INTRODUTORY GUIDE TO NEONATAL INTENSIVE CARE

VOLUME I

by

THE PERINATAL SOCIETY OF SRI LANKA

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Ministry of Health
Nutrition & Indigenous Medicine

Perinatal Society of Sri Lanka
Towards healthier mothers and newborns

Family Health Bureau

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An Introductory Guide to Neonatal intensive Care

for

Medical and nursing staff

of

Neonatal Intensive Care Units

Perinatal Society of Sri Lanka

2022

Message from the Deputy Director General, Ministry of Health

Dr. Susie Perera MBBS MSc (Com Med) MD (Com Med)

As Sri Lanka strives to meet the sustainable development goals for Neonatal care, the introductory book for NICU care fills a vital need. The importance of standards in care, is a key requisite in the path towards sustaining achievement and accomplishing the goals set for neonatal care. This book to be used by professionals: doctors and nurses brings that much needed understanding for standards and a guide for practice.

The technical contributions to the development of this comprehensive guide book by the Sri Lanka College of Paediatricians and the Perinatal society of Sri Lanka is well appreciated by the National Program for Maternal and Child health in the country.

As a first step the wide dissemination and monitoring of use of this book will be vital. I firmly believe that with the guidance given, a mechanism of using standards and ensuring accountability with good practice can be adopted throughout the Neonatal Intensive care units and SCBU throughout the country. For this the support to the family Health bureau from the Sri Lanka College of Pediatricians

and the Perinatal society will be invaluable.

To all practitioners making use of the book, I urge mindful use, adhering to guidelines and also giving a useful feedback for future improvement of services.

Dr Susie Perera

Deputy Director General Public Health Services

Message from the Director Maternal and Child Health, Family Health Bureau

Dr Chithramalee de Silva

The planning and delivery of clinical care to critically ill neonates is a complex process that involves a variety of unique functions, skills, and responsibilities that are essential in assessing, understanding, and safely supporting the newborn infant and family during this critical time. Health staff in the Neonatal intensive care units (NICU) are also responsible for the safe and appropriate use of technical equipment in the care of these critically ill newborns. This necessitates a standard guidebook and training of health staff based on that to ensure high quality clinical and supportive care is delivered to these babies in NICUs.

“An Introductory Guide to Neonatal Intensive Care for Medical and Nursing staff” is a long felt need and I must congratulate the Perinatal Society of Sri Lanka for successfully accomplishing that task. A dedicated team of Consultant Neonatologists and Consultant Paediatricians have come together to develop this resource in collaboration with the Family Health Bureau. My special thanks go to UNICEF Sri Lanka for agreeing to print this guide book.

I look forward to the continuous support by the Perinatal Society of Sri Lanka and the Sri Lanka College of Paediatricians for training of health staff in neonatal intensive care units based on this guide book to ensure best possible care for the most vulnerable sick and small newborns.

Dr Chithramalee de Silva

Director Maternal and Child Health, Family Health Bureau

Message from the President
Perinatal Society of Sri Lanka-2022

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The launch of this book, "A basic guide to neonatal intensive care"; I call this moment, a long awaited dream becoming a reality. I am honestly proud as the president of the PSSL and as the first neonatologist in the country to be able to contribute to this book in many ways and also to witness It's being published during my tenor as the President of the PSSL. Long years ago, I suggested to initiate a training program for neonatal nurses during Prof. Dulani Gunasekara's term of the office as the president, and it has turned a reality today.

The success stories of neonatal units mainly depend on the knowledge, skills attitude and dedication of nursing and junior medical staff. This is a fact I strongly believe in my carrier as a neonatologist. We, the PSSL should be proud because, we have been able to pave the way for professional development of neonatal nurses as well as junior medical officers.

I must thank Prof. Dulani Gunasekara, “the iron lady” who worked tirelessly, for coordinating chapter by chapter with an extremely busy set of consultants with great difficulty. I must also thank all the consultants who contributed for this book by writing chapters as well as for the support given throughout.

I am very sure that this book will make a ground breaking change in the professional development of neonatal nurses and doctors and will contribute remarkably for improved neonatal mortality and morbidity in Sri Lanka.

Dr. L.P.C. Saman Kumara

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Preface

With improving health care, neonatal mortality has reached a significant low in Sri Lanka. We have achieved this by investing heavily in the primary health care network. However we have now reaped maximum benefit from this investment, To improve further, we now have to invest in improving quality of care.

Annually, just under 300,000 births occur in the country. According to a bottle neck analysis done in Sri Lanka(EmOC survey, 2012), between 7– 28% of these babies need neonatal intensive care or special baby care. If we are to reduce our neonatal morality figures and improve the outcome for these babies, we need to further strengthen our neonatal intensive care.

To have quality care, staff need to be familiar with the proper methodology needed in an NICU setting, with easy access to reference guides to common problems which occur in these units. At present, there is no standard protocol or practical guide for staff (both doctors and nurses)starting work in these Neonatal Units or Special Care Baby Units in the country. During my presidential year at the Sri Lanka College of Paediatricians, one of my aims was to have an orientation course for staff manning NICU/SCBU units; I am happy that the initial steps for this is the launch of this book, even though it is happening several years afterwards.

This handbook aims to help medical and nursing staff caring for newborns to learn the basic management of a sick baby in an NICU setting. Two volumes are planned for this handbook.

This book(volume 1) is divided into ten chapters which deal with knowledge and skills needed in the day to day management of babies receiving neonatal intensive care, with technical details included where necessary. Some of the ‘hands on’ skills needed will be demonstrated through several workshops planned, based on the chapters of the book.

We hope that this guide will be helpful to provide a sound foundation specially for new recruits (both doctors and nurses) to the NICU setting, helping them to care for these neonates in accordance with

accepted standards. The references for the chapters have been taken from internationally accepted scientific protocols, and a bibliography is provided with each chapter for further reference.

Certain 'soft skill' areas such as communication, bereavement and record keeping have not been included, but we hope to compile these as a second volume to this edition.

I sincerely thank the authors who worked tirelessly to produce and fine tune the chapters to the final high standard which we have achieved in this volume.

I thank the World Health Organization for the funding, the Ministry of Health for the guidance provided and the Family Health Bureau for the logistics.

Finally, I thank Dr. Nimesha Gamhewage for the editorial assistance given.

Professor Dulanie Gunasekera MBBS MD FRCP(Lon) FSLCP

Editor

Contents

The Golden Hour

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The concept of "Golden Hour" has been introduced in the field of neonatology, highlighting the importance of neonatal care in the first 60 minutes of postnatal life.

Learning Objectives –

- To recognize the importance of the concept of "Golden hour"
- To identify the main components to be addressed during this 60 minute of life
- To identify a sick newborn following birth who requires stabilization and care
- To identify the challenges in managing newborns during the golden hour
- To know how to prevent and manage complications arising during this period

Components of Golden Hour (GH)

1. Antenatal counseling, team briefing
2. Delivery room and NICU preparation
3. Delivery - delayed cord clamping (DCC)
4. Prevention of Hypothermia
5. Respiratory support
6. Cardiovascular support
7. Nutritional support
8. Prevention of sepsis

9. Laboratory investigations
10. Monitoring/Record keeping
11. Communication and counseling of family
12. Stabilization and transportation in the Golden Hour
13. Handing over baby and stabilization at NICU/other hospital

1. Antenatal counseling and team briefing

Infants born at an extremely low gestational age have a high mortality rate and are at risk of having neuro-developmental disabilities ranging from subtle to severe in grade. Gestational age and weight of delivery has shown strong association with neuro-developmental outcome, and it serves as the basis for antenatal counseling.

When a preterm delivery is planned, it is important that the mothers/ parents should be counselled prior to delivery to educate them regarding the risks and possible complications of the preterm baby to be born.

2. Delivery room and NICU preparation

When called for attending birth of high risk neonate ,the resuscitation team should decide for the team leader and every member of the team should be given role before the delivery of the neonate so that during resuscitation there are no confusions over interventions and thus avoiding any miss-happening. The NICU personal need to be informed for the expected neonatal admission, especially if the team is going to attend birth of any preterm neonate. Working condition of the instruments needed during resuscitation should be checked and should be in adequate number if twins or triplets are being expected. Pre-resuscitation check list use make this equipment checking process very easy and rapid. Maternal history should be read in detail from the maternal records and required details should be noted down. The team who is going to attain the delivery of premature, should be expertise in attending such neonates and should have necessary skills for all interventions that may be required in the delivery room. During the time neonate reaches NICU, neonatal bed should be made

ready and all required medications should be procured, thus avoiding delay in treatment once the shifting process is over

3. Delivery - delayed cord clamping (DCC)

Physiologically early cord clamping (ECC) has been defined as clamping of cord when circulation of blood from placenta to newborn is still there and delayed cord clamping (DCC) has been defined as clamping of cord after stoppage of placental circulation.

The factors that determine the placental transfusion include cord clamping time, uterine contractions, umbilical blood flow, newborn respiration, and gravity. The placental flow to fetus decreases rapidly after the neonatal birth and after three minutes of birth, placental blood flow becomes insignificant, and by 5 minutes it absolutely ceases.

A delay in cord clamping (DCC) for at least one minute (1- 3 minutes) is recommended for all preterm and term newborns not requiring resuscitation at birth.

4. Prevention of Hypothermia

Hypothermia is defined as temperature < 36.5 °C and is a dangerous problem in newborns especially in very low birth weight (VLBW) babies (< 1500g) and extremely low birth weight (ELBW) babies(<1000g). Admission temperature in NICU is a strong predictor for neonatal

mortality. The highest risk of neonatal hypothermia is within the first minutes to hours after birth as there is wide difference between in-utero and environmental temperature.

At delivery, babies (<32 weeks or <1500g) are covered with polyethylene wrap/cling wrap or transferred into a clean food grade plastic bag **without drying**. (Fig 1). All necessary examination and resuscitation steps should be carried out with newborn covered in wrap. The head should also be covered with a cap during these procedures.

The wrap/bags are to be removed **only after** the newborn is shifted to nursery and is stabilized in the incubator and normothermia achieved. (refer chapter 2 for further details on prevention of hypothermia)

Figure 1

5. Support of respiration

The goal of providing support to respiratory system is to help in the smooth transition of gas exchange from placenta to baby's lung.

Support of the respiratory system forms an important part of Golden Hour management.

Neonatal Resuscitation Programme 2020UK(NRP UK 2020), recommended that resuscitation of preterm newborns (less than 35 weeks of gestation) should be started with 21 - 30% oxygen(O2), and in newborns more than 35 weeks of gestation, to be started with room air.

At the delivery, resuscitate using room air in the absence of blended O2. If blended O2 is available, use 21-30% O2 for newborns less than 35 weeks gestation.

Use of pulse oximetry is recommended in the following situations- after initiation of resuscitation, continuing positive pressure ventilation (PPV), if central cyanosis persists beyond the first 5 minutes of life, or when supplementary oxygen is administered.

The goal of oxygen therapy is to achieve pre-ductal oxygen saturation as per the time specific interquartile range recommended in NRP UK 2020: (at one minute 60-65%, two minutes 65-70%, three min 70-75%, 4 min 75-80%, 5 min 80-85% and 10 min 85-95%). (Annexure 1)

Prophylactic CPAP commencing from the delivery room using a T piece device (e.g. neo puff) is beneficial for ELBW babies and babies with moderate respiratory distress.

When neonates are transported to NICU and started on supplementary oxygen then targeted saturation should be between 90-94% in preterm infants and more than 95% in term babies.

6. Support of the cardiovascular system

The goals of giving support to the cardiovascular system is to have a:
• Capillary refill time(CRT) of less than 3 seconds (<3 secs)
• Heart rate (100 -180/min)
• Acceptable Mean Blood Pressure; (MAP =gestational age) in all newborns

The first parameter that shows effectiveness of resuscitation is improvement in heart rate. To assess the response to initial steps of resuscitation, auscultation along the left side of the chest is the most accurate physical examination.

Drugs - In situations where drug administration is needed (normal saline and adrenaline), venous access should be established at the earliest, the umbilical vein being the easiest vein to be cannulated.

Investigations - blood lactate measurement can be done in a blood gas analysis and is used as a biomarker in diagnosing

and assessing the severity of systemic hypoperfusion and acidosis. This can help in diagnosis of previous shock in normotensive neonates during the golden hour.

Bed side functional echocardiography (FE) when possible, has come into use and is used as a point of care intervention in the Golden Hour to find out the cause of shock and help in the acute management.

Drugs are required during resuscitation only when the newborn still has a heart rate below 60 beat per minute, despite effective ventilation and chest compression.

7. Supporting nutrition

Providing support to nutrition for both term and preterm newborns is a priority. In case of term newborns with no contraindications to feeding, breast-feeding should be started as

soon as possible, within one hour of birth. Stable newborn babies should be kept on skin-to-skin contact with mother immediately after birth.

After admission to neonatal unit, the very low birth weight babies / extremely low birth weight babies should be started on total parenteral nutrition (TPN) (dextrose, lipids and protein) **ideally within the first hour of post-natal life.** Enteral feeding with mother's milk should be started within golden hour in the absence of contraindications (e.g. surgical conditions).

(Please refer chapter on intravenous fluid balance and enteral feeding for further details)

8. Prevention and treatment of infection

Many interventions are done to prevent neonatal sepsis, but the most important are **hand washing** and using **aseptic precautions** while handling the newborn. The newborn should be handled with strict aseptic techniques starting from the time of birth. Minimal handling, skin to skin contact, breast feeding and sterile procedures soon after birth also contribute.

In any baby needing respiratory or cardiovascular support, a blood culture should be drawn mandatorily and the first dose of antibiotic (as per unit policy) needs to be commenced where indicated.

9. Laboratory investigations

The investigations need individualization as per the newborn clinical status and ante-natal risk factors. The list of various investigations includes complete blood count, blood culture, blood glucose and blood gas analysis. In case of perinatal asphyxia cord arterial blood gas (ABG) or ABG (from baby) within first hour will help us to decide upon starting of therapeutic hypothermia.

10. Monitoring/Record keeping

Monitoring and record keeping is an important part of golden hour. The following vital parameters of the newborn should be monitored:

- **Temperature**
- **Heart rate**
- **Respiratory rate**
- **Capillary refill time**
- **Invasive/ non-invasive blood pressure**
- **Oxygen saturation, blood sugar, blood gas analysis**

These should be monitored and recorded in the newborn case record. Records need to be kept of the various interventions done with their timing as this will guide us in monitoring the progress of the baby and planning further interventions.

Record keeping includes Apgar Score, interventions done during resuscitation, birth weight, axillary temperature at time of admission to nursery, and timing of all interventions done during the golden hour.

11. Communication and counseling of family

This is an important aspect of the Golden Hour and includes talking with parents and relatives of the newborn to update the postnatal

condition of newborn. The parents of preterm and term newborns admitted in nursery or requiring referral to a higher center, should be counseled regarding the present status, interventions that have been done till that time and further plan of management. This should be done by the **senior most medical officer** available at the time, while the consultant should be involved in complicated scenarios as soon as possible.

A communication Form should be used to document information given and signed by both the medical officer and the parent.

12. Stabilization and transportation in the Golden Hour

In Golden hour, the neonate should be first **stabilized prior to transportation.**

- **Establish and maintain respiratory support**
- **Establish and maintain circulation**
- **Check blood oxygenation by way of an O2 saturation monitor and/or blood gas analysis**
- **Maintain normal temperature by resuscitating under a warmer/ resuscitative**
- **Check and maintain normal sugar levels**

Necessary interventions should be done to support heart, lungs, and brain (e.g. ventilatory/ CPAP support if required and fluid boluses if the newborn is in shock). (Refer Resuscitation of the newborn – NRP UK 2020 for details)

All sick/preterm newborns should be transported in a pre-warmed, well-equipped TRANSPORT INCUBATOR with a T-piece (e.g., neo-puff)/transport ventilator facilities where indicated. Make sure that the incubator is turned on BEFORE the delivery, since it will take some time to warm up to the required temperature.

13. Handing over baby and stabilization at NICU/other hospital

Sick newborns in need of intensive care should be admitted to NICU for further management. At the admission to NICU, a brief clinical history of mother. This information should be given by the transporting team which should include a doctor **and** a nurse accompanying the baby to the NICU/other hospital.

It is important to note that although all precautions are taken, the baby may become destabilized during transport.

Stabilization at NICU - if the baby has respiratory distress, respiratory support should be instituted immediately. Body temperature, blood sugar levels and blood pressure should also be checked again, and interventions should be done where needed.

Summary

- Parent should be counseled regarding imminent delivery of the preterm/high risk baby
- At Delivery – perform delayed cord clamping if neonate does not require resuscitation
- Use plastic wrap for ELBW babies
- Keep baby warm- dry thoroughly, use cap to cover head
- Initiate breast feeding within the first hour of life if baby does not require intervention
- Record all vital signs and procedures done during resuscitation
- Perform blood sugar and blood pH (from UVC sample if available) if resuscitation needed
- **Stabilize** baby before transfer to the NICU
- Start CPAP in labour ward for ELBW babies and also for babies in respiratory distress
- Hand over baby to NICU staff with proper records and communication
- **Communicate with parents** regarding baby's condition

Key Points to Remember

- "Golden hour" is a novel concept coming up in the field of neonatology.
- It deals with the first 60 minutes of the life of the newborns following birth.
- It starts with antenatal counselling and ends with safe transport and diligent record keeping and handing over to the NICU where applicable.
- The main aim is to prevent hypothermia and other common issues following birth.
- Sick newborn should be differentiated from a well newborn and and the ways of prompt stabilisation and transport is of paramount importance to reduce future neuro-developmental disabilities.
- It is essential to stabilise the sick newborn before transferring to the NICU

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Thermal Care in the Neonatal Unit

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Introduction –

Newborn babies have poor control of body temperature. Their heat conservation mechanisms are not well developed. Since their body surface area is relatively large compared to their weight, they lose much heat from their body, specially from the head area.

Body organs function effectively in a 'thermoneutral environment'; i.e. when the body does not have to burn energy to keep warm. For humans this optimal temperature is (36.5^0 -37.5^0C). If body temperature drops below this, organ function deteriorates, and the body spends energy to keep warm.

Learning objectives

- The importance of maintaining thermoneutrality
- What is hypothermia
- The dangers of hypothermia
- Temperature regulation in an incubator
- How to prevent hypothermia – incubator care
- Kangaroo Mother Care (KMC)

The following diagram shows ways of heat loss in a newborn *(Figure 1)*

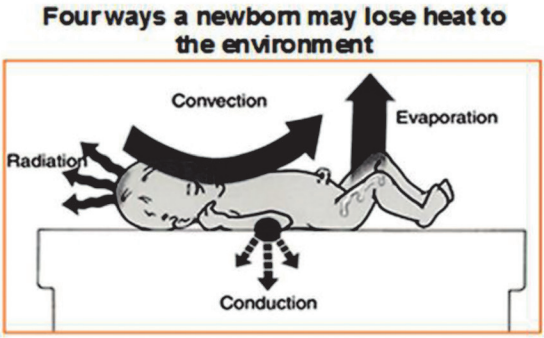

Figure 1

In preterm babies, this loss is worsened by the fact that they have less or no brown fat to insulate them from the cold environment, and sick babies lose their ability to control temperature as well. This situation is called hypothermia. When hypothermia occurs, all organ functions are affected. This may result in metabolic acidosis, hypoglycemia, decreased surfactant production, increased caloric requirements, multiorgan malfunction and if chronic, impaired weight gain.

