC) coordinated with mask ventilation (V) at a ratio of 3:1.
4. *Evaluate the spontaneous HR every 30 seconds:* briefly suspend chest compressions without interrupting mask ventilation.
5. *If HR remains < 60/min after 30 seconds of mask ventilation with 100% O_2 and chest compressions:* insert a venous access (UVC) and administer 10–30 mcg/kg/dose of adrenaline (epinephrine) i.v. every 3–5 minutes.
6. *If HR remains < 60/min despite the above measures:* adrenaline (epinephrine) preferably i.v. (30 mcg/kg/dose) every 3–5 min; consider intubation, adrenaline (epinephrine) 50–100 mcg/kg/dose intratracheally.

c) The use of a pulse oximeter or an ECG device is useful and helpful during chest compressions. If the ECG can be applied very quickly, this method is superior to pulse oximetry. The latter takes a little longer until a reliable pulse signal can be read and may also underestimate the HR[77]. Measuring heart rate by palpation of the umbilical cord is not suitable either for the indication for chest compressions or for the evaluation of HR during their application.

Endotracheal Intubation *(Table)*
The indication for an intubation depends on the gestational age, the clinical situation, the extent of respiratory depression, the efficacy of mask ventilation or the presence of certain malformations (such as diaphragmatic hernia). Intubation should only be performed by a trained person. If intubation cannot be performed, the newborn should continue to be ventilated using a bag/mask or T-piece system (e.g. Perivent®) until a person competent in intubation is available. *Orotracheal intubation* is easier and more rapid to perform; it is therefore preferable to naso-tracheal intubation for the treatment of acute hypoxaemia and/or bradycardia. *Nasotracheal intubation* allows better fixation for possible transport; however, it is technically more challenging. Heart rate should be monitored during intubation. An intubation attempt is stopped after 30 seconds at the latest if bradycardia occurs or after an unsuccessful attempt.

The correct intratracheal position of the endotracheal tube must be confirmed after each intubation. In most cases, this can easily be accomplished by clinical assessment (visually during intubation, rapid rise of heart rate and oxygen saturation, humidity fogging of the tube, thorax excursions, auscultatory symmetric breath sounds). Measurement of expiratory CO_2 (e.g. using a colorimetric device) is simple and rapid; it is the gold standard for confirming endotracheal intubation, but does not rule out unilateral intubation[d)][(2,18,19,119)].

With the endotracheal tube in place, the infant should always be ventilated with a positive pressure and a PEEP of 5 cmH_2O. Spontaneous breathing via endotracheal tube without PEEP can lead to atelectasis and should imperatively be avoided.

Preterm infants intubated in the delivery room remain intubated for transport to the neonatal unit. Exceptionally, extubation by the transport team may be considered for term neonates if the cardiopulmonary situation has normalised, the infant has a normal oxygen saturation in room air and the blood gas analysis is normal.

Therapeutic Hypothermia
Neonates ≥ 35 0/7 weeks GA and ≤ 6 hours old with severe neonatal acidosis (pH ≤ 7.0 obtained within the first 60 minutes of life; base deficit ≥ –16 mmol/L and/or blood lactate ≥12 mmol/L) and clinical signs of moderate to severe hypoxic ischaemic encephalopathy (documented by Thompson or Sarnat scores) should be treated with therapeutic hypothermia[(120,121)]. This can significantly improve survival and neurological outcome[(122)]. Since the therapeutic window is only 6 hours, this treatment should be started as soon as possible. For this purpose and after consultation with the neonatology reference centre, any external source of heat should be switched off until the transport team arrives, and the newborn should remain uncovered[(123)]. This measure should not interfere with initial resuscitation and stabilisation; however, it is important for further care of the infant[(19)]. Active cooling, e.g. by means of ice packs etc., should not be carried out because this can quickly lead to excessive hypothermia. The rectal temperature should be checked every 15 minutes until arrival of the transport team; the target range in the peripheral hospital is between 34–35°C to be on the safe side. If the rectal temperature falls below this target range, a further drop in temperature should be prevented by covering the patient or by using an alternative heat supply. The temperature should continue to be measured every 15 minutes. Cooling during transport to the centre is performed according to the transport protocol[(124)]. Hyperthermia should always be avoided. Further hypothermia treatment (target range core temperature 33–34°C) is carried out under strict criteria and according to strict protocol exclusively in neonatal intensive care units SwissNeoNet Level III[(19,123)].

Volume Expansion and Buffering *(Table)*

Venous Access
Venous access must be established in intubated or cardiopulmonary unstable neonates. In emergency situations and shock, insertion of an umbilical venous catheter is the method of choice (*see List 1*). Only if this is not possible should an intraosseous approach be used, insofar the expertise and material are available[(126)]. Intraosseous access is associated with significant complications in the newborn such as osteomyelitis, tibial fractures, extravasation of injection fluid and drugs, etc.[(3)]. The correct position of the intraosseous needle should be confirmed by bone marrow aspiration and fluid bolus prior to drug administration.

If venous access becomes necessary at a later stage and not as an emergency, a peripheral venous catheter can be placed. After stabilisation of the circulation, the infusion is continued by means of a 10% glucose solution at 3 ml/kg/hour, corresponding to a glucose supply of 5 mg/kg/min.

d) There are few data on the use of expiratory CO_2 measurement in neonatal resuscitation. Nevertheless, positive detection of CO_2 in expired air, in addition to clinical assessment, is a valuable method of confirming the intratracheal position of the tube[(18,19,64)]; a negative result indicates oesophageal intubation. However, if lung perfusion is poor, the result of the measurement may be falsely negative. When using a colorimetric method, contamination of the material with surfactant, adrenaline or atropine may result in a false positive reading[(19)]. In this case, however, and in contrast to successful intubation, there is a permanent, non-breath-synchronous colour signal change.

Volume Administration *(Table)*
If signs of hypovolaemia or circulatory insufficiency are present, such as reduced peripheral perfusion, weak palpable pulses, low blood pressure, pallor and tachycardia, volume replacement (over 5–10 minutes)

must be given. The following solutions can be used for this purpose:

- **NaCl 0,9%:** Initially 10 ml/kg, to be repeated depending on blood pressure and clinical signs.
- **Packed red blood cells:** E.g. in acute anaemia, bleeding history; use untested 0 Rh-negative blood. Dosage: 10 ml/kg, repeat if necessary. In acute hypovolaemia, NaCl 0,9% should be administered as a bridging solution until infusible erythrocytes are available. Blood should be drawn for newborn screening before the red blood cell transfusion.

Albumin 5% is contraindicated as a volume substitute in neonatal resuscitation[127].

D – Drugs *(Table)*

Drugs are rarely needed during neonatal resuscitation; if at all, then primarily volume replacement and adrenaline (epinephrine) are used[18,29]. Bradycardia in the newborn is usually due to significant hypoxia caused by inadequate lung ventilation[19]. Adequate oxygenation is thus a prerequisite for successful drug treatment[116].

Adrenaline 1:10'000 (0.1 mg/mL)

If the heart rate remains <60/min despite ventilation with 100% oxygen and chest compressions over 30 seconds, the administration of adrenaline (epinephrine) is useful[19]. Adrenaline should be administered intravenously if possible[8].

***Intravenous* dosage**[e]**:** 10–30 mcg/kg/dose, corresponding to 0.1–0.3 ml/kg of a 1:10'000 adrenaline solution. Preparation of this solution with 1 ml of adrenaline 1mg/ml + 9 ml NaCl 0,9%; corresponding to 1 mg adrenaline in 10 ml solution or 0.1 mg/ml. The use of commercially available adrenaline 1:10'000 prefilled syringes can help to save time and avoid drawing up mistakes in emergency situations.

***Intratracheal* dosage:** 50 to maximum 100 mcg/kg/dose[18,29].

e) No studies exist on high-dose intravenous adrenaline application (100 mcg/kg/dose)[128]. For this reason, and because of potential side effects, this high dosage is not recommended. Although in neonatal resuscitation intubation is usually achieved before placement of a venous access (umbilical venous catheter), intravenous administration of adrenaline is preferable to intratracheal whenever possible. An ineffective intratracheal administration must be repeated intravenously if possible. If the HR remains <60/min, adrenaline 30 mcg/kg/dose can be given repetitively every 3–5 minutes, preferably intravenously[2,3,18,29,129].