Hypothermia increases the mortality rate in newborns. Therefore, when caring for sick or preterm babies, it is vital to maintain a thermo neutral environment, where body systems will function optimally.

A body temperature less than 36.50C is defined as hypothermia. *(Figure 2)*

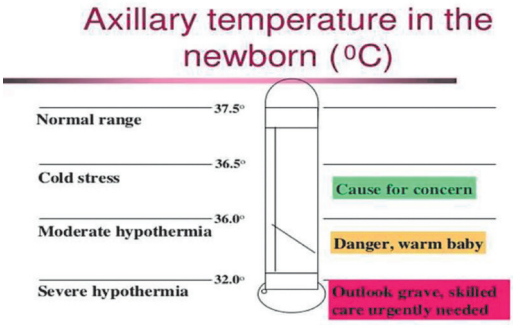

Figure 2

Thermoregulation in the NICU setting –

Babies admitted to NICU settings are sick or preterm babies, and are prone to hypothermia.

It is essential that you detect this and take immediate steps to warm the baby, except when they are targeted for medically induced hypothermia (i.e. total body cooling).

On admission –

1. Defer weighing until in warm ambient environment (eg. in incubator)
2. On admission axillary temperature should be checked. On transferring into the incubator, attach a skin probe over the right hypochondrium for continuous monitoring of skin temperature. Infants should be nursed in the neutral thermal environment and have a body temperature between 36.5^0C – 37.5^0C.

> Aural temperature is not reliable in the newborn.
> Rectal temperature is relatively invasive.

On-going monitoring

- Check axillary temperature half hourly/hourly (if not using continuous skin monitoring).
- Servo controlled humidified incubators should be used where possible. If in manual mode, adjust the incubator temperature by 0.5^0C at a time, to maintain baby's temperature within the required range.
- Set incubator temp. to 35^0C initially (figure 3). Servo-controlled incubators will adjust temperature to suit baby's required body temperature.
- Routine care/ monitoring should be done through the incubator 'ports' rather than opening the doors whenever possible.
- Care should be given as **'cluster care'**, e.g., nappy change, turning baby, naso-gastric feeds etc. could be bundled at one

time; similarly checking blood sugar/taking blood could be done together when mother is handling the baby and giving Kangaroo Mother Care (KMC)(see below).

- For stable babies, cluster care could be combined with breast feeding and KMC.

(refer chapter on Developmental Care for details of cluster care).

Recommended environmental temperature (for closed incubators) for naked infants on the day of birth *(Figure 3):*

Birth weight	***Temperature (°C)***
1000 g	35.0
1500 g	34.5
2000 g	34.0

Figure 3

Neutral Thermal Environment Chart – *Refer annexure 2*

Maintaining humidity in- incubator –

- **It is essential to humidify the incubator air**
- **Environmental humidity should be maintained in the incubator**

Infants born at less than30 weeks gestation have an immature epidermis and stratum corneum and are at an increased risk of trans-epidermal water loss (TEWL). The use of environmental humidity assists to reduce TEWL and in turn supports temperature regulation, fluid and electrolyte management and skin integrity.

All neonates below 30 weeks gestation AND less than 2 weeks of age should be nursed in the incubator maintaining environmental humidity and servo control thermoregulation functions.

The following should be monitored and recorded :

- Four hourly axillary temperatures. On commencing environmental humidity, perform hourly until stable, increase frequency if outside of normothermia.
- An accurate fluid balance.

The water reservoir within the incubator should be filled with sterile water to prevent bacterial colonization, and regularly checked and refilled as required. If condensation occurs in the incubator, the humidification is adequate.

Humidification settings - annexure 3

Monitoring humidification

The impact of TEWL and serum sodium levels should be regularly assessed, by testing for hypernatraemia as an indicator of excessive TEWL or water deficit, this signifies a necessity for a higher humidification percentage in the incubator.

Weaning off humidification

Gradual weaning should occur with staged reductions in the humidity percentage after 7 days of life, as long as this is clinically appropriate.

Transferring from incubator to cot (i.e to ambient temperature) –

This should be attempted gradually when the baby is about 32-34 weeks (corrected age).

- Reduce the incubator temperature gradually while monitoring the baby's temperature.
- Wean temperature by 0.5°C hourly (as a maximum) until the temperature is at the 26-27°C.
- In servo-controlled incubators, heating can be switched off when the incubator heat generation in less than 25%
- Once the baby can maintain normal body temperature with the incubator thermostat in the **'switched off'** position, then the baby can be transferred into a cot.

- Dress the baby(including cap) and wrap in a blanket when transferring to a cot.

Ambient Temperature in the NICU/SCBU

Ambient temperature should be set at 26-280C specially in the SCBU area.

Kangaroo mother Care (KMC)

KMC basically means skin to skin contact of mother and baby, thereby using the mother's body heat to keep the baby warm. It is a very cost-effective way of preventing hypothermia, especially in preterm babies. KMC does not require special facilities, but simple arrangements and can make the mother's stay more comfortable.

KMC has been shown to have the following benefits:

- KMC is as/more efficient than an incubator, with less chance of cross infection and handling by multiple staff members.
- regularizes breathing and reduces apnoeic attacks and regularizes sleep patterns.
- colonizes the baby with healthy maternal flora and reduce the incidence of nosocomial (hospital acquired) infections.
- expedites weight gain of the newborn
- KMC benefits mother as well, by improving the bonding with the baby.

KMC can be carried out by the mother, father or any care giver.

Conditions for starting KMC

- Babies weighing less than 2500g
- Should be haemo dynamically stable. Babies on noninvasive respiratory support (e.g. CPAP, NIMV, High flow oxygen) can be given KMC provided that they are carefully observed for accidental obstruction of airway.

Babies should be dressed in a sleeveless, front opening baby shirt, cap & socks. Mother can wear a culturally accepted light garment with a front opening. Position of the neck, colour and temperature of the baby should be checked regularly while providing KMC *(Figures 3,4).*

Figure3

Figure 4

(Source: Family Health Bureau)

There is no real time limit to stop KMC. It can be discontinued when baby reaches more than 2.5Kg in weight or when baby feels uncomfortable.

(KMC and delivery into a plastic bag will be demonstrated during the practical sessions)

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Annexures –

Annexure I – optional KMC Attire

CONCEPT

Kangaroo-mother care is a non-conventional method for caring for low birth weight and preterm newborns after initial stabilization.
The primary features of kangaroo-mother care are:

» - Uninterrupted use of adult body heat (skin-to-skin contact) in order to maintain the newborn's body temperature; and

» Exclusive breast-feeding.

The newborn is placed in a prone and upright (or diagonal) position between the mother's breasts, and covered with the mother's clothes and a cloth/ blanket/shawl, for most of the day and night.

This method can be tiring for the mother and restricts her freedom of movement.

The apparel is designed in such a way that its easier, comfortable and more friendly to practice KMC for the mother. She mother should be able to practice KMC even without any additional help. It should not make movement very restrictive.

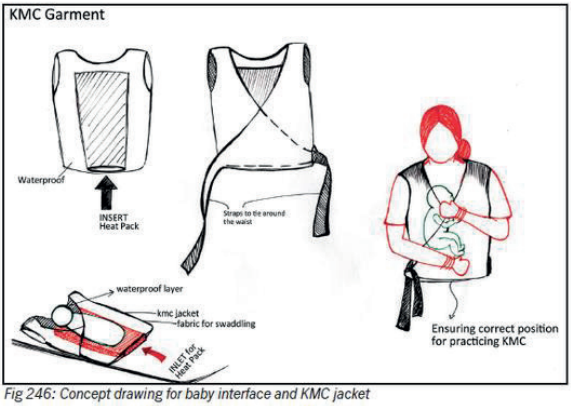

Fig 246: Concept drawing for baby interface and KMC jacket

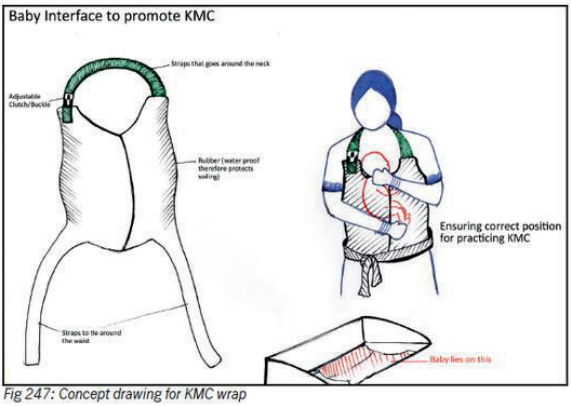

Fig 247: Concept drawing for KMC wrap

(Source - WHO Essential Newborn Care Course- Training Manual)

Annexure 2 – Age related 'Neutral Thermal Environment' Chart

Age	Weight (grams)	Starting Temperature (°C)	Range of Temperature (°C)
0 – 6 Hours	< 1200	35.0	34.0 – 35.4
	1200 – 1500	34.1	33.9– 34.4
	1501 – 2500	33.4	32.8 – 33.8
	> 2500	32.9	32.0 – 33.8
6 - 12 Hours	< 1200	35.0	34.0 – 35.4
	1200 – 1500	34.0	33.5 – 34.4
	1500 – 2500	33.1	32.2 – 33.8
	> 2500	32.8	31.4 – 33.8
12 -24 Hours	< 1200	34.0	34.0 – 35.4
	1200 – 1500	33.8	33.3 – 34.3
	1501 – 2500	32.8	31.8 – 33.8
	> 2500	32.4	31 – 33.7
24 – 36 Hours	< 1200	34.0	34.0 – 35.0
	1200 – 1500	33.6	33.1 – 34.2
	1501 – 2500	32.6	31.6 – 33.6
	> 2500	32.1	30.7 – 33.5
36 – 48 Hours	< 1200	34.0	34.0 – 35.0
	1200 – 1500	33.5	33.0 – 34.1
	1501 – 2500	32.5	31.4 – 33.5
	> 2500	31.9	30.5 – 33.3
72 – 96 Hours	< 1200	34.0	34.0 – 35.0
	1200 – 1500	33.5	33.0 – 34.0
	1501 – 2500	32.2	31.1 – 33.2
	> 2500	31.3	29.8 – 32.8

Age	Weight (grams)	Starting Temperature (°C)	Range of Temperature (°C)
4 – 12 Days	< 1500	33.5	33.0 – 34.0
	1501 - 2500	32.1	31. – 33.2
	> 2500	Day 4-5: 31.0 Day 5-6: 30.9 Day 6-8: 30.6 Day 8-10: 30.3 Day 10-12: 30.1	30.5 – 32.6 29.4 – 32.3 29.0 – 32.2 29.0 – 31.4 29.0 – 31.4
12 - 14 Days	< 1500	33.5	32.6 – 34.0
	1501 - 2500	32.1	31.0 – 33.2
	Over 2500	32.8	31.8 – 33.8
	> 2500	29.8	29.0 – 30.8
2-3 weeks	< 1500	33.1	32.2 – 34.0
	1501 - 2500	31.7	30.5 – 33.0
3-4 weeks	< 1500	32.6	31.6 – 33.6
	1501 – 2500	31.4	30.0 – 32.7
4-5 weeks	< 1500	32.0	31.2 – 33.0
	1501 – 2500	30.9	29.5 – 35.2
5-6 weeks	< 1500	31.4	30.6 – 32.3
	1501 – 2500	30.4	29.0 – 31.8

(Source: Royal Children's' Hospital, Melbourne, Australia – clinical guidelines)

Annexure 3 – Humidity settings for Incubator

Day of Life	Environmental Humidity (%)
1-7	80%
8	75%
9	70%
10	65%
11	60%
12	55%
13	50%
14	45%
15	CEASE

(Source: Royal Children's' Hospital, Melbourne, Australia – clinical guidelines)

Monitoring & Emergencies in the NICU

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Learning objectives –

- Routine monitoring of a sick newborn in NICU
- Clinical signs of further deterioration
- Steps to be taken upon identification of deterioration
- Causes of sudden deterioration
- Emergencies in NICU – identification and management of:
  - ✦ Neonate in Shock
  - ✦ Neonatal convulsions
  - ✦ Tension Pneumothorax
  - ✦ Pulmonary Haemorrhage
  - ✦ Intra Ventricular Haemorrhage
  - ✦ Endo Tracheal Tube problems

1. Routine care and monitoring of a sick newborn in NICU

1. Nurse baby in Incubator / open care warmer
2. Connect to multi para monitor
3. Document vital signs:

   Respiration: Document respiratory rate hourly. 40-60 breaths/ min is satisfactory. Less than 30/min or more than 60/min needs medical attention.

   Heart Rate: Document hourly. 90-160 beats/min at sleep is satisfactory. Less than 90/min or more than160/min needs medical attention.

Blood Pressure: Blood pressure should be monitored and recorded 4-6 hourly. Mean Arterial Pressure(MAP) less than gestational age requires immediate action. *(blood pressure normogram - Annexure 1)*

Temperature: Document every 4-6 hours. Axillary/skin temperature should be maintained between 36.5^0C – 37.5^0C. Temperatures outside this range (hypothermia/ hyperthermia) need urgent medical attention

Pulse Oximetry: Document SpO_2 hourly. Preterm babies - maintain between 91-95%. Term babies - maintain between 94-98 %

4. Monitor **capillary blood sugar** 4-6 hourly, if less than 45mg/dl or more than 150mg/dl, needs medical attention.
5. **Fluids and Electrolytes:** Fluid requirement varies according to birth weight and chronological age of the baby. This is given as 10% Dextrose. Calcium gluconate should be added for sick babies from **day 1** onwards. Sodium and potassium should be added from day 3 onwards *(for further details refer chapter on iv fluids and TPN)*
6. **Nutrition:**

   Baby may need to be kept nil orally until stable. Breast milk should be started as soon as possible. Gradually step-up feeds according to the gestation, increasing by 15 -20 ml/kg/day. Parenteral nutrition should be considered for sick preterm babies <1500g & any baby unable to be fed orally for over five days *(for further details refer chapter on iv fluids and TPN)*
7. Document passage of urine: Absence of urine for more than 12 hours without a palpable bladder may need a fluid challenge and renal function assessment. Urine output should be maintained at 1-3ml/kg/hr.
8. Manage the clinical problem/s as per specific protocol (e.g. Antibiotics for Sepsis, Respiratory support for surfactant deficient lung disease)

9. **Maintain asepsis:**

   Handle with clean hands, manage the cannula sites and central lines with strict aseptic precautions. Follow aseptic steps in all procedures including nasal, oral and endotracheal suction. (refer chapter on infection control for details)

10. Weekly IM/IV Vitamin K (0.5 mg) for babies less than 1500g or 34 weeks gestation, till 6 weeks of age

11. Avoid unnecessary disturbances – e.g. excessive light / noise /pain / handling should be avoided. *(for further details refer chapter on Developmental Care)*

Handling a sick infant, roughly or unnecessarily (too frequent suction, causing pain by venesection, arterial puncture for ABG, procedures such as ultrasound scanning etc.) may lead to IVH, pneumothorax, apnoea, hypothermia, sepsis etc. Only essential handling & procedures should be done.

Practice **cluster care** as much as possible

2. Clinical signs of further deterioration

Deterioration can be gradual or sudden. The medical/nursing officer should have a clear understanding of signs of deterioration, in order to recognize them. Immediate appropriate action should be taken to prevent irretrievable morbidity or death.

The Important clinical signs that indicate deterioration are:

1. **Cardiovascular:**
   - Persistent tachycardia (a heart rate more than 180 beats per minute)
   - Bradycardia (a heart rate less than 80 beats per minute)
   - Prolonged capillary re-fill time (CRT) more than 3 seconds
2. **Respiratory:**
   - Slow, shallow, irregular respiration
   - Tachypnoea more than 80 breaths per minute

- Grunting, recessions, nasal flaring, gasping
- Apnoea

3. **Neurological:**
   - Excessive lethargy or poor response to stimulation.
   - Abnormal/subtle movements or convulsions
   - Hypertonic episodes/Neck retraction
   - High-pitched/weak cry
4. **Gastrointestinal:**
   - Poor feeding tolerance/vomiting
   - Blood stained / coffee ground aspirates / bloody stools
   - Tensed / distended abdomen +Periumbilical erythema
5. **General:**
   - Temperature instability (Hypothermia/ Hyperthermia - **if persisting for more than an hour, consider infection until proven otherwise)**
   - Change in colour, pallor or cyanosis
   - Mottled skin
   - Bleeding tendency (petechiae, ecchymosis, excessive bleeding during cannulation, fresh blood on ET suctioning)
   - Increasing jaundice
   - Change in respiratory pattern or drop in SpO2 during handling
6. A baby who **"does not look right"** without a specific problem should also be considered as deteriorating.

3. Steps to be taken on detecting deterioration of a sick baby;

1. Immediately move baby to the high dependency/resuscitator (if already not in HDU)

2. Call for help
3. Resuscitate baby if needed: (refer NLS protocol for details)
    a. Open the airway, commence Bag and Mask breaths if apnoeic
    b. Oxygen once breathing assured
    c. cardiac compressions if HR <60/min
    d. Intravenous(IV) access–two canulae if central line not available
    e. N. Saline 10ml/kg IV if perfusion is unsatisfactory
4. Inform Doctor/senior staff immediately
5. Document vital signs after stabilizing baby (HR, BP, RR, SpO2, Temperature)
6. Document the incident and resuscitation steps taken after baby is settled.

4. Causes of deterioration of a neonate in ICU care

1. Sepsis – Septicaemia, Meningitis, Pneumonia
2. Intra Ventricular Haemorrhage
3. Convulsions
4. Opening of Ductus Arteriosus
5. Closure of ductus arteriosus in babies with duct dependent congenital heart diseases
6. Hypotension/shock
7. Pneumothorax
8. ET tube displacement/block (mucous plug/blood clot)
9. Pulmonary Haemorrhage
10. Equipment failure
11. Uncompensated respiratory / metabolic Acidosis
12. Bowel Rupture in Necrotizing Enterocolitis

13. Undetected Hypoglycaemia
14. Unattended Hypothermia
15. Hypo/ hypernatremia

5. Management of emergencies in the NICU

5.1 Neonate in Shock

The compensated phase of shock is commonly missed in neonates, in whom it's mostly recognized in the uncompensated phase. Neonatal shock is characterized by a decrease in vital and non-vital organ perfusion. This will lead to cellular hypoxia, and if not acted upon immediately will result in multi-organ failure and death.

How to recognize a baby in shock;

The signs of shock are:

- Prolonged capillary filling time (CRFT>3 seconds)
- Pallor or mottling
- Cold extremities
- Tachycardia/ bradycardia/ arrythmia
- gasping/apnoea
- Absent/ weak /rapid pulse
- Low blood pressure(MAP)/wide pulse pressure
- Absent/Reduced urine output <1ml/kg/hr
- Non /hypo responsiveness

What actions should be taken if you detect a baby in shock?

- Shout for help - Inform doctor/senior immediately
- Take care of Airway and Breathing, secure IV access
- Normal saline 10 ml/kg should be given IV over 10 to 20 minutes. This will correct the perfusion and capillary filling time. Another 10ml/kg of Normal Saline IV may be repeated if the circulation is still not satisfactory.