Naloxone (0.4 mg/ml)

There is no evidence for the efficacy of naloxone in reversing opiate-induced respiratory depression at birth. In addition, there are concerns about long-term safety; thus, naloxone cannot be recommended as a routine medication for respiratory depressed neonates in the delivery room[130]. Respiratory support and ventilation should be used in the first instance; in the majority of cases these are sufficient measures and the infant begins with a sufficient regular breathing after a few minutes of mask ventilation.

Possible indication: In newborns whose mothers have received an opiate preparation within 4 hours before birth and who show persistent respiratory depression despite ventilation and a good circulatory situation.

Dosage: 200 mcg/dose intramuscularly (independent of body weight); this achieves a constant plasma concentration over 24 hours[2,131]. The half-life of naloxone is usually shorter than that of the opiate preparation, which is why it is imperative to monitor the infant during the first 24 hours, and thus to transfer it to a neonatal unit (level IIA or higher). Rebound tachypnoea may occur after administration of naloxone.

Contraindication: Children of opiate-dependent mothers (medical history!).

Buffering

In the presence of metabolic acidosis, the aim should be to treat the primary cause. The administration of sodium bicarbonate can cause severe side effects (paradoxical intracellular acidosis, osmotically induced myocardial dysfunction, reduction of cerebral blood flow and cerebral haemorrhage, especially in premature infants). There is no evidence for the efficacy of sodium bicarbonate in the initial resuscitation of the neonate; therefore, this treatment is contraindicated in this phase[29,128,132-134]. Rarely, sodium bicarbonate may be considered in a prolonged resuscitation situation with cardiac arrest without therapeutic response to other measures and with adequate ventilation and chest compressions. The aim of this buffering is to reverse intracardiac acidosis to improve myocardial function and restore circulation.

Dosage: 2–4 ml/kg (equivalent to 1–2 mmol/kg) of a 4.2% NaBic solution (NaBic 8.4% 1 mmol/ml diluted 1:1 with distilled water), slowly i.v.[2].

Care of the Parents during the Delivery

Caring for parents during the delivery is an important task. This becomes particularly demanding when the adaptation of the newborn is disturbed or when a child is born with severe malformations. In these cases, resuscitation measures often require a lot of space and interfere with opportunities for contact and interaction between parents and child. It is best to discuss the expected course of care for the newborn and any expected problems with the parents before the birth. It can also be discussed whether resuscitation should take place in the delivery room, if local conditions and the overall situation permit[135-138]. If the parents wish this, it should be supported whenever possible[2,137,139]. For some parents, witnessing resuscitation measures is a positive experience, for

others it is associated with anxiety and negative impressions[137,139]. Often, specific measures cannot be explained and discussed immediately in the acute situation. In addition, the presence of parents can expose the team to additional stress and distraction; therefore, the view of the resuscitation team must also be taken into account in this regard[2]. The decision about the presence of the parents during initial care is made by the team leader and should be communicated to the parents. If the newborn is resuscitated in a separate room in the presence of the partner, the information should be provided by an additional team member. If the newborn is cared for without the parents being present, it is important that the parents are regularly informed about the condition of their child and about the measures taken by the team providing care[19]. Ideally, a suitable person who is not actively involved in resuscitation should be assigned this task. If there is a possibility that the newborn may not survive despite all resuscitation measures undertaken, timely information of the parents is very important[2,140].

Following a difficult resuscitation, sufficient time should be allowed for discussion with the parents and they should be given the opportunity to see and, if the clinical situation permits, touch their child in direct skin-to-skin contact. Similarly, parents should be able to see and touch their child before separation or transfer of their newborn, if the child's health permits. A photo of the child should also be taken for the parents. The address, telephone number of the neonatal unit and the name of a contact person to whom the parents can turn for further information should be given to them. The mother and carers should be reminded that even in a critical situation, breast milk production should be stimulated by pumping. The possibility of transferring the mother to the obstetric ward in the same hospital as the neonatal unit should also be discussed with the local obstetricians.

Additionally, the possibility of a team debriefing should be offered on site or soon after resuscitation, if necessary together with the neonatology department in charge.

Care of the neonate following resuscitation

Neonates who required resuscitation may deteriorate again at a later stage. Therefore, once adequate ventilation, oxygenation, and circulation have been established, these infants must be transferred to a neonatal unit (Level ≥ IIA) where continuous monitoring, observation and care are ensured[18,19].

Discontinuation of Resuscitation

If after 20 minutes of continuous, adequate and technically correct resuscitation with ventilation using 100% O_2, with coordinated chest compressions and intravenous adrenaline[118,141-143], there are no vital signs (no cardiac activity, no spontaneous breathing, Apgar score still 0), discontinuation of resuscitation may be justified[144]. In this situation, survival is unlikely and if, then it is associated with severe neurological impairment[18,29,145,146]. Auscultation of the heart rate can be difficult; pulse oximetry or an ECG monitor allow a more reliable assessment. If there is uncertainty, resuscitation measures should be continued until the arrival of a physician competent in neonatal resusci-

A. Drugs	Dilution/preparation	Indication	Dosage	34 weeks 2 kg	37 weeks 3 kg	40 weeks 4 kg
Adrenaline 1:1'000	1:10'000 1 ml = 0,1 mg = 100 mcg →Dilute 1 ml of adrenaline (1 mg/ml) with 9 ml NaCl 0,9%	Bradycardia, asystoly	***intravenously*** 10–30 mcg/kg i.v. (0.1-0.3 ml/kg i.v.) ***intratracheally*** 50–100 mcg/kg i.tr. (0.5–1 ml/kg i.tr.)	0.2–0.6 ml 1–2 ml	0.3–0.9 ml 1.5–3 ml	0.4–1.2 ml 2–4 ml
NaCl 0.9%		Hypovolemia	10 ml/kg i.v.	20 ml	30 ml	40 ml
Glucose 10%		Symptomatic hypoglycaemia	200 mg/kg (2 ml/kg i.v.)	4 ml	6 ml	8 ml
Glucose 10%		Glucose infusion	5 mg/kg/min (3 ml/kg/h)	6 ml/h	9 ml/h	12 ml/h

B. Intubation	34 weeks 2 kg	37 weeks 3 kg	40 weeks 4 kg
Endotracheal tube size	ID 3.0	ID 3.5	ID 3.5
Insertion depth (orotracheal intubation)	8 cm	9 cm	10 cm
Insertion depth (nasotracheal intubation)	9.5 cm	10.5 cm	11.5 cm

ID = internal diameter (in mm)

tation, and should be discontinued only after joint evaluation of all recommended resuscitation steps, after exclusion of remediable causes and after informing and involving the parents. If the parents agree, the infant can then be handed over to them for direct skin-to-skin contact.

After discontinuation, the neonatal unit should be contacted to arrange potential further investigations.

Comfort Care

If life-sustaining measures are not, or no longer indicated because they are futile, attention should be paid to good *comfort care* for the child and parents[147]. If local space and personal resources allow, a quiet room with attentive care by the local team is helpful. Wishes and support needs, including those of a spiritual nature such as an emergency baptism, a blessing or another desired ritual should be ascertained and implemented individually. Photographs of the child with its parents should be taken in consultation with them and handed over to them.

Laboratory Tests in the Delivery Room

If necessary, the clinical assessment of adaptation can be complemented by the following "*laboratory-triad*":

- Blood gas analysis, ideally including blood lactate (especially in case of low 5 and 10 min Apgar scores)
- Haematocrit or haemoglobin
- Blood glucose level

A *blood gas analysis* is indicated if umbilical artery pH is < 7.10 and in the presence of clinical signs of impaired adaptation.

A *haematocrit* or haemoglobin value should be determined when suspecting polycythaemia (post-term pregnancy, dysmaturity, or peripheral cyanosis) or anaemia (pallor, circulatory instability).

Blood glucose testing in the delivery room is only done if there are symptoms suggestive of hypoglycaemia, after resuscitation or if there are signs of diabetic fetopathy. Low blood glucose values are common during early postnatal transition. Measurements of blood glucose in the first 2–3 hours of life are therefore misleading and not clinically useful in asymptomatic term infants with normal birth weight[148]. In neonates with hypoxic-ischaemic encephalopathy, hypoglycaemia should be avoided and normal blood glucose levels should be aimed for [2,149-151].

Postnatal Transport of High Risk Newborn Infants

Neonatal transport should be avoided, whenever possible, by prenatal transfer of the mother to a perinatal centre.