- NB: An intravenous infusion of dopamine/dobutamine at a rate of 5 µg/kg/minute may be used to increase cardiac output if fluid alone does not correct the shock. The dose may be increased or consider adding another inotrope. (Refer NLS protocol for details)
- Correct hypoglycaemia
- Document and convey your findings around the time of shock to relevant team members
- Work- up to identify the primary cause for the shock
- Manage the possible primary contributor/s on clinical judgement pending investigation results

5.2 Neonatal Convulsions

How to recognise a convulsion in a neonate

- Twitching of part of the body, one side, or the whole body
- Extension of part of the body (e.g., an arm) or the whole body
- Subtle convulsions (e.g., sucking/ swallowing/ smacking movements, deviation of the eyes to one side, repeated eye blinking or cycling movements of a limb).
- **Apnoeic attacks**
- Look for supporting evidence such as tachycardia, blood pressure fluctuation and reduction in SpO_2

Action upon identification of convulsions:

- Inform doctor/senior medical officer immediately
- Clear the mouth and pharynx and remove any vomitus
- Give oxygen by face mask if SpO2 unsatisfactory
- If the baby does not breathe, ventilate using bag and mask
- If fits are repeated/prolonged - empty, the stomach to prevent aspiration.
- Always check the blood sugar, as hypoglycaemia is a common cause of fits.

- A neonate with fits should be nursed in an incubator & transferred to the high dependency section
- Medication - Repeated / prolonged convulsions will need loading doses of Phenobarbitone. If repeated fits occur, further medications could be given *(Annexure 2)*

5.3 Pneumothorax

Spontaneous pneumothorax may happen in any neonate. It is the end spectrum of air leak syndrome. Usually, neonates who are not well sedated and those with high ventilator pressures are at high risk. Babies with congenital cystic lung malformations, pneumatoceles and lung hypoplasia are also more prone.

When to suspect a tension Pneumothorax

- Sudden deterioration of a ventilated neonate
- Reduced/Absent air entry on one side of chest
- Tensed abdomen
- No improvement with increasing ventilator support

  Trans-illumination immediately with light source may help with diagnosis

Action to be taken on suspicion of a tension pneumothorax

Insert a large bore butterfly needle (e.g., 21 G-green) at the 2nd intercostal space mid clavicular line, keeping the distal end under water to confirm pneumothorax. If baby is on a ventilator, immediately replace with a size 12 French gauge (intercostal tube)IC tube (10F for <750g birth weight) and connect it to an underwater seal drainage system.

Do not wait for radiological confirmation if clinically diagnosed.

Further Management

- Confirm by Chest X-ray(CXR) →do daily Chest X-rays till affected lung fully expands
- Keep baby sedated to minimize pain & struggling

- Step down the ventilator settings to pre-pneumothorax settings ASAP or adjust ventilator settings to minimum requirements (request senior opinion)
- Keep a close observation for bubbling/swinging of the water level in the tube
- When lung expands & bubbling stops for 24 hours, IC tube can be removed. It may be clamped for a few hours & a CXR may be performed to confirm lung expansion prior to removal IC tube.

Inserting a wide bore needle / IC tube can never do more harm than leaving a tension pneumothorax un-attended.

If no senior help is available, do not hesitate to insert a needle to save the baby

5.4 Massive Pulmonary Haemorrhage

Usually occurs in premature (<32 weeks) babies with birth weights less than 2000g. Commoner in neonates with severe surfactant deficiency lung disease and patent ductus arteriosus. Other risk factors include congenital heart disease with increased pulmonary blood flow, pulmonary oedema, coagulopathy and disseminated intravascular coagulation.

When to suspect Pulmonary Haemorrhage

- Pinkish froth / frank blood in ET tube
- Respiratory deterioration needing higher ventilator settings
- Bilateral coarse crepitations.
- Reduced air entry or reduced lung expansion

Management of Pulmonary Haemorrhage

- Ask for senior help
- Adjust ventilator settings to increase the PIP, PEEP and Ti. Increase PEEP (6 – 10mmH_2O). Increase PIP as required based on chest expansion. Make sure ventilator settings are adjusted to deliver a prolonged Ti (0.5 secs).

- Vitamin K 1mg IV stat
- Fresh Frozen Plasma to provide clotting factors
- RBC transfusion if significantly pale (Hb<12g/dl)
- Suction should be **cautiously done** to avoid further triggering of haemorrhage.
- May obtain a chest X- Ray after completing initial management

5.5 Grade 3 or 4 Intra Ventricular Haemorrhage

Usually occurs in premature (<32 weeks) babies with birth weights <2000g. Commoner in unstable and/or ventilated babies. Other risk factors are perinatal asphyxia, fluid boluses, poor sedation, painful procedures, hyperglycaemia, hypernatremia, undue treatment for cerebral oedema, thrombocytopenia, severe acidosis, Haemorrhagic Disease in Newborn and coagulation defects.

When to suspect grade 3 or 4 IVH

- Unexplained sudden pallor
- Persistent unexplained tachycardia
- Unexplained metabolic acidosis and hyperglycaemia
- Sudden drop in perfusion / evidence of impending shock
- Increasing oxygen requirement / Drop in SpO2 • Need of increasing ventilator support
- Convulsions
- Tensed/bulging anterior fontanelle

How to Manage grade 3 or 4 IVH

- N. Saline 10ml/kg slow IV bolus if circulation is poor, until blood is available
- Vitamin K 1mg IV stat
- Fresh Frozen Plasma (to provide clotting factors)
- Manage convulsions

- Provide adequate analgesia and sedation
- Provide adequate respiratory support
- Ultrasound for confirmation and grading after attending to all of the above

Grade 3 & 4 IVH is highly likely to cause long term morbidity even if the neonate survives through the catastrophe. **Therefore, preventive measures are of utmost importance.**

5.6 Endo-Tracheal (ET) Tube Related Problems

ET tube block and displacement are significantly common in Neonatal Intensive Care Units.

It is the intubating medical officer's duty to secure the ET tube well at the correct level. Secretions should be sucked out if indicated. Frequent un- warranted suction will not only disturb the baby, but it may trigger secretions and bleeding leading to ET blockage.

When to suspect ET block

- Baby starts breathing against the ventilator
- Chest movements reduced/absent / asymmetrical
- Air entry absent/ reduced / unequal • Drop in SpO_2
- Need of stepping up of ventilator settings • Increased CO_2 or deterioration of blood gas

How to suspect a dislodged ET tube?

- Deterioration of respiratory parameters
- Audible grunting/crying
- visible milk /gastric aspirate in the ET tube
- Suction tube will go in beyond the expected length without any resistance/restriction
- Resuscitation through the ET tube will distend the stomach • You will hear air entry more over the stomach area than in the lungs

- Higher percentage of leak showing on the ventilator

Ventilation sounds are conducted all over the chest and stomach.

It is common to hear air entry in the lungs even with a dislodged ET tube.

How to Manage ET Tube block/ dislodgement

- Check and adjust the lip level of the ET tube (lip level should be "6+ birth weight" approximately)
- Suction the ET tube after inserting 2 to 3 drops of distilled H2O prior to each suction
- Check for symmetry of air entry
- If no improvement after above steps, may need removal of ET tube and replacing with new tube
- CXR to confirm the position, if in doubt

Continuing resuscitation with a blocked / displaced ET tube is disastrous

It's better to remove the tube and give IPPV by T-piece device or self- inflating bag till help arrives to intubate

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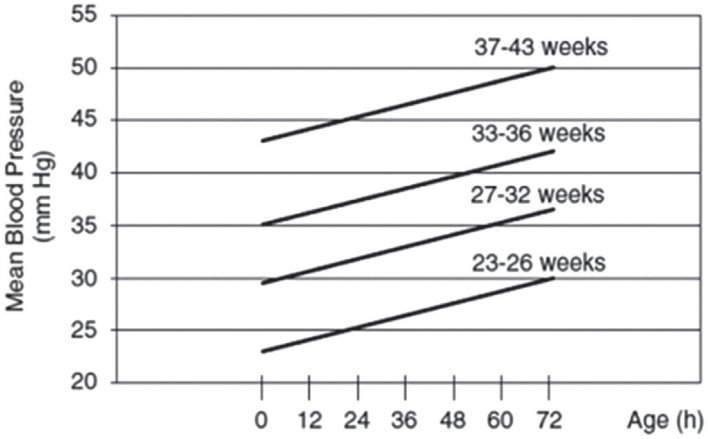
Annexure 1

Graph showing 10th centile for mean blood pressure (MBP) in the first 72 hrs



(Source: Leeds Teaching Hospitals NHS Trust 2018)

Mean Blood Pressure(MBP) varies with maturity and age over the initial few days and stabilizes thereafter.

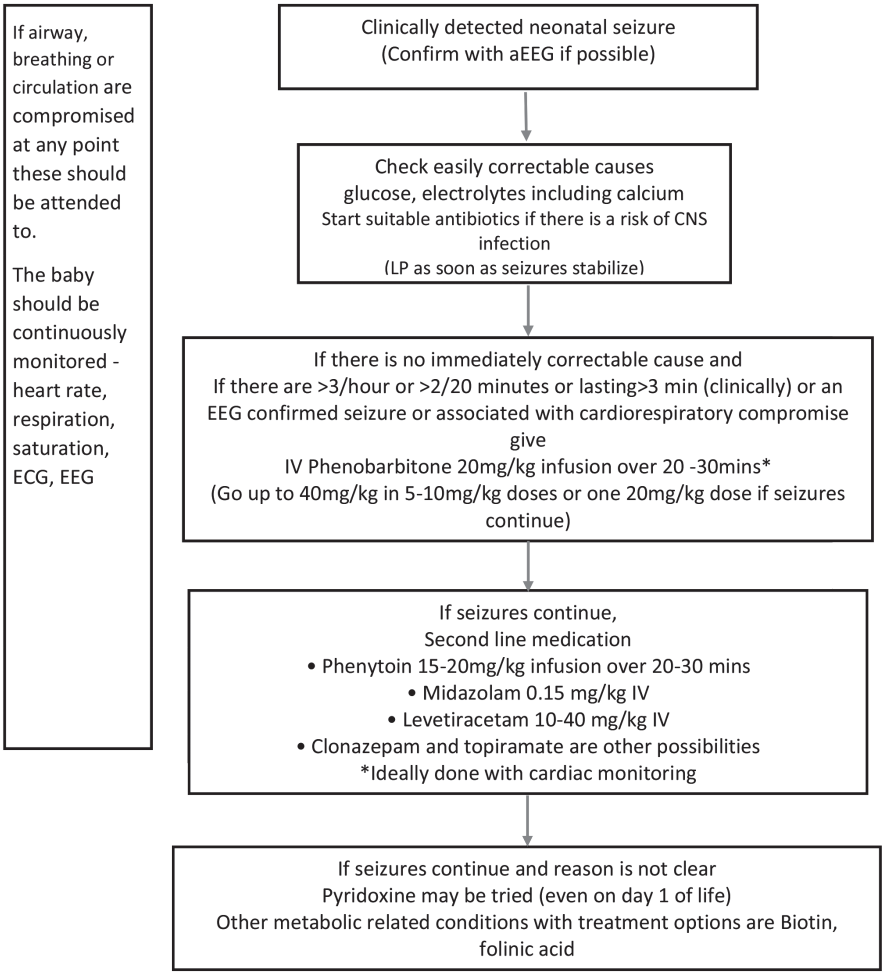
The American Academy of Paediatrics recommends a targe MBP of

- > 30mmHg in extreme preterm (<28 weeks)
- between (30- 50) mmHg in POA (28- 40) weeks
- > 50-60mmHg in term infants with PPHN

Immediate action should be taken if Mean BP is less than GA in weeks.

Annexure 2

ALGORITHM FOR NEONATAL SEIZURES – ACUTE MANAGEMENT



(Source: NHSGGC Guideline on Neonatal seizures)

Fluid management & Parenteral Nutrition

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Introduction

Maintenance of fluid and electrolyte balance is an integral aspect of neonatal care. Breast milk is sufficient to provide nutrition and maintain fluid balance in most new-borns. However, sick and small neonates require parenteral nutrition(PN) to meet their higher nutritional demands and survive with the best neurodevelopment outcomes. The goal of early fluid management is to allow normal weight loss while ensuring physiological stability.

Learning Objectives

- Explain the basic principle behind fluid requirements of the new-born baby
- Identify babies who need IV fluids and Total Parenteral Nutrition(TPN)
- Calculate daily fluid and electrolyte requirements and type of fluid
- Indications and administration of TPN
- Preparation of IV fluid infusion (according to age, birth weight and condition of the baby)
- Administering IV fluids
- Monitoring babies receiving IV fluids
- Adjusting IV fluids with enteral feeding
- Escalate enteral feeding with proper monitoring
- Prescribe IV fluid requirements in special situations

Basic principles behind the fluid management in new-born baby

Postnatal physiological weight loss is approximately 5–10% in first week of life. Preterm babies have more total body water and may lose 10–15% of their weight in first week of life. Proper fluid management is needed for good weight gain and proper neurodevelopment of the baby.

Indications for IV fluid therapy

- Any sick baby not tolerating enteral feeds
- Surgical conditions contraindicating enteral feeds
- Severe dehydration or shock
- Severe perinatal asphyxia
- Severe/prolonged hypoglycaemia

  Some babies in NICU may require TPN more than intravenous fluid therapy.

Indications for parenteral nutrition (TPN)

1. Preterm babies less than 31 weeks of gestation
2. Preterm babies more than 31 weeks of gestation, if sufficient progress is not made with enteral feeds in first 72 hours of life
3. For a preterm baby already on enteral feeds, if feeds must be stopped and unlikely to be re-started in 48 hours.
4. If enteral feeds must be stopped and unlikely to be re-started in 72 hours in a term baby
5. Surgical conditions contraindicating enteral feeds, eg: Gastroschisis

Volume of IV fluid to be given

Volume of fluid depends on birth weight, gestational age and postnatal age. Fluid requirement of preterm new-borns are more when compared with term babies due to higher insensible losses.

Table 1 gives a guideline for IV fluid administration.

Day of Life	Term neonate	Preterm neonate >1500g	Preterm neonate 1000 – 1500g	Preterm neonate <1000g
1	40-60	60-80	70-90	80-100
2	50-70	80-100	90-110	100-120
3	60-80	100-120	110-130	120-140
4	60-100	120-140	130-150	140-160
5	100-140	140-160	150-180	160-180

Table 1: Fluid requirement of neonates (ml/kg/day)

(Source :Espghan: NICE guidelines)

- Total fluid prescription can be increased by 10-20ml/kg/day until 150ml/kg/day due to high evaporative water loss within the first week, (which occurs predominantly from skin and accounting for 10-15% weight loss). However, evaporation is minimised with effective humidification (90%) of incubators.
- Certain clinical conditions may afford modification of daily fluid intakes, e.g. infants with asphyxia, respiratory distress syndrome.
- Fluid will need to be restricted in certain neonates, eg. heart failure, renal failure
- Body weight (measured twice daily – preferably by an inbuilt scale) should be used to guide fluid volume rather than blindly increasing based on the day of life.
- Birth weight is used to calculate total fluid requirement calculations.

Actual body weight is used for all calculations once birth weight is regained.

Choice of IV fluids

The following types of iv fluids are used in the NICU setting;

10% dextrose, 10% dextrose with electrolytes and parenteral nutrition.

- The choice depends on the baby's maturity and general condition of the baby.
- **Total Parenteral nutrition(TPN)** needs to be started when necessary and if indicated, should be included in the daily fluid calculations.
- The most important goal of parenteral nutrition is to provide sufficient energy and nitrogen to prevent catabolism and to achieve a positive nitrogen balance. Preterm infants have very low energy reserves due to low amounts of fat as well as low glycogen reserves in the liver.
- The ideal distribution of calories should be 60% carbohydrate, 10-15% proteins and 30% fats. A 10% dextrose solution provides 0.34 kcal/ml. A 10% lipid solution provides 0.9 kcal/ml. Although protein is a potential energy substrate, it should be utilized only for tissue growth. Glucose and lipids should provide sufficient calories to avoid protein catabolism.
- Energy requirements of preterm and term babies needing parenteral nutrition range from 75 to 120 kcal/kg/day. Starting with a range of 40 to 60 kcal/kg/day, it should gradually be increased to a maintenance range of 75 to 120 kcal/kg/day over the next 4 to 5 days.
- **Amino acids(AAs)** should be provided **soon after birth** in order to improve cognition and brain growth, prevent protein breakdown and to promote growth.
- Protein must be administered with energy. In the absence of non-protein energy
- (i.e dextrose, lipids), protein is oxidized and is not available for protein synthesis.
- A minimum of 1 g/kg/day of protein together with 30 kcal/kg/day of non-protein energy have been shown to prevent negative nitrogen balance.
- Therefore, an AA solution should be started together with 10% dextrose on day one itself

- Lipids provide the highest amount of energy as well as essential fatty acids that are required for brain development. A minimum of 0.5-1 g/kg/day of lipids should be given from day one and is safe and recommended, to prevent essential fatty acid deficiency.
- The carbohydrate requirement is determined by the glucose utilisation rates which is higher in preterm infants at 6-8mg/kg/minute compared to term infants with a rate of 3-5 mg/kg/minute and forms the basis for the initial empirical fluid prescription of 80ml/kg/day for preterm babies and 60ml/kg/day for term babies. Carbohydrate is provided with a minimum concentration of 10% dextrose as lower concentrations fail to meet the energy demands.
- It is recommended to administer TPN through a central venous access. However, in the absence of such access, TPN can be given through a peripheral IV line under close monitoring.
- While amino acids can be added to dextrose and electrolyte drips, lipid infusions should not be mixed with other bags of IV solutions. However, all TPN solutions can be infused with the same cannula access using a three way tap.

A Guide to prescribing intravenous amino acids and lipids are given in tables 2 and 3.

Age (days)	Protein requirement	Amino acid volume
1	1.5g/kg/day	25ml/kg/day
2	2.0g/kg/day	34ml/kg/day
3	2.5g/kg/day	43ml/kg/day
4	3.0g/kg/day	50ml/kg/day
5	3.5g/kg/day	60ml/kg/day+

Table 2: Guide to prescribing intravenous amino acids (0.24kcal/ml, 5.8g/100ml)

(Source :Espghan: NICE guidelines)

Age (days)	Lipid requirement	20%	10%
1-2	1g/kg/day	5ml/kg/day	10ml/kg/day
2-3	2g/kg/day	10ml/kg/day	20ml/kg/day
3-4	3g/kg/day	15ml/kg/day	30ml/kg/day
4-5	4g/kg/day	20ml/kg/day	40ml/kg/day

Table 3: Guide to prescribing intravenous lipids (10% - 1kcal/ml, 20% - 2kcal/ml)

(Source :Espghan: NICE guidelines)

Electrolytes

- Electrolyte needs are relatively low in the first few days due to free water diuresis. During this time, evaporative water loss is more than the fractional sodium excretion, increasing the risk of hypernatremic dehydration. However, soon after there will be a diuresis resulting in the rapid loss of water and electrolytes. This increases the risk of hyponatraemia. Therefore, supplementation of sodium from day three of life is recommended.
- **Calcium** is best administered as an infusion when required. It should be given with caution to avoid extravasation. Calcium is given from day 1 for infants of diabetic mothers and for those with hypoxic ischaemic encephalopathy. Calcium should not be added in the same drip with sodium bicarbonate.