Indications for neonatal transfer of newborn infants to a neonatal unit (Level ≥ IIA):

- Preterm infant below 35 0/7 weeks GA.
- Birth weight less than 2000 g.
- Severe neonatal metabolic acidosis (pH < 7.0, base deficit ≥ –16 mmol/l and/or lactate ≥12 mmol/l), independently of the clinical situation (Level III).
- Neonates ≥ 35 0/7 weeks GA with clinical signs of hypoxic ischaemic encephalopathy *(see above)* after prior consultation with the responsible neonatal referral centre (Level III) for therapeutic hypothermia as early as possible (within 6 hours of birth).
- Neonates after resuscitation (bag and mask ventilation > 5 min, intubation, volume expansion, chest compressions, medication etc.).
- Cardio-pulmonary disturbances persisting 4 hours after birth.
- Persistent or recurrent hypoglycaemia (< 2.6 mmol/l with a rapid determination test) despite early feeding[148].
- Suspected neonatal infection (no antibiotics to be given orally or intramuscularly)[152].
- Seizures, withdrawal symptoms (maternal opiate use).
- Icterus at birth[153].

This list is not exhaustive; unclear situations should be discussed with the neonatal referral centre in charge. Newborn infants should be transported by a trained neonatal transport team using transport incubators.

Preparations before transport:

- Mother's and infant's data, copy resuscitation protocol sheet.
- Maternal blood (10 mL EDTA blood) and cord blood.
- Preserve placenta.
- Show the infant to mother/parents before departure.
- Photo of the infant for the parents
- Provide the parents with the address and telephone number of the neonatal unit.

List 1

Equipment for delivery in a hospital setting

Inventory of the resuscitation equipment

- Mobile resuscitation unit or permanent resuscitation place.
- Radiant warmer, warm and draught-free environment.
- Connections for electricity, oxygen/compressed air[f] and suction.
- Work surface and space for material.
- Stopwatch/Apgar timer.
- Access for transport incubator.
- Non-sterile gloves (sizes S, M, L).
- Head covers, sterile gowns.

Lighting
- Bright light, preferably integrated into the radiant warmer.

Heat sources
- Adjustable overhead radiant heat source with a fixed distance to the surface.
- Sufficient supply of warmed blankets/diapers.
- Preheat resuscitation area early.

Suction devices
- Mouth-operated suction device with a mucus trap.
- Vacuum pump with negative pressure set at –200 mbar (–20 kPa, ca. –0.2 atm, –2 mH_2O, –150 mmHg).
- Suction tubing and adaptors for suction catheters.
- Suction catheters sizes 8 and 10 Ch (rounded tip, no side ports).
- Meconium adaptor for intratracheal suctioning.

Monitoring
- Infant stethoscope.
- Pulse oximeter[g], self-adhesive tape.
- ECG with electrodes for neonates.

Oxygen and compressed air supply
- Oxygen and compressed air sources with flow meter, oxygen blender[f].
- Tubing connecting to face mask/bag and mask device/T-piece system.
- Oxygen face mask.

Equipment for ventilation
- Bag and mask device with a reservoir and a PEEP valve; one extra backup device[h].
- Face masks (sizes 00 and 01); one extra backup set.
- Optionally, a T-piece ventilation system.
- Laryngoscope (video laryngoscope if available), blade sizes 0 and 1; additional back-up batteries.
- Endotracheal tubes: sizes 2.5 / 3.0 / 3.5 (mm internal diameter) for oral (with stylet) and nasal intubations.
- Magill forceps.
- Adhesive tape.
- Stethoscope for infants.
- Guedel oropharyngeal tube sizes 00/000, optionally, Wendl nasopharyngeal tubes.
- Optionally, single-use laryngeal mask airways (sizes: newborns, e.g. AIR-Q® 0.5 and 1.0).

f) Every resuscitation unit (but not necessarily each infant care area in the delivery rooms) is equipped with its own oxygen/compressed air outlets, as well as an oxygen blender and a pulse oximeter.

g) In the delivery room, transcutaneous oxygen saturation measurements to monitor oxygen therapy should always be measured in a preductal position by applying the sensor to the right hand or right lower arm. This is in contrast to the later postductal measurement of transcutaneous oxygen saturation to rule out certain forms of congenital heart disease[154].

h) Adequately trained health care professionals can also use a T-piece resuscitator (i.e. Neo-Puff/Perivent®). Because thorough instruction and regular use is required for its safe and efficient application, it is mandatory to always have a bag and mask device with masks, tubing, and connectors available.