Table 4 provides a guide to the administration of electrolytes;

Age(days)	Electrolyte	Requirement	Preparation
3	Sodium	3-4 mmol/kg/day	6-8ml/kg/day (3% NaCl)
3	Potassium	2 mmol/kg/day	1ml/kg/day KCl
1-3	Calcium	1mmol/kg/day	4ml/kg/day 10% Cal gluconate

Table 4: Guide for intravenous/oral electrolyte supplementation from day 3

(Source :Espghan: NICE guidelines)

Worked example of preparation of iv fluids :

Calculation of IV fluids for a 3 day old preterm neonate with a birthweight of 1.2kg:

Total fluid requirement on Day 3 of life (as per Table-1)= 125ml/kg day

=125 x1.2 =150 ml/day=6.2 ml/hour(fill 50 ml syringe for 8 hrs at a time)

Fluid prescription must be documented as:

Total fluids required: 150 ml in 24 hr at 6.2mL/hr with a syringe pump/infusion pumpor6micro drops/min with a micro drip set

Administration of IV fluid

- Syringe or infusion pump is a more reliable way to deliver small volumes fluids and medications in sick babies. In this device, pressure monitoring (PMO) line connects the syringe containing fluid to the IV cannula
- A syringe pump is the preferred method to administer infusions less than 50ml, as well as drugs, inotropes, sedation etc.
- The intravenous connection line between the pump and the cannula should be primed with the IV fluid to be administered prior to being attached to the baby.
- If an infusion or syringe pump is not available, a micro drip infusion set (Burette set) can be used. In this device, one millilitre is equal to 60 micro drops and number of drops per minute is equal to ml of fluid per hour e.g., if a baby needs 6ml/hr. provide six micro drops/minute.
- Check the infusion rate of fluid hourly and document in the monitoring chart to ensure delivery of correct amount of fluid.
- Use aseptic precautions including washing hands, alcohol rub, sterile gloves while filling the syringe pump/infusion pump or micro drip set with fluid, or giving IV medications.(refer chapter on infection control for further details)
- Calculate and prepare fluids for a **maximum of 24 hours** if infusion pump is used.

- Fluids may need to be adjusted according to the metabolic state of the baby.
- Maintain strict input/output chart and review it every 6 hours.
- Urine output can be calculated by measuring the weight of diapers/nappies using a kitchen grade electronic scale.
- Include the volume of medications and IV flushes in the total fluid calculations.
- Secure the IV cannula properly and ideally attach to a connector and bacterial filter.
- Before infusing IV fluid, check: -

  a. expiry date of the fluid

  b. seal of the infusion bottle for its intactness

  c. that the fluid is clear and free from any visible particles
- The syringe, PMO line and micro drip infusion set and fluid bag are changed every 24 hours to avoid contamination and nosocomial infection.
- Protect the syringes and infusion sets of both aqueous and lipid parenteral nutrition solutions from light.

Monitoring of babies receiving IV fluids

- Once iv fluid commences check the cannula during cluster care for erythema and swelling
- Look for redness and swelling around the insertion site /tip of the cannula
- If redness or swelling is seen at any time, stop the infusion, remove the cannula, and establish a new IV line in a different vein.
- Check the volume of fluid infused and compare to the prescribed volume, record all findings **every hour** in the fluid monitoring chart.

- Measure blood glucose regularly initially every 8 hours.
- Meticulous monitoring is needed to decide the total daily requirement for fluids
- **Weight**
  - Weigh the baby daily, preferably using an in-built electronic weighing scale where a vailable.
  - A baby in an incubator should be weighed using the inbuilt scale, if available.
  - If the daily weight loss is more than 5%, increase the total volume of fluid by 10-20 ml/kg body weight for one day and then reassess.
  - If there is no weight loss or there is weight gain in the initial 3 days of life, do not give the daily increment, keep the fluid rate same as the previous day.
  - However, if there is excessive weight gain (3-5%) and or signs of over hydration such as puffiness over the eyelids and or oedema, decrease the fluid intake by 15 – 20 ml/kg/day
- **Urine output**
  - Urine output is measured by weighing wet nappies and subtracting its dry weight, on an electronic kitchen grade weighing scale.
  - Avoid bladder catheterization in babies passing urine spontaneously.
  - Oliguria is defined as a UOP < 1.0 ml/kg/hr.
  - If there is oliguria and weight loss, increase daily fluid intake by 10-20 ml/kg.
  - However, if there is oliguria with weight gain, decrease daily fluid volume by
  - 10 ml/kg and evaluate for renal failure.

Adjusting IV fluid with enteral feeding

Term, appropriate for gestational age babies

- As soon as a baby has been stabilised after birth, breast milk can be commenced even in the smallest babies. If the baby cannot be directly breastfed, give expressed breast milk by cup or nasogastric tube. If baby can tolerate enteral feeds and is suckling well, omit intravenous fluids.
- If baby has been hypoglycaemic, tail off intravenous fluids gradually.

Preterm / small for gestational age babies

- If the baby is tolerating cup or tube feeds, increase the volume of breast milk, while decreasing the volume of IV fluid to maintain the total daily fluid volume according to the baby's daily requirement.
- Calculate the total fluid requirement per day. Subtract the daily volume of feeds and give the remaining as IV fluid.
- Maximal benefit of aggressive parenteral nutrition is achieved by continuing it until enteral feeds intake is above 120 to 140 ml/kg/day. However, to reduce the risk of sepsis-associated with central lines, TPN can be stopped once enteral nutrition delivers two-third of desired energy intake (roughly 100 ml/kg/day of oral feed).

Worked example on fluid management

Calculation of fluids for a 1-day-old 31-weeker with a birth weight of 1.0kg.

Expressed breast milk was not sent regularly but received 0.2-0.3ml 4 times. Expressed breast milk volume can be included in the fluid calculation when receiving regularly.

Total fluid requirement	=	80ml/kg/d = 80ml/day
Amino acids	=	25ml/kg/d = 25ml/day
Lipid	=	5ml/kg/d = 5ml/day (optional)
10% dextrose	=	(80ml/kg/d - 30ml/kg/d) = 50ml/day

Special situations

- **Intestinal obstruction** - Aspirate should be replaced with normal saline with added potassium chloride(KCl) on a volume basis every 8 hours. (Replace nasogastric losses with 0.9% NaCl + 10 mmol KCl/per 500ml bag)
- **Acute kidney injury -**Replace insensible losses and urine output.

  Choice of IV fluids should be a combination of 10% dextrose with added sodium (without potassium) to maintain normoglycaemia and normal blood chemistry. During fluid restriction, glucose infusion rate should not be below 4 mg/kg/min to avoid hypoglycaemia. This may necessitate giving higher dextrose concentrations.

Management of dehydration

- Serial recording of weight is the most reliable way to assess the severity of dehydration. How-ever up to 10% weight loss maybe normal during the first week in a new-born.

  Physical signs of dehydration are less reliable in new-borns.
- Dehydration is corrected slowly in new-borns unless there are features of shock when fluid boluses would be indicated. The deficit, maintenance fluid requirement and ongoing losses

should be taken into account when calculating the amount of fluids to be given.

- Addition of potassium can be done after reviewing electrolyte reports and once urine output is established.
- Babies with sepsis, necrotising enterocolitis and dehydration due to excessive trans epidermal losses or inadequate intake often require a maximum of 2 fluid boluses of 10ml/kg of 0.9% NaCl.

Hypernatraemic dehydration

- This occurs most often due to delayed establishment of breastfeeding. The delay leads to reduced removal of breast milk from the breast, build-up of factors inhibiting lactation which thereby reduce the breast milk flow.
- The high sodium levels are due to the stasis and reduced removal of milk from the breasts and / or due to high sodium levels in the breast milk itself (irrespective of the volume being produced or being removed from the breast.)
- Delayed establishment of breastfeeding leads to gap-junctions in the breast alveolar epithelium remaining open resulting in higher transfer of sodium to the breast milk. Establishment of breast milk feeding will lead to closure of these gap junctions and normalisation of sodium content in the breast milk.
- Therefore, **breastfeeding should be promoted and supported throughout the management of hypernatraemic dehydration.**
- Hypernatremia can cause brain haemorrhages that result in permanent neurological damage.
- Babies present with lethargy, poor feeding, convulsions, or they would be alert, hungry and crying irritably. Classical signs of dehydration(eg. reduced skin turgor), may not be present.
- A slower sodium drop (< 0.5mmol/hr) is desired if the baby is haemodynamically stable.

Management of hypernatremia:

- Baby should be admitted if the weight loss is more than 10% of birth weight.
- Unrestricted breastfeeding / expressed breast milk should be provided in addition to fluids mentioned below.
- Shock should be treated with normal saline (0.9% NaCl) bolus of 10ml/kg.
- Initial intravenous fluid volume used should be 100ml/kg/day or less depending on availability of breast milk (rather than 150ml/kg/day).
- Commence IV fluid therapy with normal saline (0.9% NaCl) if serum sodium is more than 160mmol/l or if the sodium level is not known yet. This is because the IV fluid should have a sodium concentration 10-15mmol/l lower than the serum level.
- Monitor serum sodium 4-6 hourly
- **During rehydration, the target maximum drop in sodium concentration should be 0.5mmol/l/hr or 12mmol/day.**
- **Rapid correction of hypernatremia causes cerebral oedema**

Summary

1. Use 10% Dextrose in first 48 hours of life together with amino acids
2. After 48 hours of life add sodium and potassium to parenteral fluids.
3. Use syringe/infusion pump or micro drip infusion set to facilitates the administration of small volume of IV fluids.
4. Serial weight recording and urine output are useful in assessing fluid balance in new-borns.
5. Initiate enteral feeding as soon as baby's hemodynamic condition is stable.

6. Proper identification of feed intolerance is important before withholding enteral feeding
7. If unable to feed, start TPN on day one with amino acids
8. Lipids could be added to TPN on day one
9. TPN can be stopped when enteral feeds reach 2/3 of (100ml/kg/day) Total daily requirement.

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Preterm Enteral Nutrition

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Preterm babies have greater nutritional needs in the neonatal period than any other times of their lives. They experience and premature cessation of nutrients supplied by the placenta. They have medical conditions that increase metabolic energy requirements. In addition, this situation is confounded by physiological immaturity, reduced motility and reduced enzyme activity of the intestines. Having a better understanding of these factors and maintaining an aggressive nutritional approach will help to minimize the impact on growth and achieving better neurodevelopment in the post-natal period.

Learning Objectives

- To achieve optimal growth and neurodevelopment
- To prevent specific nutritional deficiencies

Principles

Early enteral feeds promote normal gastrointestinal structure and function, motility and enzyme activity. A delay in introducing expressed breast milk / colostrum can result in growth restriction with long term complications.

Energy Requirements

Energy requirement for a preterm baby to achieve optimal growth are calculated from the estimated resting energy expenditure plus the energy requirements for activity, thermoregulation, fecal loss, growth and chronic medical conditions.

Factor	Kcal/kg	Comment
Resting energy expenditure	50	Resting metabolic rate
Activity	15	30% above resting
Cold stress	10	Thermoregulation
Synthetic effect of feeding	8	Dietary thermogenesis
Fecal loss	12	10% of intake
Growth	25	Calories stored
Total caloric requirement	120	

(Source: Sinclair JC. Clin Obstet. Gynecol 1971; 14:840)

Daily recommended intake of nutrients for preterm babies:

Nutrient	Term baby	Preterm baby (ESPGHAN)
Energy (kcal/kg)	95–115	110 -135
Protein (g/kg)	2	4.0-4.5: <1000g 3.5- 4.0: 1000-1800g
Sodium (mmol/kg)	1.5	3–5
Potassium (mmol/kg)	3.4	2–3
Calcium (mmol/kg)	3.8	2.5–5.5
Phosphate (mmol/kg)	2.1	2.0–4.5
Vitamin A (µg RE/kg)	59	400–1000
Vitamin D (µg/d)	8.5	10–25

[Source: Black-country-newborn neonatal-guidelines 2017-19]

Enteral Feeding in Preterm Infants

Mother's own breast milk is the best milk for all babies with measurable benefits for preterm and term infants, and mothers. Mothers who breast feed are less likely to develop breast & ovarian cancer and metabolic syndrome.

Goals

Aim for growth at least 10-15g/kg/day after regaining birth weight. Preterm babies may take 14-21 days to regain their birth weight. Promote use of mother's own breast milk for all preterm babies on the neonatal unit throughout their stay so that babies are breast fed on discharge. Avoid unnecessary cessation of milk feeds.

Contraindications for breast feeding

There are very few contraindications for breast feeding. It is expected that all mothers will choose to breast feed/express breast milk to feed their babies with the exception of;

- Mothers undergoing chemotherapy / radiotherapy / radioisotopes*
- HIV positive mother – decision to breastfeed should be on a individualised basis after discussion with STD consultant and counselling of the mother
- Life threatening illness in mother
- Specific metabolic disease in the baby with inability to digest human / mammalian milk (galactossaemia, phenylketonuria etc)

*(*Discuss with oncologist)*

Route of administration

Babies who cannot co-ordinate sucking, swallowing and breathing effectively (less than 32 weeks) and must be tube fed.

Nasogastric tubes partially obstruct the anterior nares and increase airways resistance.

Orogastric tubes are therefore preferred in preterm babies who are receiving non-invasive breathing support. Both NG and OG tubes can be used for babies who are ventilated.

Initiating enteral feeds

Mother's own breastmilk should be started as soon as possible, ideally within six hours of life as soon as baby is stabilised. Initiation of breast milk, and rapid advancement have not been found to increase the risk of necrotising enterocolitis. Mother should be supported

to express breastmilk every 2-3 hours soon after birth. Antenatal expression of colostrum has also proved to be beneficial.

The rationale for early introduction of feeds is that lack of enteral nutrition impairs intestinal development. Intestines may become small in size, reduced motility, atrophy of mucosa and delayed maturation of intestinal enzymes. These effects may be mediated by reduced production of gastrin hormone which is the trophic hormone for intestinal growth. Lack of enteral nutrition increases intestinal permeability and translocation of bacteria predisposing to sepsis.

Clinical benefits of early enteral feeding with breastmilk in premature babies include

- Better feeding tolerance, permitting rapid advance of feeds
- Rapid maturation of intestinal motility
- Increased lactase activity
- Higher serum levels of intestinal hormones (Gastrin, gastric inhibitory polypeptide, enteroglucagon)
- Reduced intestinal permeability
- Decreased risk of late onset of sepsis
- Reduced incidence of conjugated hyperbilirubinemia
- Greater absorption of calcium and phosphorus leading to less chance of osteopenia of prematurity

Volume increase

Accumulating evidence suggests feeds can be advanced more rapidly than previously thought in preterms who are healthy;

- Mother's own milk - Advance feeds as available and as tolerated by baby
- Gestation specific donor milk – Advance feeds by 20 to 30 ml/kg/day

Timing of feeds

Initiate breast milk feeds 2 hourly, as frequent expression helps to increase the milk volume in the mother. Once mother is able to

produce breast milk at 180ml/kg/day, feeds can be spaced to 3 hourly to allow babies to be fed according to hunger cues, which are more likely to occur with 3 hourly compared to 2 hourly feeds. Recent research has shown feeding frequently, cut down the time to reach full feeds, days on parenteral nutrition and greater weight gain.

Target volume

Target volume of feeds of 180ml/kg/day supports a weight gain of 15g to 30 g/day weight gain.

Drip versus bolus feeds

Preterm babies should be commenced on bolus feeds lasting 10-15 minutes. This mimics the physiological feeding and stimulates greater hormonal response.

Bolus feeds are gravity assisted and they should be run over 10-15 minutes. The syringe can be attached to the inside wall of the incubator and observed.

If feeds are not tolerated when given as bolus feeds

1. You can adjust positional changes-elevate head end of incubator.
2. Keep the baby in prone position
3. Adjust feed frequency (2 hourly to three hourly and vice versa)

If feed intolerance persists despite the above-mentioned interventions a drip feed can be commenced. Duration of a drip feed is longer than bolus feeds-example over 20 or 30 minutes. It can be extended upto one hour. When kept in a tube for longer period nutritional value of breast milk would be reduced due to loss of human milk fat.

Feed tolerance

Feeds should not be withheld unless there is tense abdominal distension, blood stained or bilious aspirate and should be restarted as soon as the situation is resolved .

Gastric residues should not be checked routinely.

Tube position should be checked prior to every feed.

Residual milk aspirate is not an indication to stop enteral feeds.

Light bilious aspirates should be considered as physiological. Physiological aspirates including undigested or light bilious aspirate should be returned to the baby.

Elevation of the head end of incubator, prone position, adjusting feed frequency and changing to drips feeds may be useful in babies with feed intolerance.

Increasing / persistent residual aspirate, despite the above-mentioned measures, warrants close monitoring for other features of sepsis / necrotising enterocolitis etc.

Withhold feeds in case of dark bilious, blood and feculent aspirates until further evaluation is completed

- **Feeds should be withheld in the following instances:**
  - Congenital abnormalities of the gut (e.g. small or large intestinal atresia, gastroschisis, exomphalos, diaphragmatic hernia, Oesophageal atresia with or without tracheo-oesophageal fistula etc)
  - Post GI surgery
  - Necrotising enterocolitis
  - Gastrointestinal perforation
- **Feeds should be continued in the following situations**
  - **Hypotension**

    Gut under-perfusion is likely in babies who have significant haemodynamic instability. These babies should be fed cautiously. Do not withhold feeds.
  - **Muscle relaxation**

    Babies who have undergone muscle relaxation with non-depolarising neuromuscular blocking drugs (e.g.pancuronium, vecuronium) can still be fed enterally as these agents have only a minimal effect on smooth muscle.

Total fluid intake should be reduced in babies who have undergone muscle relaxation since they may become oedematous because of reduced movements.

- **Blood Transfusion**

  Significant anaemia appears to increase the risk of NEC. There is a debate as to whether blood transfusion adds an additional risk. Continue feeds during transfusion.

- **In utero growth restriction with absent or reversed end diastolic flow velocity (AREDFV)**

  Babies less than 32 weeks with AREDFV breast milk should be started soon after birth and advanced as tolerated by the baby while monitoring the clinical condition including the abdomen.

Supplementation

Multivitamin supplements

Commence multivitamin(MVT) in the form of drops at 0.3ml once daily and increase to 0.6mlonce daily in all breast milk fed preterm babies, with advancement of breast milk feeds. Continued until 2 years of age. Folic acid 0.5mg should be given once a week with the above vitamins.

Iron supplementation

Supplemental iron in the form of elemental iron 3mg /kg/day prophylactic dose, if the baby is not anaemic. If the baby is anaemic 6mg/kg/day treatment dose is selected. It is usually started from 2 weeks of age and continued upto 2 years. Treatment dose of iron should be started earlier in babies noted to have anaemia prior to 2 weeks of age.