Material for venous access

Peripheral IV lines
- Peripheral IV catheters (e.g. Insyte BD 24G, Neoflon BD 26G).
- Extension lines (paediatric size).
- Three-way stopcock.
- Dressing plasters.
- Splints.
- Syringes (10 ml, 5 ml, 2 ml and 1 ml; 5 each).
- Needles (18 G).

Umbilical venous catheters (emergency placement)
- Sterile gloves (different sizes), surgical hat, sterile gown.
- Disinfectant (containing either alcohol or octenidin-phenoxyethanol), sterile swabs.
- Sterile umbilical catheter set (e.g. Vygon®): umbilical tape, slit/fenestrated sterile drape, 2 Péan clamps, 1 small and 1 large anatomical forceps, 1 surgical forceps, scissors, needle holder, scalpel, suture (e.g. Mersilene Ethicon® 2.0 or 3.0 with atraumatic needle).
- Umbilical venous catheters sizes 3.5 Fr and 5 Fr.

Umbilical venous catheter placement
(Fig. 7 and 8)

1. Assistant holds up umbilical cord.
2. Disinfect abdominal skin around the umbilical stump and umbilical cord.
3. Place sterile umbilical tape around the skin-covered base of the umbilical cord, tighten slightly.
4. Using the scalpel, cut the umbilical cord 1 cm above its skin-covered base; assistant removes the cut cord.
5. Place sterile slit/fenestrated drape over remaining cord stump (continued observation of the infant must be guaranteed).
6. Identify the umbilical vein and the two umbilical arteries.
7. Insert the umbilical venous catheter (usually 5 Fr) previously flushed with 0,9% NaCl; if necessary, grab the Wharton's jelly with a Péan clamp to stabilise the stump.
8. The catheter should be inserted to the appropriate depth according to the size of the infant; in emergency situations, an insertion depth of 4–5 cm is sufficient (confirm intravenous position by aspirating blood).
9. Using a 4-0 thread, suture the catheter to the Wharton's jelly (for short-term insertion) or to the skin-covered cord base (more stable for transport).

Additional equipment
- Umbilical cord clamps.
- Gastric tubes, sizes 6 Fr and 8 Fr.
- Peripheral venous catheters for drainage of a pneu-

mothorax (e.g. Venflon Pro® BD 18 G or 20 G).
- Tape measure.
- Thermometer.

Intravenous fluids
- Glucose 10%: 100 ml bottles and 10 ml vials.
- NaCl 0.9%: 100 ml bottles and 10 ml vials.

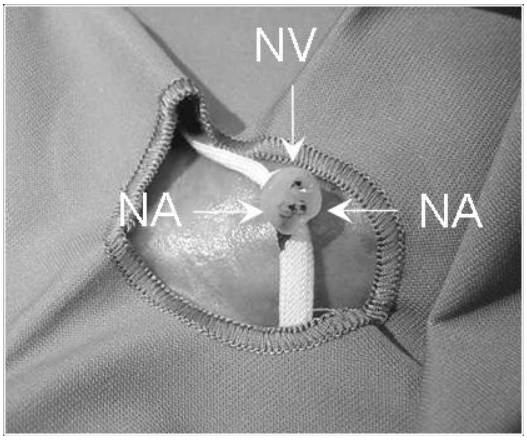

Figure 7: *Vessels of the umbilical cord (NA: umbilical artery; NV: umbilical vein.*

Figure 8: *Introduction of the umbilical venous catheter (UVC).*

List 2

Minimal equipment requirements for delivery in a birthing centre

Inventory
- Warm environment (at least 25°C).
- Designated resuscitation area (can be a mobile unit).
- Storage area and work surface, padded surface at table height, shoulder roll (e.g. folded towel).
- Umbilical scissors, umbilical clamps.
- Stopwatch, Apgar timer.
- Non-sterile gloves (sizes S, M, L).
- Infant stethoscope (to make the heart sounds of the newborn audible to all present, it may be helpful to use a doptone ultrasound heart sound measurement device).
- Thermometer.
- Blood glucose measuring device.
- Resuscitation protocol.
- Telephone access (with telephone numbers of responsible neonatology department, regional ambulance service, and the responsible obstetrics department readily available).
- Secure access routes (ready access for transport incubator at all times).

Lighting
- Bright light, if possible integrated into the radiant warmer.