Calcium and phosphate supplementation

Enteral feeding on discharge

Consider discharge from the NICU / SCBU when the premature infant is maintaining temperature in a cot and gains weight 10-30g/day with

direct breastfeeding and expressed breast milk via cup >180ml /kg/ day, where mother can feed the baby on demand safely without any episodes of aspiration.

Use preterm growth chart. Ensure baby grows along the birth trajectory. Expressed breast milk via cup can be stopped and baby can be fed solely via direct breastfeeds as baby reaches 2.5kg or starts refusing expressed breastmilk via cup. Growth parameters include weight, length and OFC should be monitored on a weekly to bi weekly basis for the first 4 to 6 weeks after hospital discharge. After this initial period infants who are growing normally can be monitored monthly.

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Basics of Neonatal Ventilation

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Providing respiratory support in the sick or preterm neonate is a significant component of the care delivered in the neonatal unit. Many of the neonates admitted for neonatal care require some degree of respiratory support. The aim of neonatal ventilation is to achieve adequate gas exchange without significant lung injury.

Learning Objectives

- Basics of mechanical ventilation
- Strategies to minimize ventilator induced lung injuries
- Monitoring and care of a baby on a ventilator

Indications for mechanical ventilation

- Inadequate breathing to maintain normal oxygenation and carbon dioxide level (gas exchange)
- To support and reduce the work of breathing.
- In extremely sick babies, as part of the intensive care treatment, despite having normal gas exchange and minimal respiratory distress.

Conventional mechanical ventilation

The machine (ventilator) artificially pushes a volume of gas in to the lungs within a given time period (inspiratory time). This is called **inspiration**. During inspiration, lungs expand and oxygen in the delivered gas diffuses through the alveolar wall into capillaries and thereby increases blood oxygen level. Theoretically the same volume of air comes out of lungs due to chest recoil during **expiration**

(because of the leak through vocal cords, the expiratory volume could be less). Expiration is a passive process and the ventilator does not suck out gas from the lungs. CO2 in alveolar capillaries diffuses into the alveolar space and is removed during expiration.

The ventilator has two main tubes connecting to the ET tube:

Inspiratory limb- air is pushed in to lungs(actively by the ventilator)

Expiratory limb- air goes out from lungs(passively by chest recoil)

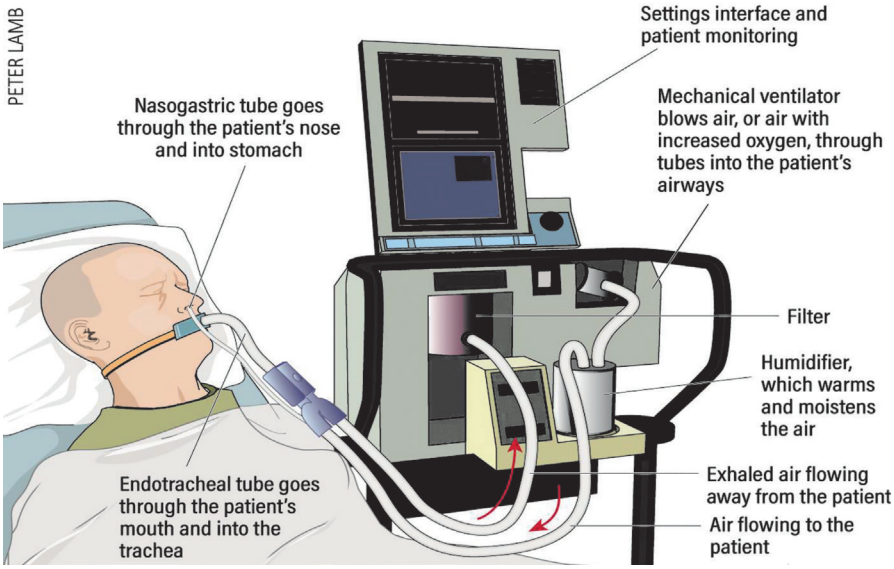


Figure 1: mechanical ventilator for positive pressure ventilation
Courtesy : Peter Lamb

The air that goes in should be;

- Warm &
- Humidified

This is done by the humidifier

At the end of the expiration the ventilator still maintains a small flow of air into the lungs to keep the alveoli partially distended/open, thereby preventing the collapse of alveoli (atelectasis) at the end of expiration.

This is called **Peak End Expiratory Pressure (PEEP)** (usually 5-7cm H2O) and this can be adjusted in the ventilator.

During the early phase of inspiration, the lung volume increases slowly and then suddenly starts expanding and the volume increases rapidly. The pressure at this point of rapidly increasing lung volume is called the "opening pressure" **(lower inflection point)**. Towards the end of inspiration, the lung volume increases very slowly despite increasing pressure this point is called **"upper inflection point"**, and after this point lungs get over distended(figure 2). It is important to minimize both atelectasis and over distension during mechanical ventilation. This can be assessed clinically by observing the chest rise during mechanical breaths and also further assessed by a chest radiograph.

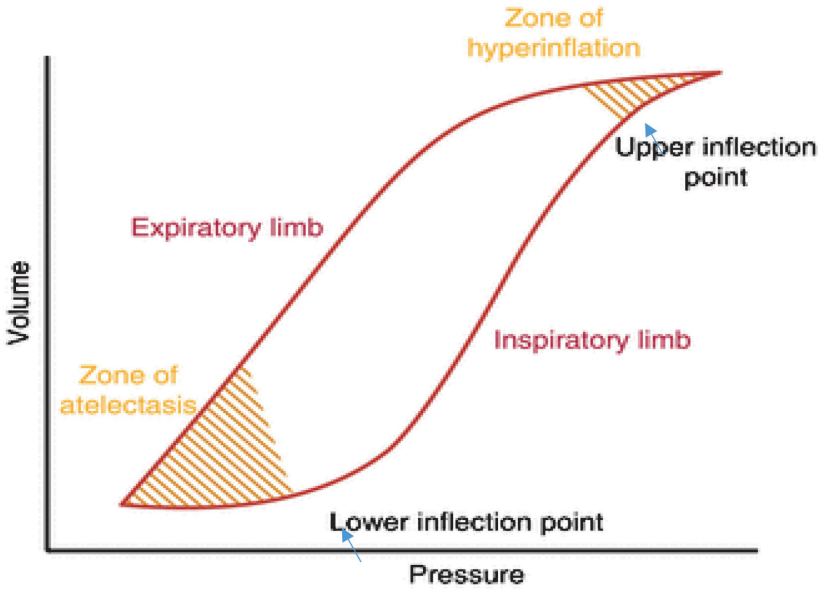


Figure 2: Pressure Volume curve

TERMINOLOGY

The following terms are used when ventilating babies:

Mechanical Ventilator Breaths:

Controlled Breaths:

- Machine driven breaths are completely "controlled" by the ventilator

Assisted Breaths:

- Triggered by patient's breathing effort, then
- Machine delivers a full mechanical breath

Supported Breaths:

- Triggered by patient effort (like assisted breaths)
- Once triggered the ventilator will give some pressure support

Delivery of a ventilator breath:

The two types of breaths delivered by a ventilator are:

- Volume controlled breaths
- Pressure controlled breaths

Volume controlled breaths:

- The ventilator will deliver a preset tidal volume
- Pressure is decided by the ventilator and depends on the lung compliance

Stiff lung (surfactant deficiency) – has low compliance- needs higher pressures to deliver the set tidal volume

Pressure controlled breaths:

- A preset pressure will be delivered (PIP)
- Tidal volume will depend on the lung compliance (No control of tidal volume)
- A lung with low compliance needs higher pressure to achieve target tidal volume
- Here, we try to achieve a tidal volume of 4-6ml/Kg

Current evidence suggests that volume controlled method of mechanical ventilation is less injurious to the lung.

Ventilator Terminology:

Fraction of inspired oxygen (FiO2)

How much oxygen is delivered - expressed as a fraction of 1.0 (0.21 to 1.0) It can also be expressed as a percentage(21% to 100%).

Mean airway pressure (MAP)

The total average pressure (in cmH2O) within the lungs throughout the respiratory cycle. (Determined by PIP, PEEP, Ti and flow). Along with FiO2, this influences oxygenation.

Tidal volume (Tv)

The volume of gas entering the lungs in one breath; expressed in milliliters (ml) (Inspiratory Tv and expiratory Tv)

Minute volume (Vmin)

The volume of gas entering the lungs in 1 minute(expressed as liters/ minute). Affects CO2 elimination. Calculated by:

Minute Volume = Tidal volume x Respiratory rate

Ventilator Rate

The number of mechanical breaths delivered in a minute—as breaths per minute

Peak inspiratory pressure (PIP)

The peak pressure reached at the end of inspiration (cm H2O)

Positive end-expiratory pressure (PEEP)

The end pressure reached at the end of expiration (cm H2O)

Inspiratory time (T*i*)

The inspiratory time of one respiratory cycle expressed in seconds

Expiratory time (T*e*)

The expiratory time of one respiratory cycle expressed in seconds

I:E ratio

The ratio of inspiration to expiration time.

This should be 1:1 or more: expiratory time should not be shorter than the Inspiratory Time.

Trigger threshold

The sensitivity of the ventilator and flow sensor to detect the neonate's breaths. This could be either flow or pressure trigger.

Air leak

Air flow that is lost from the respiratory circuit; this is mainly from the space between the ET tube and vocal cords.

Parameters in High-Frequency Oscillatory Ventilation (HFOV)

Mean Airway Pressure (MAP)

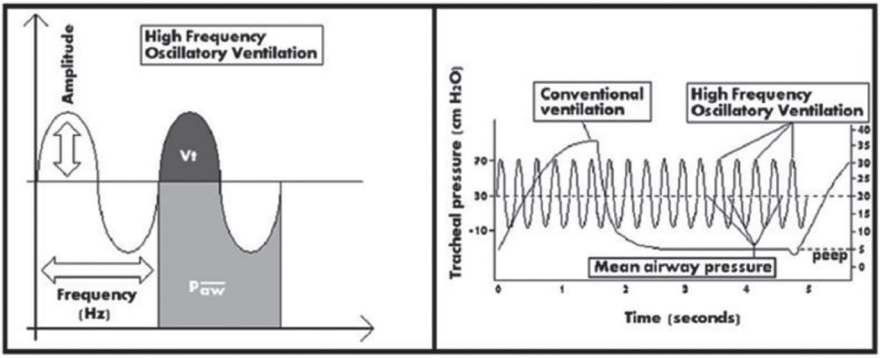
Controls oxygenation along with FiO2 as explained above.

Frequency

Measured in Hertz (Hz)—number of oscillations per second(eg; Frequency 10 means there are 10 oscillations per second and 600 per minute).

Amplitude /Delta P

The variation round the MAP, also known as Delta P or power and affects chest "wiggle" (wobble/bounce) controls CO2 elimination. Set according to extent of chest wiggle and blood gas analysis.



A B

Figure 3: Graphic representation of HFOV(A) and comparison with conventional ventilation(B)

MODES OF VENTILATION

The terminology used to identify modes of ventilation may differ between makes and models of different ventilators.

Nasal continuous positive airway pressure (NCPAP)

Continuous positive airway pressure maintains an elevated end expiratory lung volume in spontaneously breathing infants by providing a continuous flow of heated humidified gas at a set pressure (usually 5-8 cmH2O)

Non-Invasive Positive Pressure Ventilation (NIPPV)

In NIPPV, the mechanical breaths are delivered with all the parameters as set in Assist Control (A/C) or Synchronized intermittent mandatory ventilation (SIMV) mode but through a nasal mask/prongs (No intubation). In NIPPV, it is necessary to use relatively higher inspiratory time (about 0.5 seconds) compared to 0.3-0.4 seconds in an intubated patient). The PIP needs to be set slightly higher compared to invasive ventilation, to compensate for the leaks and achieve satisfactory lung expansion.

Eg. Invasive ventilation PIP = 16 cmH2O NIPPV PIP = should be 18 -20 cmH2O

Synchronized intermittent positive pressure ventilation (SIPPV/AC)

SIPPV/AC provides supported ventilator breaths at a preset PIP,PEEP and Ti, synchronized with the onset of each spontaneous breath. Therefore, every breath the infant takes is

supported by the ventilator. If the infant does not make spontaneous breaths, the ventilator delivers mechanical breaths at the back-up rate set by the operator. The infant therefore “controls” rate of breathing. This mode is used for most infants during the acute period of ventilation and when muscles are relaxed.

Synchronized intermittent mandatory ventilation (SIMV)

SIMV provides supported mandatory ventilator breaths at a preset PIP, PEEP and Ti as determined by the back-up rate. The onset of inspiration of a mechanical breath is synchronized with the onset of the infant’s spontaneous breath if it occurs within a ‘trigger window’.

All other spontaneous infant breaths above the set rate are only supported by PEEP. If the infant does not make spontaneous breaths, the ventilator delivers mechanical breaths at the back-up rate set by the operator.

Pressure support

All the unsupported breaths in the SIMV mode will be supported with a smaller PIP.(set pressure support).

HFOV

High frequency oscillatory ventilation provides small tidal volumes at a very fast rate. This results in significantly lower alveolar pressure which reduces the risk of lung injury caused by excessive pressure and volume.

Volume guarantee (VG)

This mode of ventilation targets tidal volume – not the pressure. The aim of VG is to provide a preset tidal volume by automatically adjusting the PIP (peak inspiratory pressure) to achieve the target tidal volume.

Ensuring adequate ventilator settings

If the ventilator setting are adequate, the baby achieves satisfactory oxygen saturation. within 15-30 minutes, a normal or near normal carbon dioxide level, minimal work of breathing and adequate chest expansion.

If the saturation does not improve:

- ❖ Check the ventilator for technical errors
- ❖ Check the patient circuit for accidental disconnections
- ❖ Check whether the ET is in place/blocked
- ❖ Watch for chest rise/expansion with mechanical breaths
- ❖ Think of pneumothorax/air leaks syndrome
- ❖ Think of circulatory insufficiency

If saturation does not improve - think of DOPE

DOPE
D - Dislodge/Disposition/disconnection of ET tube
O - Obstruction
P - Pneumothorax
E - Equipment failure

How to improve oxygenation:

Increase FiO2.

Increasing oxygen requirement means the baby is deteriorating. Inform the medical team about increasing oxygen requirement. If the baby needs more than 40% of Oxygen (FiO2 0.4) to maintain normal saturation, the patient needs further evaluation and escalation of respiratory support.

Increase PIP and or PEEP or MAP (Mean Airway Pressure in HFOV)

This will help increase oxygenation but risk of pneumothorax and lung damage are high. Normally the PIP is increased by 1-2 (cmH2O) at a time. (PEEP should not be increased more than 8cm H2O)

How to reduce Carbon dioxide:

Conventional ventilation -

Increase Ventilator rate:

This will help wash out CO2. The rate is normally increased by 5-10/ min at a time

(If the baby is on AC or SIPPV with active breathing, increasing ventilator rate will not be helpful)

Increase PIP and decrease PEEP:

These will increase the tidal volume and help CO_2 wash out

HFOV:

Increase the amplitude or **delta P**

Reduce the frequency so that expiratory time becomes longer

If you have to adjust the ventilator settings to increase oxygenation or reduce Carbon dioxide, you should carefully think why the baby is requiring higher settings.

Re-evaluate the baby!

Suctioning while on ventilator:

- There is **no need for regular suctioning** of the ET tube.
- ET suctioning should only be done if tube is suspected to be blocked with secretions or there are visible secretions in mouth or nose.

- ET blockage should be suspected when there is increased work of breathing and CO2 retention in the blood gas in a previously stable baby.
- The ventilator circuit should not be disconnected from the baby without a valid reason. (This can cause collapse of alveoli).
- Ideally suctioning should be done using “in-line” suctioning method.

Weaning off the ventilator

- First try to wean off FiO2 gradually to a reasonably low level (less than 40%). This can be reduced as 5-10% at a time depending on the oxygen saturation or arterial oxygen level.
- **Then** start weaning/reducing the PIP. (It is not safe to wean the PIP in a baby who has a high oxygen requirement, which means that the baby is still not ready for weaning from the ventilator). PIP can be reduced 1-2 (cmH2O) at a time.
- The ventilator rate can be reduced by 5-10/min at a time provided the CO2 remains within normal limits.
- When on volume control mode there is no need to wean the PIP. The PIP will undergo auto weaning with the improvement of the lung compliance.

Extubation of Baby

Consider extubating if:

- PIP is reduced to about 12-14cmH_2O in a term baby (10-12 in a preterm baby),
- baby is clinically stable
- required ventilator rate is low (25 -30/minute)
- you may extubate the baby to CPAP, NIPPV, Nasal high flow, Nasal prong oxygen or even room air.

- If a relatively high PEEP was used (such as 7 or 8 cmH_2O), it should be weaned off to around 5 (1cmH_2O at a time) before extubation.

Considerations before extubation:

- **The baby should be completely off sedation (Morphine/ Midazolam infusion etc.) and paralytic agents (Atracurium, Vacuronium etc.)**
- **Should have a satisfactory spontaneous breathing effort**
- **Should be clinically stable and off inotropes**
- **Prime with respiratory stimulants if indicated (caffeine citrate or aminophyllin, especially for premature babies)**

Infection control measures to prevent Ventilator Associated Pneumonia (VAP)

VAP Bundle

VAP is a serious complication in neonates on mechanical ventilation. Prevention of VAP has been primarily achieved by the **"bundle approach"**; this involves the simultaneous application of several preventive strategies. Prevention of VAP involves limiting exposure to resistant bacteria and discontinuing mechanical ventilation as soon as possible.

Two processes are crucial to VAP development:

- bacterial colonization of the oral cavity
- aspiration of contaminated secretions into the lower respiratory tract

The ventilator **bundle** consists of a group of evidence-based practices that, when implemented together, dramatically reduce incidence of VAP in mechanically ventilated patients.

The interventions in VAP bundle:

Prevention of transmission of microorganisms:

- Standard Precautions
  - ✦ Strict hand hygiene practice
  - ✦ Gloving
  - ✦ Minimal handling
- Sterilization or disinfection and maintenance of equipment and devices
  - ✦ Thoroughly clean all equipment and devices to be sterilized or disinfected
  - ✦ Minimize breaks in the ventilator circuit
  - ✦ Change the ventilator circuit only if visibly soiled or malfunctioning

Precautions for prevention of aspiration

- Use noninvasive positive pressure ventilation whenever possible
- Minimize the duration of mechanical ventilation
- Elevation of head (30°–45°)
- Oropharyngeal suctioning is to be done prior to handling ET tube; eg. suctioning, ETT strapping, extubation, re-intubation
- Minimize sedation if baby is comfortable
- Daily evaluate for suitability for weaning/extubation

Prevention or modulation of oropharyngeal colonization

- This can be done by giving oral care with breast milk

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Care of the Small Baby in the Neonatal Unit

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Care of the small / sick baby in the neonatal unit

Once a sick or "small" baby is stabilised after the critical phase, feeding, growing and maintaining normothermia would be its next set of challenges before planning discharge.