Heat sources
- Adjustable overhead radiant heat source with a fixed distance to the surface.
- Sufficient supply of warm towels/diapers.
- Preheat resuscitation area early.
- Plastic wrap to minimize heat loss.

Suction device
- Mouth-operated suction device with mucus trap.

Equipment for ventilation
- Bag and mask device (e.g. Baby-Ambu or Laerdal-bag with reservoir) and masks (e.g. Laerdal masks sizes 00 and 01).
- Oxygen face mask and tubing to connect to oxygen source.
- Oxygen cylinder with flowmeter (up to 6–10 l/min), preferably with a blender[f], compressed air cylinder, tubing to face mask/bag and mask device.
- Pulse oximeter[g], self-adhesive tape.

List 3

Minimal equipment requirements for home delivery

Inventory
- Provisional resuscitation area at table hight (no draft!).
- Shoulder roll (e.g. folded towel).
- Thermometer.
- Stopwatch.
- Non-sterile gloves (sizes S, M, L).
- Plastic wrap to minimize heat loss.
- Infant stethoscope (to make the heart sounds of the newborn audible to all present, it may be helpful to use a doptone ultrasound heart sound measurement device).
- Blood glucose measuring device.
- Resuscitation protocol.
- Telephone access (with telephone numbers of responsible neonatology department, regional ambulance service, and the responsible obstetrics department readily available).
- Secure access routes (ready access for transport incubator at all times).

Lighting
- Bright light, over provisional resuscitation area.

Heat sources
- Adjustable radiant heat source (heat lamp or fan heater, no red-light lamp).

- Sufficient supply of warm towels/diapers.
- Preheat provisional resuscitation area early.

Suction device

- Mouth-operated suction device with mucus trap.

Oxygen and gas supply

- Bag and mask device (e.g. Baby-Ambu® or Laerdal®-bag with reservoir) and masks (e.g. Laerdal masks sizes 00 and 01).
- Oxygen face mask and tubing to connect to oxygen source.
- Oxygen cylinder with flowmeter (up to 6–10 l/min).
- Pulse oximeter[g)], self-adhesive tape.

List 4

Minimal equipment requirements for outpatient postnatal care in a home setting

- Telephone access (with telephone numbers of responsible neonatology department, regional ambulance service, and the responsible obstetrics department readily available).
- Bag and mask device (e.g. Baby-Ambu® or Laerdal®-bag with reservoir) and masks (e.g. Laerdal masks sizes 00 and 01).
- Mouth-operated suction device with mucus trap or manual suction flask (e.g. Laerdal Penguin®).
- Warm work space, thermometer, good lighting.
- Blood glucose measuring device.
- Infant stethoscope.
- Plastic wrap.

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Characteristics of various devices for non-invasive ventilation of neonates*[1]

	Self-inflating bag (e.g. Ambu® reusable)	Flow-inflating bag (e.g. Laerdal® reusable)	T-piece system, flow-controlled, pressure limited (e.g. Perivent/NeoPuff®)
Handling	easy	easy	requires training and regular use
Ready for mobile use	yes	yes	no
Flow-dependent performance	no	yes	yes
Ventilation with room air not requiring compressed gas	yes	no	no
FiO_2 reduction without blender possible?	yes, upon removal of reservoir	no	no
Built-in manometer	no (optionally available)	no (optionally available)	yes
Built-in PEEP valve	no (optionally available)	no (optionally available)	yes
Reliable application of PIP	±, if manometer is installed	±, if manometer is installed	yes
Reliable application of PEEP	±, only if PEEP valve is installed	±, more reliable than self-expanding bag, if manometer is installed	yes
Suitable as a CPAP device	no	yes (only short-term)	yes
Inspiratory pressure (peak inspiratory pressure PIP)	limited by pressure relief valve (40 cmH_2O)*[2] enables immediate PIP adjustment by observing chest expansion and pressure at manometer	limited if pressure relief valve is installed*[2] enables immediate PIP adjustment by observing chest expansion and pressure at manometer	device-controlled PIP cannot be increased if flow remains constant, breath-by breath adjustment of PIP rather difficult adjustable maximum PIP
Maximum oxygen concentration (FiO_2 100%)	only with reservoir tube	possible	possible
Control of inspiratory time	± yes	± yes	yes

*[1] *Above devices may be used for invasive ventilation of a neonate if the child is intubated.*
*[2] Higher PIP values only achievable by closure of the pressure relief valve.