Learning objectives

- Prevent infection
- Maintain Normothermia
- Ensure adequate provision of breastmilk to the normal/ small baby
- Measure, plot and interpret anthropometry
- Supplement vitamins and minerals
- Screen for ROP
- Assess neurodevelopment
- Provide age appropriate immunisation
- Arrange a family meeting before discharge
- Plan discharge and follow up

1. Preventing infection

- Ensure strict hand hygiene
- Establish breast feeding
- Skin to skin contact

- Minimal handling
- Ensure tubes / lines are removed as early as possible
- Minimise visitors
- Strict antibiotic policy

2. Maintaining normothermia (36.5^{0}C – 37.5^{0}C)

Incubator care

Initially the "small "baby is nursed inside the incubator as it has limited ability to control its body temperature. Temperature control improves in the first 7 – 10 days as the skin permeability decreases. Ensure air probe is exposed to air while the baby probe is attached to the baby. Heat probe should always be visible and never underneath baby, as it can cause skin burns.

Positioning the heat probe

- Place on the right hypochondrium - when in the supine position
- Place on the loin when in prone opposition

The incubator temperature can be controlled via "manual" or "servo" control

- **Manual control**
  - Set temperature according to the weight / maturity of the baby
- When baby can maintain body temperature at 37^{0}C at a certain incubator temperature, manually reduce the incubator temperature gradually

  (Refer chapter on thermal care for more details)
- **"Servo control"**
  - Baby's skin temperature is set at 370C
  - Incubator generates enough heat to maintain baby's temperature at 370C, percentage output is shown by the number of coloured bars in the indicator.

- When baby can maintain his/her own temperature, the coloured bars will be one/none indicating minimal heat generation by the incubator. The incubator reduces its heat output to maintain the set target temperature.

Transition from the incubator into the cot

- When the baby can maintain body temperature with minimal support from the incubator as indicated by the manually set temperature being at room temperature or single bar / none indicated in the servo mode baby is ready to be transferred into the cot.
- Get parents to bring warm clothes, including hat, mittens, socks, flannel, full body suit etc. before moving to the cot

Cot care

Once the baby is able to maintain body temperature, baby can be nursed in the open cot with ongoing monitoring for hypothermia.

- **Layering**

  Layering with warm clothes is important. Baby shirt, nappy, flannel jacket with trousers /sleep suit, hat, mittens and socks with woollen / thick flannel blankets will help to keep the "small" baby warm.

- **Skin to skin care**

  Skin to skin care starting at the time of birth should be conducted in all babies whenever possible. All babies on non-invasive ventilation (CPAP/NIPPV) should be given to mother for skin-to-skin care while monitoring continues. It should be continued in the low dependency care unit, postnatal ward and at home.

  (Refer chapter on thermal care for more details)

3. Breastfeeding the "small/sick baby"

- **Initiate soon after birth**
  - Antenatal counselling should include that mother would require to express breast milk soon after birth
  - Start expressing as soon as mother is stabilised, before 6 hours of birth and continue at least 8 -12 times a day
  - Nurses/midwives may need to support mother to express initially until mother is empowered with the skills
  - Encourage mother to visit the neonatal unit and hold the baby as soon as possible
  - Neonatal unit doctors should go and speak to mother if she is unable to come to the neonatal unit
- **Expression of breast milk**
  - Educate, train, and empower staff in maternal ICU/high dependency /postnatal ward on how to express breast milk from mother using the correct technique.
  - Correct technique in expressing breast milk
    a. Hold on either side of areola with thumb
    b. Push back towards the rib cage
    c. Approximate thumb and other fingers on the same plane – DO NOT pull forward (figure 1)
    d. Release and repeat

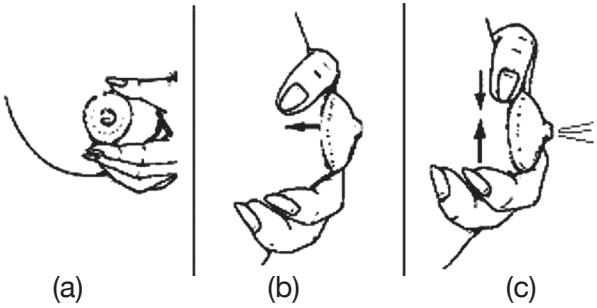

Figure 1: Steps in expression of breastmilk

- Ensure that breastmilk is expressed, and breast is emptied frequently and regularly (prevent build-up of feedback inhibitor and simulate suckling to increase prolactin)
- Initiate expression 2 hourly – express around 20 minutes each time – continue even if breast milk is not secreted – feeling of wetness around the areola indicates the onset of breastmilk secretion – regular expression will result in increase of the volume of breast milk secreted – use a one ml syringe to collect the milk initially as starting volume is usually less than 0.5 ml per session.
- Factors that will increase the volume of expressed breastmilk
    - Correct technique
    - Regular and frequent emptying of the breast
    - Expressing at the bedside of the baby
    - Thinking positive thoughts about the baby
    - Looking at a photograph of the baby
    - Positive feedback from the staff

- **Maintaining and monitoring the milk volume**
    - Maintain a feeding chart and document the volume of breastmilk given for each feed
    - Milk volume should steadily increase with reaching 160-180ml/kg/day in 3-4 days
    - Always show interest in daily amounts expressed.
    - Observe the expressing technique from time to time.
    - Give positive feedback, frequently!
    - Work “Your breastmilk is great for your baby because... ”into your conversations daily
    - Encourage and assist the mother into kangaroo care
    - Encourage mother to let baby nuzzle/suckle at her recently-expressed, empty breast

- **Overcoming challenges when breastmilk volume is not increasing / decreasing**
  - Build confidence in the mother, positive feedback – ↑ oxytocin
  - Ensure that breast is emptied 2 hourly – ↑ prolactin / ↓inhibitor
  - Ensure that expression occurs 2hrly at night as well – ↑ prolactin
  - Increase skin to skin contact – ↑ oxytocin
  - Get mother to touch/talk to baby – ↑ bonding – ↑ oxytocin
  - Suckling on the empty breast – ↑ oxytocin > prolactin
- **Mode of feeding breastmilk** *(Refer chapter on preterm enteral nutrition for further details)*

  It is important to ensure that baby receives breast milk irrespective of the mode –breast, tube or cup - depending on the clinical situation.

  Initiate with tube feeds when unstable, cup feeds when more stable and direct breastfeeds when baby demonstrates readiness.
- **Demonstrating readiness for breastfeeds**
  - Assess during skin-to-skin care
  - Spontaneous suckling
  - Co-ordinated jaw and tongue movement
  - Nutritive vs non-nutritive sucking
  - Suck, swallow, breath co-ordination

  When readiness is demonstrated initiate suckling from the recently expressed breast, gradually moving onto quarter filled, half filled breast etc.
- **Ensure mother's feeding competency prior to discharge**
  - Mothers should be taught to feed and should be tested for competency and safety before planning discharge.

- Ensure safe breast feeding without episodes of desaturation / aspiration
- Ensure mother can express and empty breast
- Ensure mother can cup feed safely

(Refer chapter on preterm enteral nutrition for further details)

4. Check weight, length and head circumference

- Babies lose up to 10% of their birth weight and regain it by 10-14 days in term babies and 14-21 days in preterm babies
- Weight is the best guide to adequacy of intravenous fluids (Refer chapter on intravenous fluids for further details)
- Check weight daily if baby is on intravenous fluids more than 50% of daily requirement
- Early/excessive weight gain is likely to be due to oedema
- When more than 50% of daily requirement is provided via enteral nutrition, ensure that weight is checked at least twice a week and plotted preferably on the sex specific preterm growth chart to see if weight gain is on track.
- Expected weight gain is 10g/Kg /day
- Head circumference should be measured at least once a week and plotted on the head circumference chart to track head growth. Sudden increase should warrant an USS brain to assess for post haemorrhagic hydrocephalus

5. Vitamin and mineral supplementation

- **Multivitamin supplementation**

  Start oral multivitamin (MVT) drops 0.3ml/kg/day (maximum 0.6ml) and 0.5mg folic acid weekly as soon as baby is on a breastmilk feed of at least 1ml hourly. MVT drops should be continued at 0.6ml daily and folic acid at 0.5mg weekly until 2 years of age. Multiple micronutrient supplementation (MMN)

should not be given while the baby is MVT supplementation due to overdosing. Similarly, Vitamin A megadose should also be avoided while on MVT supplementation

- **Iron supplementation**

  Iron supplementation should be started at the prophylactic dose of 3mg/kg/day elemental iron from 14 days of age. Therapeutic dose of 6mg/kg/day should be used in instances of low haemoglobin at any age. Therapeutic dose should be started before the age of 14 days in case of low hemoglobin at the time. Iron supplementation should also be continued until the completion of 2 years of age. (0.5mg once a week), iron supplements (prophylaxis 3mg/kg/day elemental iron) should be administered for all "small " babies until the age of 2 years.

- **Vitamin D, calcium and phosphate supplementation**

	Total fluid <150ml/kg/ day	**Total fluid is 150ml/kg/day**	**Full enteral feeds**
Calcium	40–120 mg/kg/ day 1–3 mmol/kg/ day	75–90 mg/Kg/ day 1.8–2.2 mmol/ kg/day	140 & 160 mg /100 kcal
Phosphate	31–73 mg/kg/ day 0.9–2.2 mmol/ kg/day	60–70 mg/Kg/ day 1.9–2.2 mmol/ kg/day	95 to 108 mg/100 kcal
Vitamin D	160–280 IU/ day	160-280 IU/ day	200-400 IU/ day

Figure 3- Vitamin D, calcium and phosphate supplementation(source: AAP guideline)

- Calcium and phosphate supplementation is recommended until 36 weeks gestation or 2kg weight.

- Measure alkaline phosphate (ALP), serum phosphate and serum calcium 2-weekly until 2-4 weeks post discharge.
- ALP > 900 IU/L and phosphate < 1.8mmol/L indicate a low bone mineral density.
- Mineral supplementation is needed if ALP >800 IU.
- Phosphate supplementation should be considered if phosphate < 5.5mg/dL(1.3 mmol).

Preterm infants on long term diuretic or corticosteroid treatment, and those with neuromuscular disorders or brain injuries are at high risk of developing MBD of prematurity.

The optimization of TPN and the reduction of the duration of TPN, the success of early achievement of full enteral feeding are important goals for the prevention and management of MBD of prematurity.

6. Screening for Retinopathy of Prematurity (ROP)

- Initial eye referral should be done between 3-4 weeks of birth.
- Screening is indicated for all babies less than 34 weeks, below 1500g birth weight and any sick baby.
- Screening is conducted by the ophthalmology team inside the NICU/SCBU during the baby's stay.
- Arrange reviews 2 weekly or more frequently as planned by the ophthalmology team until 42 weeks or until regression of ROP

7. Neurodevelopmental assessment before discharge and during subsequent clinic visits

- Observe baby for alertness, orientation, behaviour as well as quantity and quality of movement
- Incorporate neurological assessment into daily examination

- All babies should have a neurodevelopmental assessment prior to discharge, to detect early signs of abnormal neurological development (early hypertonia etc).
- General Movements Assessment and Hammersmith Neonatal Neurological Examination are some tools that are useful in this assessment.
- Include a neurodevelopmental examination at each clinic visit
- Start early intervention with physiotherapy/occupational therapy/speech therapy immediately if any abnormality is detected
- Stimulate all babies to achieve age-appropriate milestones in all developmental domains

8. Immunization

Ensure immunization is given according to the **chronological age** according to the Expanded Program of Immunization (EPI). BCG may be given at the same time as the pentavalent vaccine in case delayed discharge around 60 days of age.

9. Arranging a family meeting before discharge for high-risk babies

Parents should be educated about,

- Preventing infection by handwashing, minimal handling and minimising visitors
- How to check for hypothermia and how to keep baby warm
- How to breast feed effectively – small babies may need limited time(10 min) at the breast initially followed by feeding on demand
- Safe feeding – minimising risk of aspiration
- Bathing • Co-sleeping and risk of suffocation
- Early stimulation and avoiding screen time

- Hands-on training on basic resuscitation and first-aid for choking
- Identification of danger signs – poor activity, apnoea, milk coming through nose
- Plan of action in case of danger signs – first aid, how to transport and where to go
- Make a contingency plan on how to reach the hospital in case of emergency
- Educate on contact details of the hospital and where to go in case of emergency
- Importance of regular follow up including screening for retinopathy of prematurity and hearing evaluation at 40weeks of corrected gestational age

10. Planning discharge and follow up

- The weight gain should be consistently demonstrated for 3 consecutive measurements if the baby is more than 1 week old (or weight loss should be less than 10%). The weight, head circumference and the length should always be recorded at the time of discharge.
- Mother should be confident in breastfeeding the baby directly and via cup.
- Methods of temperature regulation like the KMC and any other skills should be well known to mother and adequately practiced in the hospital under supervision.
- A neurological examination should be done early intervention commenced.
- Vitamin and mineral supplements should have been started prior to discharge.
- Baby should have received BCG prior to discharge.
- A family meeting with both parents and all potential caregivers should be held to educate the caregivers and assess the safety of discharge

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Developmental care in the neonatal unit

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Learning objectives

- Light reduction
- Noise reduction
- Protection from noxious odours
- Protection from oral aversion and promoting suckling
- Minimal handling, tactile stimulation, clustering care
- Positioning
- Involving parents in care
- Understanding baby's stress signals
- Consoling strategies

Developmental care

Developmental care is a broad category of interventions that is designed to minimize the stress of the NICU environment. Control of external stimuli (vestibular, auditory, visual, tactile) by noise and light reduction as well as minimal handling, clustering of nursery care activities, and positioning of the preterm baby to provide a sense of containment similar to the intrauterine experience is included under the umbrella of developmental care. The goal of developmental care is to provide a structured care environment which supports, encourages and guides the developmental organization of the premature and/or critically ill infant.

1. Light reduction

- **Why is light reduction important?**

  Light reduction is important as this facilitates protected sleep which enhances growth and reduces unlimited light exposure as pupillary constriction is absent until around 32 weeks and light goes in through the thin eyelids even when sleeping.

- **Which babies would benefit from light reduction?**

  Babies less than 34 weeks gestation and those post Retinopathy of Prematurity (ROP) screening

- **How can we reduce light in the neonatal unit?**

  - Have individual lights with dimmers wherever possible.
  - Blinds/curtains can be used to shade brightly lit windows or doors.
  - ***Incubator covers*** (Figure 1) for babies less than 32 weeks gestation nursed in incubators. The incubators can be covered / uncovered using the multiple flaps according to the infant and care givers specific needs over the 24 hour period e.g. ward round examinations and cares vs sleeping. They should be changed every week or earlier if soiled to minimise infection.

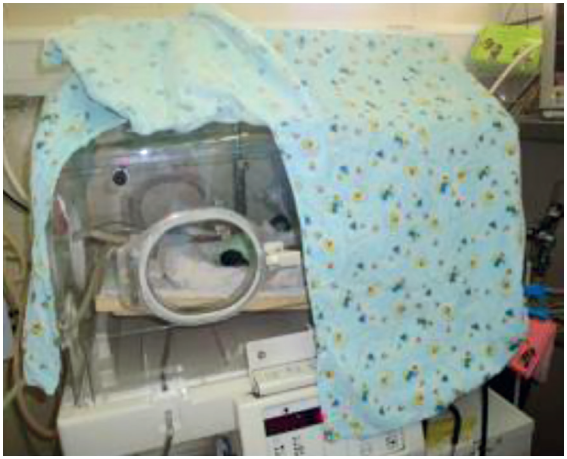

Figure 1: Incubator Cover
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- From 32 weeks the baby should be gradually exposed to ambient light during awake periods during skin to skin, feeding or nursing care.
- **Cot covers** should be used till 34 weeks or till a week prior to discharge.
- **Avoid fluctuating bright light on the baby's eyes during care giving procedures.** Provide eye protection (cover eyes with nappy/ rolled towel) for babies undergoing cannulation, umbilical line insertion etc. and also during phototherapy.
- Babies who undergo **ROP screening** should be protected from light for a **minimum of 12 hours** after the procedure.
- Darkness at night should be provided for an infant approaching term by dimming lights near stable babies.

- **How to provide visual stimulation for the preterm baby….**
  - Minimise visual stimuli for babies less than 32 weeks - **toys and pictures should not be placed** within direct visual space
  - Support emerging need for eye contact - generally infant shows preference for human faces after 32 weeks.
  - Offer opportunities for visual stimulation when the infant is displaying longer attention spans
  - Use moving, bright, curvilinear, large, contrasting objects 8-12 inches away from baby for stimulation after 37 weeks gestation
  - Check for fixing and following in near term babies - if any concerns are noted - start early stimulation – and refer urgently
  - **Enhance development of circadian rhythms**

    Dim lights in room at night if safe to do so. It improves A meta-analysis on cycled lighting effects on preterm infants in NICU reports a trend to improved weight gain, shorter

length of hospital stay and less incidence of Retinopathy of Prematurity (ROP) when compared to near darkness or continuous bright light.

2. Noise reduction

- **Why is noise reduction important?**

  High frequency noises have been shown to cause impaired language development, disorganization of the auditory cortex, apnoea, fluctuations in heart rate, blood pressure, and oxygen saturation and increase the risk of hearing loss. Reducing noise levels in the NICU can improve the physiologic stability of sick neonates and enhance the potential for brain development.

- **How can we reduce noise in the neonatal unit?**
  - Use thick incubator covers
  - Talk softly near open cots. Do not talk with the portholes of the incubator open. Avoid loud noise and multiple sound sources.
  - **Attend to alarms promptly and set alarm volume as low and set the alarm limits as is clinically safe.**
  - Decrease volume/tone of telephone ring and no radios in rooms. Audio tapes are not recommended for babies less than 37 weeks.
  - Close incubator doors quietly. Do not tap or bang on incubator.
  - Discourage the use of the top of the incubator as a writing surface and or storage area.
  - Ensure CPAP and ventilator tubing is regularly cleared of water.

- **Auditory stimulation of the preterm baby**

  Encourage parents to talk softly to their baby as cues allow. Start with soft voice leading on to normal conversation volume/tone. Soft calm music is also beneficial.

3. Protecting babies from noxious odours

- **Why is it important?**

  Unpleasant and noxious odours arising from the hospital disinfectants, solutions, and antibacterial compounds can have a negative impact on already deprived smell and taste sensations. Unpleasant procedures like intubation, suction as well as long duration of tube feeding can have a negative impact on the sucking behaviour in preterm infants.

- **How can we protect babies from noxious odours?**

  Open alcohol wipes and antiseptic preparations away from the incubator and infant. Avoid use of strongly scented perfume.

- **Stimulate baby with pleasant odours**

  Parents may familiarize their infant with the smell of breast milk by using milk-soaked gauze prior to and during a feed which should be discarded immediately after use.

4. Minimising oral aversion and promoting suckling on the empty breast

- **Why is it important?**

  - *Oral aversion:* Preterm neonates have many negative oral experiences like insertion of endotracheal tubes, suctioning and insertion of orogastric tubes.

    These negative experiences lead to oral aversion where the neonate rejects any object that comes into contact with the mouth. This may lead to delayed establishment breast feeding.

  - *Suckling on the empty breast* facilitates the sucking behaviour of infants and improves digestion of enteral feeds, decrease in the length of hospital stay age and age of achieving full oral feeds while improving weight gain, heart rate, oxygen saturation, intestinal transit time and behavioural state.

- **How can we minimise the oral aversion and create a positive oral experience?**
  - Suction orally only when clinically necessary.
  - Encourage hand to mouth contact.
  - Encourage stable babies to nuzzle at the empty breast during skin to skin contact under close supervision.