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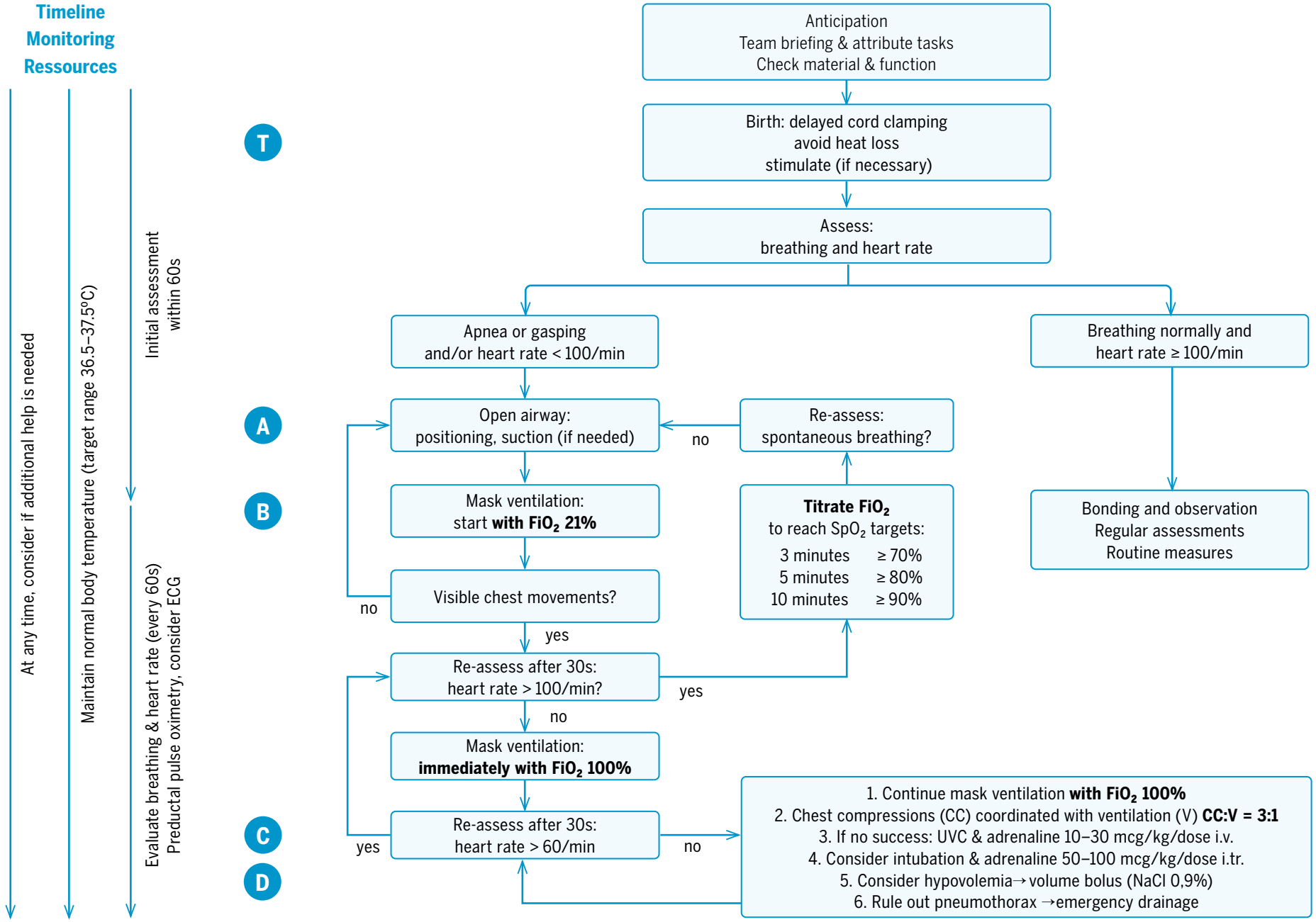
Appendix: *Characteristics of different devices for non-invasive respiratory support of newborn infants.*



Algorithm: *Support for adaptation and resuscitation of the newborn. UVC: umbilical venous catheter; SpO2: oxygen saturation measured by pulse oximetry.*

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