5. Tactile stimulation, minimal handling and clustering nursery activities

- **Why it is important?**

  Adverse effects of handling include hypoxia, bradycardia, sleep disruptions, increased intracranial pressure and behavioural agitation. Therefore, ensuring minimal and gentle handling is indicated while appropriate tactile stimulation is indicated at the same time.

- **How?**
  - **Swaddling a baby** during the non-contact period provides tactile stimulation and longer and calmer sleep duration with fewer startles, lowers heart rate, improves neuromuscular development organization, alleviates pain and prevents hypothermia.
  - **Cluster care**s but avoid completing several potentially distressing interventions at the same time. If an infant indicates signs of stress during handling - stop and provide 'time out' for the infant to recoup from that intervention.
  - **Combine doctors' ward rounds, nurses' care, blood sampling, gases etc.** and ensure that the baby has multiple opportunities of undisturbed rest.
  - **Do not unnecessarily examine stable babies** at the end / beginning of each shift
  - **Gently prepare infant for handling** with a soft voice or gentle touch to help promote physiological stability and

'state organization' i.e. how babies manage to protect their sleep, comfort themselves and organise their sleep and awake states

- Interventions should ideally take place when an infant is in a gently aroused state and with consideration of infants' cues. Abrupt/fast changes in position are likely to be poorly tolerated for babies under 33 weeks.
- Hold infants during feeding if awake - this includes tube feeding.
- Vary infant head and body position being mindful of infant physiological status and response to handling.
- To soothe the infant during uncomfortable procedures, contain infant-head and hands in midline, shoulders forward, lower limbs flexed and adducted towards the midline. Elicit help from a parent or another nurse *(figure 2)*

Figure 2: Containing head and hands in midline

- Avoid stimulating the infant with stroking or patting babies under 32 weeks. Patting or stroking may be tolerated for after 32 weeks.

- Where clinically possible consider day/night patterns for interventions from 24 weeks onwards like weighing infant, changing bedding and encouraging socialization in the daytime to enhance sleep/wake organization.
- Ensure good nutrition with parenteral nutrition and breastmilk as well as use virgin coconut oil massage to keep the skin healthy. Minimise venepunctures / heel pricks that damage the skin barrier.

6. Positioning

Baby is contained securely by uterine boundaries while in-utero. Positioning simulates intrauterine boundaries.

- **Position**
  - Baby's arms and legs are flexed
  - Knees and elbows tucked towards the middle of the body
  - Spine is curved
  - Head is tucked slightly forwards

- **Why is positioning important?**
  - Muscle tone is still developing until 36 weeks
  - Supports ex-utero movement development
  - Prevents postural deformities
  - Helps self-consoling.

Figure 3: Uterine boundaries

The nest

Supportive positioning technique used should enhance flexion, promote comfort and provide opportunities for movement as well as have simulated intrauterine boundaries. *It can be made with rolled up towels / blankets or cot sheets.*

Step 1- Roll the towel

Step 2- Fold towel into a "U" Shape

Step 3- Add a second rolled towel to snuggly fit the baby in the fixed position

Step 4- Cover with a soft cloth and tuck it in

Step 5- the completed nest

Figure 4: Steps in making a nest

- **Which babies need nests?**

  Nests are indicated for babies below 34 weeks, weight less than 1500g, and acutely ill, immobile newborns

- **Timing of different positions**
  - Prone position is best until the baby is stable.
  - Side lying position can be introduced as the baby is becoming more stable and supine position is introduced when preparing to discharge

- Nesting boundaries should be gradually decreased and removed as the baby approaches term / discharge

- **Cleaning of the nest**

  The nest should be replaced every 48 hours unless visibly soiled and the soft cloth that is used to line the nest should be changed daily or more frequently if soiled.

- **Prone position**

  In this position the baby must be well supported, as gravity will push the knees out to the sides. It helps breathing movements by supporting the rib cage, reduces reflux, increases time spent in quiet sleep and saves energy and helps faster weight gain (figure 5).

Figure 5: Prone position

Figure 6: Kangaroo mother care

Kangaroo care is another method of keeping babies in the prone position *(figure 6).*

(Refer chapter on thermal care for further details on KMC)

- **Side lying**

  Helps to get their hands to their mouths for comfort, when upset as part of self-regulation.

Figure 7: Side lying

Figure 8: Side lying with inadequate support

Babies naturally roll out of this position(figure 8). Therefore, need to use a rolled-up towel to support a tucked up, curled in position.

Supine position (Figure 9)

Figure 9: Supine position

Can be introduced during wake periods e.g. nappy changes when the medical condition has stabilized. Face should look

up towards the ceiling and should not be turned to either side. **Rolled towels/roll pillows can be used to keep head in the midline.** This will help the pressure to go down the back of head symmetrically and will prevent premature head shape which will occur if nursed with the cheek on the cot. It will also help the baby to learn to keep the head straight.

7. Involving parents in the care of their baby

It is important to promote early and continued parental involvement.

Figure 10: Involving parents in the care of their baby

- Encourage parents to observe their infants behaviour /cues
- Teach parents to identify infant's readiness for touch and handling and emphasise the infant's potential low tolerance for stimulation.

- Encourage parents to assist with cares where they can, in particular gentle touch, containment during and after handling, top and tail wash and Kangaroo care where appropriate.
- Promote independence and enjoyment of maturing infant by encouraging parents with feeding and cares, in particular containment during and after and Kangaroo care.

8. Understanding stress signals of the baby and using consoling strategies

A comfortable baby will have his feet supported (touching the cot / incubator) with a relaxed expression and allow brief eye contact.

a. Feet supported b. Relaxed expression c. Eye contact

Figure 11: Baby is comfortable

- **The following indicate a stressed baby**
  - arched back
  - breathing rate
  - thrusting arms and legs in the air
  - a scowling face
  - toes and fingers spread out
  - looking away
  - sudden changes in heart rate or
  - frowning
  - suddenly going floppy or stiff
  - waving arm movements
  - yawning / hiccups

a. Thrusting arms and legs in the air, finger and toes spread out

c. Looking away

b. Frowning / scowling / waving arms

d. Yawning

Figure 12: Baby is stressed

9. Consoling strategies

Consoling strategies that would help the preterm during stressful situations include,

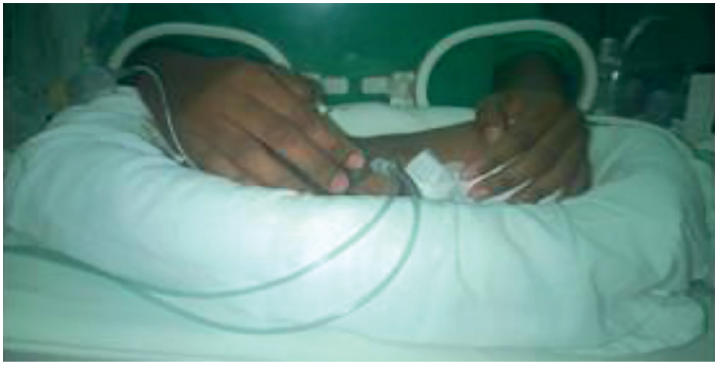

Figure 13: Containment holding

- **Containment holding (Figure 13)**

  Holding the preterm by placing one hand over the head and the other over the lower back
- Grasping a finger
- Suckling on a gauze soaked with breast milk
- Gentle touch
- Quiet talking

10. Protect sleep

Schedule interventions when baby is awake. Cluster cares to minimise distruption. DO NOT WAKE BABY UP ! Ensure a minimum of 60 minutes sleep without distruption. If a neonate must be woken up, it should be done from active sleep, by talking and touching gently. Support baby to go back to sleep if he displays unsettled behaviour.

11. Protect skin

Minimise investigation and procedures. Use heel prick for blood drawing. In very small babies use umbilical venous catheter for intravenous access and umbilical arterial catheter for blood drawing. Keep skin healthy by optimizing nutrition, using skin to skin care and massaging the skin using virgin coconut oil.

12. Optimise nutrition

Start Parenteral nutrition from day 1 until 50% of requirement is from breast milk in babies < 32 weeks and < 1500g. Own mother's breast milk from the first day via cup /tube and increase as available.Support mother to express milk

Summary

Implementation of developmental care in the neonatal unit calls for commitment and dedication rather than sophisticated equipment. These include,

- **Protect from**
  - Light
  - Noise
  - noxious odours
  - oral aversion
  - excessive procedures, blood drawing
  - excessive handling
- **Promote**
  - Non-nutritive suckling on the recently expressed breast
  - Age-appropriate stimulation
  - Using nest to simulate uterine boundaries
  - Protected sleep
  - Minimal handling
  - Involvement of parents in care
  - Use of consoling strategies
  - Skin care using coconut oil massage
  - Initiation of parenteral nutrition and breastfeeding soon after birth

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Infection control in the neonatal intensive care setting

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Neonates are at high risk for nosocomial infections also known as hospital acquired/health care-associated infection (HAI). The risk of infection and the associated complications increase with the degree of prematurity and low birth weight, incomplete immunity, prolonged hospital stay and frequent invasive procedures. Microorganisms can easily be transmitted to neonates from various sources including the hospital environment, patient care supplies and equipment, infected personnel, and most frequently from hands of health care givers. HAIs cause increased hospital days and cost for antibiotics and services are increased unnecessarily.

HAIs are generally related to multiple factors. Prevention of infections depends on continuous observation and implementation of evidence – based practices. These practices are outlined in written guidelines, policies and procedures.

Learning Objectives:

- Outline healthcare associated infection and its significance in neonatal care
- Apply common infection control measures
- Explain how to minimize infections during procedures in neonatal care
- Identify the challenges in preventing healthcare associated infection
- Prevent and control healthcare associated infection

Health Care-Associated Infection (HAI)

HAI or nosocomial infection is an infection acquired in the hospital that was neither present nor incubating at the time of hospital admission but developing in the course of stay in hospital.

This includes infections acquired in the hospital but appearing after discharge, and also occupational infections among staff of the facility. HAI starts usually on or after the 3rd day of admission to the health facility (Day of admission is Day 1) or on the day of or the day after discharge from the facility.

Why Neonates are at high risk for Nosocomial infection?

Multiple factors are responsible. These include prematurity and the related relative immunodeficiency, use of multiple invasive devices and procedures (e.g., central venous catheters, ventilator support, use of urinary catheters), receipt of parenteral nutrition and lipids, exposure to broad-spectrum antimicrobials, multiple skin punctures.

Minimizing transmission of infection in NICU

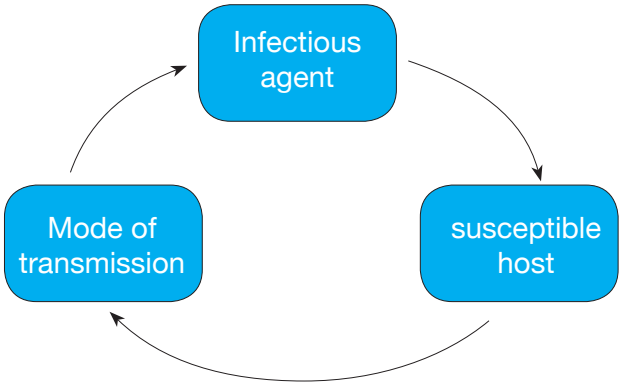
It is the prime responsibility of health care givers to take measures to prevent infection. In an NICU setting, nosocomial infections are caused mainly by bacteria and occasionally by fungi.

Terms used in infection control and prevention

Term	Description
Colonization	When an infectious agent establishes itself on or in the body but does not cause disease
Contamination	When infectious agents spread to a surface or item, creating risks for the spread of infection
Infection	When an infectious agent enters the body and multiplies to levels where it causes disease
Source	The origin of the infectious agent. Most sources are other people, but they can also be air, water, food or equipment that has become contaminated.

Term	Description
Susceptible host	A person exposed to an infectious agent who is vulnerable to infection
Transmission	The spread of infectious agents from one person to another

Chain of infection



An infection requires three main elements:

- ➢ a source of the infectious agent
- ➢ a mode of transmission and
- ➢ a susceptible host.

Breaking this chain of infection helps to stop the spread of infection.

Microorganisms are transmitted to neonates through

- the NICU environment
- contaminated equipment and utensils
- invasive devices
- **the hands of health care workers**

Common modes of transmission

Infections are transmitted commonly through contact, droplets and airborne modes. Contact can occur directly or indirectly.

- Direct contact – contact with infected blood or body fluids of a patient.
- Indirect contact – a person touching a contaminated surface/ patient and then touching another person without performing hand hygiene.

What is cross infection?

This is transmission of disease producing microorganisms from one person to another. This can happen through contaminated medical equipment or other items used for patients and mainly through hands of health care personnel.

Standard precautions in preventing infections in NICU

These are the precautions to be used when attending **to all patients, by all health care givers, at all times** to assist in controlling the spread of infection. They are designed to provide safety to both health care givers and patients.

Standard Precautions

1. Hand hygiene
2. Using Personal Protective Equipment(PPE) when applicable
3. Cleaning, disinfection and sterilization
4. Disposal of health care waste and sharps
5. Safe equipment and linen

1. Hand Hygiene

Hand hygiene includes hand washing, using hand rub and surgical hand washing to remove or destroy pathogenic microorganisms by cleaning and disinfection.

Hand washing can be defined as the careful and systematic cleaning and drying of hands in order to remove soiling and remove transient bacteria to prevent cross infection.

Effective hand washing - Ten step guide(WHO)

The above steps are as follows:

1. Wet hands and forearms
2. Soap up rubbing palm to palm
3. Rub with fingers interlaced
4. Massage between fingers, right palm over back of left palm, left palm over back of right palm
5. Rub with fingers interlocked including fingertips
6. Rub rotationally with thumbs locked
7. Rinse thoroughly
8. Dry palms and back of hands using a paper/disposable towel
9. Work towel between fingers and dry around and under nails
10. Place used towels in a bin, ensuring that you do not touch the bin lid by your hand

Hands should be wet under running water and soap dispensed into cupped hand. Hand washing should be done for 40-60 seconds (WHO-Essential Newborn Care Course).

Drying of hands

Single use towels for hand drying should be readily available. Disposable paper towels are the ideal medium to dry hands. If cloth (linen) towels are used, they should be laundered and sterilized and reused.

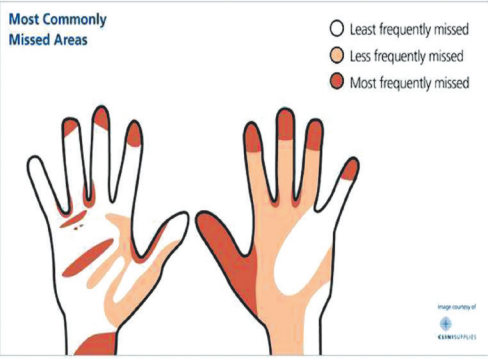
Jewelry should be removed when caring for an infant (e.g., remove watches and rings). Nails should be kept clean and short.

Hands should be washed specifically.

- before touching a patient
- before clean/aseptic procedures
- before handling invasive devices
- before and after using gloves
- after body fluid exposure/ risk
- after touching a patient/ after touching patient surroundings

Parts of hands frequently missed in hand washing

- under the nails
- thumbs
- fingertips
- between fingers
- back of the palm



- Hand washing is the single most important method of preventing infection in NICU.
- It saves money spent on antibiotics.
- It is important that it is performed at the right moments

Alcohol based hand rub

This is an alcohol-containing preparation used for reducing the number of viable microorganisms on the hands. The type of hand rub solutions should be recommended by the hospital.

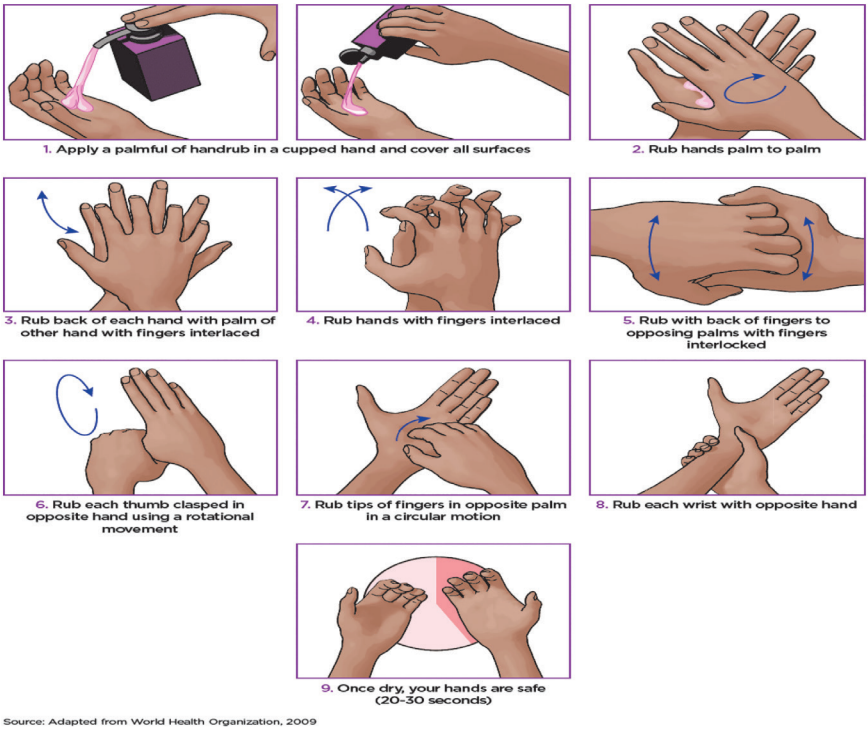
When should you use alcohol-based hand rub?

- when hands are visibly clean
- when you need to disinfect hands quickly between two procedures for the same patient.

- Alcohol based hand rub is not appropriate for all situations and should not be used when hands are visibly soiled.
- Hand rub should not replace hand washing unless in an emergency situation

One hand rub container should be available for each incubator. Duration of the entire procedure is 20-30 seconds

Correct steps in using hand rub:



Source: Adapted from World Health Organization, 2009

2. Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) includes gloves, masks, gowns, caps, goggles/eye protection. All blood, tissue and bodily fluids, are considered potential sources of infection; therefore, staff

should utilize the appropriate personal protective equipment (PPE) when performing patient care activities and procedures.

Use of gloves:

Non-sterile gloves should be used when touching blood and/or body fluids, mucous membranes, non-intact skin, or items/surfaces soiled with blood and/or body fluids for the safety of health care personnel.

Non-sterile gloves should be removed and discarded after handling each patient or any equipment part inside the incubator of that patient.

Sterile gloves are used for invasive procedures. Gloves should be worn after hand washing and drying. Hands should be washed immediately after removing gloves.

Gloves or alcohol hand rub should never replace hand washing.

Once hands are covered with sterile gloves, one should **not** handle any unsterile equipment, e.g., Incubator doors, monitors, mobile phones, bed head tickets/ stationery etc.

Gowns: Nurses should wear special clean, comfortable uniforms inside the NICU to prevent cross-infection. A gown should be worn during procedures and patient care activities that are likely to generate splashes of blood and/or body fluids onto clothing or exposed skin (e.g., suctioning, chest tube insertion). Gowns /uniforms should be changed daily and when contaminated with body fluids. Gowns are not essential in routine care.

Masks and Goggles/face shields: Masks are used to prevent airborne transmission of microorganisms. Some procedures generate splashes, sprays or droplets of blood and/or body fluids into the mucous membranes of the mouth, nose, or eyes. In such occasions a splash proof (water proof) mask and protective eye wear (face shields /goggles) should be used to cover eyes completely.

Caps: use of caps prevent hair coming in contact with the infant.

3. Cleaning, disinfection and sterilization

Definitions of cleaning, disinfection and sterilization

- **Cleaning** - Physical removal of contamination (blood, faeces, etc.) and many microorganisms using detergents. Cleaning helps to control the microbes and to prevent transfer of infection. It is also important to dry all the equipment used for cleaning purposes.
- **Disinfection** - Reduce the number of microorganisms to a level at which they are not harmful. Spores are not usually destroyed.
- **Sterilization** - Removes or destroys all microorganisms including spores

Environmental cleaning

Areas of environment need to be cleaned regularly in NICU and duration (Sri Lanka College of Microbiologists, 2005):

Floors horizontal surfaces	- twice a day with a general purpose detergent (GPD)
Horizontal surfaces	- daily with GPD
Walls and ceilings	- Once weekly with GPD
Sinks, taps, door handles	- twice a day with GPD
Utility rooms	- twice a day with GPD
Telephones	- wipe daily with 70% alcohol

Surface dusting (walls, furniture and equipment)

- Surfaces of walls, furniture and equipment have to be cleaned and dried to prevent accumulation and growth of microorganisms. Wet dusting is the preferred method than dry dusting.
- Wet dust the horizontal surfaces daily. Clean walls with a general-purpose detergent once weekly.
- Clean bedside tables, counter tops, monitors, ventilators and IV pumps at the beginning of each shift

- Sinks and the taps should be cleaned three times a day with a detergent.
- Use a general-purpose detergent for floor mopping twice a day
- During an outbreak of sepsis, use 0.1% hypochlorite for floor mopping,
- Dry the mop in upright position, preferably under sunlight.

When to use disinfectants to clean the floor/ work surfaces

- When a body fluid is spilled on the floor consider it as potentially infectious. Visible contamination of floor or any working surface with blood or body fluids must be disinfected, contained, and cleaned.
- 1% hypochlorite is the recommended disinfectant for this purpose
- Blood and body fluid spills are managed in a way that the pathogens in the spill are not spread in the environment. And it has to be carried out safely.

Three steps in cleaning a spill of body fluids:

1. contain the spill (not allowed to spread further)
2. destroy the pathogens by a disinfectant
3. clean the spill
    - **Contain the spill:** Do not let the spill flow into a larger surface area. You can soak the spill using an absorbent material - ideally with paper towels if available, or a cloth towel (that must be discarded after use).
    - Use disposable gloves
    - **Destroy the pathogens:** Pour 1% hypochlorite solution (10,000 ppm available chlorine) on the absorbent material until it is well soaked and leave it for at least 10 minutes.
    - **Clean the spill:** Remove the absorbent material with the spill using gloved hand. Discard it in the clinical waste bag.

- Swab the area (with a cloth or paper towel) or mop the area with a detergent and water and allow the surface to dry.

What is an ideal chemical disinfectant?

- A disinfectant not corrosive to surfaces or equipment, and quickly degrades, leaving no toxic residue after cleaning.

General precautions in NICU

- Handle soiled diapers as little as possible and discard those into the trash receptacle as soon as possible. When caring a neonate in an incubator, soiled diapers should be kept away from respiratory support equipment and umbilical or intravenous access lines. After discarding a soiled diaper, remove gloves and wash hands.
- Dedicated stethoscopes should be provided for each infant in the NICU. These dedicated stethoscopes should be cleaned with germicidal or alcohol swabs at the start of each shift and after a patient is discharged. After contact with infants who are not on isolation precautions, disinfect stethoscopes with germicidal or alcohol wipes between each patient examined.
- Do not eat, drink, or store food or drinks within patient care areas in the NICU.
- Dispose of single use items according to hospital policy after use. Do not reuse.
- Clean scales with detergent-wipes after each use and cover for storage.

“Traffic” in the NICU

- Keep traffic (visitors, parents, and staff) to an absolute minimum while caregivers perform sterile procedures.
- All visitors, parents and staff are required to perform hand hygiene prior to any contact with infants/infant’s environment.
- **All staff should minimize the use of all electronic devices and hands should be washed/ sanitized after each use.**

- Encourage parents and visitors to avoid using all electronic devices (e.g., cell phones, iPads) **after entering the NICU.**
- Push sleeves up **above the elbows** when having contact with babies in incubators.

Cleaning of incubators:

Incubators with a baby: The interior of the incubator should be wiped with sterile water daily when in use and kept free of visible particulate matter.

Upon discharge: Clean with soap and water.

In long term patients, change/clean incubator weekly

Important:

When cleaning an incubator or warmer;

- remove and scrub all detachable parts.
- clean portholes, cuffs and sleeves after each patient or once weekly
- incubator and parts should be dried thoroughly with clean hand towels after washing.
- incubator detachable parts should not be soaked in detergent solutions
- Replace mattresses when the surface covering is broken.

Special cleaning after a septic baby /soiled incubator

Incubators used for a septic baby should be cleaned as follows.

- Port hole, other plastic parts, hood and inner walls, mattress, mattress tray – use 2% Chlorhexidine for cleaning and dry well.
- Patient probe – clean with 2% Chlorhexidine, **do not use alcohol**
- Oxygen inlet – clean with general purpose detergent and dry
- Humidifier – empty the water, disassemble, clean with 2% Chlorhexidine, refill with sterile water after cleaning.
- Label the date of cleaning on all equipment.

4. Safe disposal of waste and sharps

- Disposal of sharps and needles should be done according to hospital policy after use.
- Do not reuse sharps and needles.
- DO NOT leave an unprotected needle lying on the sharps container or dismantle sharps
- Discard the used device (a needle and vacutainer/syringe is a single unit) immediately into a sharps container
- Place infectious waste, including items contaminated with blood or bodily fluids, in appropriate containers.

5. Providing safe linen

Used linen should be handled carefully, to avoid spreading infectious agents into the environment or onto your clothes.

- wear personal protective equipment (e.g., aprons, gloves) when sorting/handling soiled linen

- soiled linen or infected linen should be collected separately into yellow plastic bags. The mouth of the bag should be tied and sent to laundry with a tag/label attached. Care must be taken when transporting soiled linen through wards/corridors.
- linen bags should not be overfilled.
- linen should be processed according to hospital policy.
- the trollies/carts used to transport used/soiled linen should be cleaned and disinfected before transporting clean linen
- cleaned linen should be kept in a clean and dry designated area preferably a cupboard to prevent contamination.

Isolation precautions

In addition to Standard Precautions, some infections and disease conditions require additional measures (Contact, Airborne, Droplet precautions) to prevent transmission of microorganisms.

Management of an infectious patient - Patient isolation

Patients with an infectious disease are sometimes nursed in isolation rooms. The objective of isolation is to minimize the risk of microorganisms from the patient being transferred to others. Care should be planned for individual patients and practice of unnecessary precautions has to be avoided.

In addition to the standard precautions, some conditions may need additional precautions. Examples: Chicken pox, measles, antibiotic resistant organisms colonizing the skin or other body sites.

Always take advice from the infection control team regarding needed precautions.

- Infectious patients should be kept in a private room or could be kept with other patients infected with the same microorganism (cohorting)
- Protective clothing should be used by the staff when entering the room and discarded after single use.

  e.g., clean gloves, gown, masks if needed.

- Plastic aprons should be used during procedures involving heavily contaminated sites. (e.g., infected wounds and burns)
- Hand washing is essential, specially before leaving the room
- Instruments in isolation rooms have to be used separately
- Transportation of patient to other areas of the hospital should be done only when necessary.
- Instruct all visitors in appropriate hand hygiene and infection prevention measures.
- Barrier nursing (i.e. one to one nursing method) should be used for these patients.

Measures should be taken to minimize spread of infection, across the NICU in case of babies with HAI (e.g. Acinetobacter, MRSA):

- A separate nursing officer should be assigned for the care of these babies for each shift.
- The baby should be examined at the end of the ward round, unless critically ill.
- All disposable equipment (CPAP/ ventilator tubing etc.) should be discarded and **SHOULD NEVER BE REUSED.**
- Cleaning incubators -Refer section 1.1.5

Aseptic technique during procedures

Aseptic technique protects neonates during invasive clinical procedures by employing infection control measures that minimise, as far as practicably possible, from the presence of pathogenic microorganisms. Principles of aseptic technique are the same for all clinical procedures.

(for further details, please refer Chapter on procedures in the NICU)

Infection control in some specific procedures in NICU

Indwelling medical devices provide a route for infection to enter the body of a neonate. When handling these devices, care givers are also at risk of exposure to blood and body substances.

General precautions:

- Perform hand hygiene before any contact with the device or where the device enters the body.
- Select personal protective equipment (e.g. wear gloves and a mask and gown if there is a risk of exposure to blood or body fluids).
- Touch the device as little as possible.
- The longer the device is in place, the greater the risk of infection.
- Medical devices that are designed for single use must not be used multiple times and manufacturer's instructions should be followed.

Preventing Intravascular-catheter related infection

Care and maintenance of intravascular catheter site

- Hand hygiene should be performed before and after inserting, replacing, accessing, repairing and dressing an intravascular catheter at all times
- Maintain aseptic technique for insertion and care of intravascular catheters at all times
- Wear either clean or sterile gloves when handling IV catheters
- Sterile, transparent, semipermeable dressing could be used to cover catheter site
- Catheter site dressing should be replaced if the dressing becomes visibly soiled, wet or loosened maintaining aseptic technique
- Catheter site should be monitored along with other vital signs and noted in the observation chart
- Cather site should be inspected at the beginning and the end of each shift, with regard to oedema, redness, warmth, tenderness and discomfort on touching the surrounding area
- If the above signs are present, the dressing should be removed to allow thorough examination of the site.

- Do not use topical antibiotic ointment or creams on insertion sites, except for dialysis catheter

The following should be documented in the BHT/ Nurses' notes:

- Date, time, and site of insertion
- Person performing procedure and assistant
- Name of vein used and exact site
- Size of the inserted catheter/cannula
- Reason for insertion, number of insertion attempts
- Date, time and reason for catheter removal
- Any complications arising and its management

Replacing IV administration sets

- Wash hands thoroughly and wear sterile gloves
- IV administration sets should be changed every 24 hours (National Guideline for Newborn Care, 2020).
- Changing the IV administration sets has to be done maintaining sterility of the catheter hub while removing the old tube.

Preventing infections through respiratory devices:

Cleaning, disinfection and sterilization of respiratory devices used in NICU

(i) Ventilators

- Follow manufacturer's instructions whenever possible. Otherwise wipe with a general-purpose detergent daily and between the patients.
- Change external filters between patients
- Clean internal filters to CSSD to autoclave. Change internal filters once in every 3 days in long term patients
- Clean internal mechanisms according to manufacturer's instructions by authorized maintenance staff.

(ii) Ventilator tubing

- Single use tubing is the ideal
- If reused, clean with general purpose detergent and autoclave if autoclavable
- Inside of the tubes should be washed thoroughly

(iii) Humidifiers: empty and clean reservoirs with GPD, dry thoroughly and refill with sterile water

(Iv) Reservoir bags:

- Single use bags are preferred between patients.
- If reused, clean by partially filling the bag with water and GPD and shaking the bag and rinse with sterile water and dry. Outer surface is washed with water and GPD and dry.

  Autoclave or immerse in a high-level chemical disinfectant recommended by the hospital.

(vi) Oxygen tubing, nasal prongs, devices used for non-invasive ventilation and Endotracheal tubes

- Single use only

(vii) Laryngoscopes

- Wash blade with soap and water and use a high level disinfectant
- Wipe hand piece with 70% alcohol.
- Ideally blades should be autoclaved

(ix) Masks (CPAP, Nebulizer Mask)

- Use disposable masks where available and discard after each patient.
- If reused due to unavailability, wash with soap and water and wipe with 70% alcohol.
- If used in an infected patient, it is mandatory discard.

Equipment used for suction:

Suction catheters: should be single use.

Suction tubing

- Wash with soap and water and autoclave
- Change daily and between patients

Suction bottles and jars

- Autoclave after washing with soap and water.
- If not autoclavable, wash with soap and water and immerse in 1% hypochlorite solution.
- Metal lids - use a chemical disinfectant solution
- Empty when 2/3 full or daily whichever is more frequent

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Procedures in Neonatal Intensive Care Unit

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Learning Objectives: Learn the methodology of:

- **Obtaining central vascular access:**
  a. **Umbilical artery and venous catheter**
  b. **Peripherally sited central venous catheters**
- **Heal prick blood sampling**
- **Insertion of chest drains**
- **Peripheral arterial blood sampling**
- **Peripheral venous cannulation**

Obtaining Central Vascular Access

Central Venous access

Umbilical venous catheters and peripherally sited central venous catheters (PICC) are used to administer medications, which are harmful to be delivered peripherally. These include inotropes, parenteral nutrition and concentrated (>12.5%) Dextrose infusions.

Insertion of PICC lines

Different types of PICC lines are available, such as.

1. French gauge 1 (Fr 1), single lumen catheter: ideal for babies weighing less than 1000g.
2. French gauge 2 (Fr 2), single lumen catheter: ideal for babies weighing more than 1000 g
3. French gauge 2, double lumen catheter: for very sick babies weighing more than 1000 g and needing multiple infusions simultaneously

Contraindications/ cautions

- Infection at intended insertion site is a contraindication
- Systemic sepsis: administer systemic antibiotics for at least 48 hours before inserting the PICC line and blood cultures must be sterile at the time of insertion

Insertion sites for PICC lines:

Upper limb:

Choose medial ante cubital fossa veins. Avoid lateral veins, if possible, as the catheter is more likely to enter a small vein in chest wall, rather than entering a central vein.

Lower limb:

Right long saphenous vein is preferred rather than the left limb veins. Those entered in to left lower limb are more commonly associated with malposition in the left ascending lumbar vein leading to risk of extravasation of fluid into CSF.

It is recommended to identify the vein and measure the required length of PICC line before scrubbing up.

Measurement of Length for PICC lines

For upper limb: measure from insertion point to anterior axillary line and then to sternoclavicular joint. *(figure 1)*

Figure 1: measuring length for upper limb PICC lines. (Insertion point of line indicated by arrow)

For lower limb: measure from the insertion point to groin and extend to the xiphisternum. *(Figure 2)*

Figure 2: measuring the length for lower limb PICC lines. (Insertion point of line indicated by arrow)

Pain management, monitoring and preventing hypothermia during procedure

A nurse/colleague must be free to comfort the baby with measures like swaddling, non-nutritive sucking (eg: gauze soaked with mother's milk) and also to monitor baby's vital parameters. Prevent hypothermia by performing the procedure through open portholes of incubator, rather than opening the incubator door.

Maintaining sterility

Maintaining sterility during insertion of the central line is of utmost importance as line related sepsis is a major complication needing removal of the line. Please refer to chapter on infection control for details.

Procedure:

1. Scrub up

   Wash hands and forearms using 6 steps of hand washing with soap and water. Dry with sterile towels and put on the sterile gown and 2 pairs of sterile gloves.

2. Ensure that the fluids to commence post insertion are drawn up in a sterile technique and ready to be attached.
3. Make sure procedure area is adequately lit.
4. Set up trolley maintaining strict aseptic technique
5. Cleaning solution as per unit policy - 2% chlorhexidine is recommended for babies bigger than 1000g; this has to diluted 1:1 with sterile water for extreme low birthweight babies.
6. Required equipment:
   - Sodium chloride 0.9% for injection
   - Appropriate sized long line
   - Long line insertion pack or, individual items to include:
     a. sterile towels/sheets
     b. non-toothed forceps
     c. 5–10 mL syringe
     d. Steri-Strip
     e. sterile scissors
     f. Transparent dressing
     g. Sterile gauze
7. **Work through the port holes** and avoid opening the incubator side, to prevent hypothermia. Place a sterile towel underneath the limb.
8. **Clean the insertion point and the adjacent skin of the limb using 3 swabs soaked in cleaning solution.**

9. **Remove the first pair of gloves.** Drape the limb with 2 further sterile drapes.
10. Prime the PICC line with 0.9% Saline.
11. Clean the insertion site once more and allow to dry.
12. Puncture the vein with needle from the pack.
13. When the needle is in situ, insert line using non-toothed forceps
14. The PICC line must pass through the needle easily if the needle is placed appropriately in the vessel.
15. Some resistance is felt when the line passes joints, such as knee and shoulder. Gentle repositioning of the limb will help to advance the line.
16. Once the line is inserted up to the premeasured length, withdraw needle.
17. Remove the guidewire, if present.
18. If the line is in a satisfactory position, it must aspirate blood freely and can be flushed easily.
19. It is common for some bleeding to occur when the needle is withdrawn. Apply gentle pressure over the puncture site to stop bleeding.
20. Keep at least 0.5ml/hr of fluid running through the line to prevent blockages.
21. Secure the line with steri strips.

Stabilizing and checking line

1. It is advisable to avoid completing the dressing, before confirming the final tip position. This is because, if the dressing has to be removed to allow line adjustment, there is a risk that the line will get pulled out.

   A tip for easy adjustments:

   i) Cut one piece of Tegaderm (using sterile scissors) with a 1cm diamond hole in the center *(figure 3)*

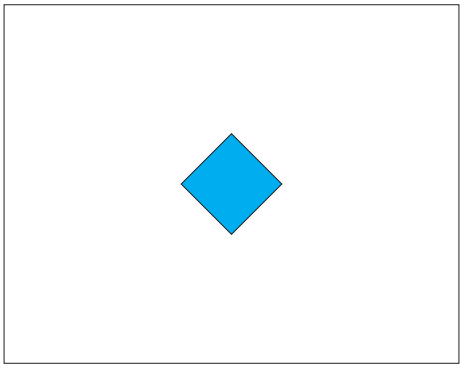

Figure 3: Tegaderm with a small diamond (0.5 cm X 0.5 cm)

ii) Place this with the hole over the insertion site. If the line needs adjustments, that can be done through this hole without removing the whole dressing.

(It is better to temporarily cover the hole with a sterile piece of gauze while x-ray is being done, to prevent infection)

iii) After confirming the correct position, place a second piece of Tegaderm over diamond hole

2. Confirm the position of the line with a X ray.
3. Upper limb must be held perpendicular to the body during X-Ray. Lower limb should be flexed at the knee and hip during
4. Place small piece of gauze under hub, and cover with Transparent dressing

Do not encircle the full circumference of the limb when applying the dressing, to avoid the distal blood flow being compromised.

The line insertion site must be visible through the dressing.

5. Confirm the position of the line with an X ray.

Upper limb must be held perpendicular to the body during X-Ray. Lower limb should be flexed at the knee and hip during imaging.

6. Recommended position of the tip of the PICC line

   Upper limb : tip should preferably be in superior vena cava, but other large veins e.g. innominate, subclavian are acceptable. Therefore, mid-clavicular position is acceptable for the line tip, if the PICC line insertion is via a medial arm vein.

   A line traversing a medial vein is seen to travel under the humeral head (Axillary vein) *(figure 4).*

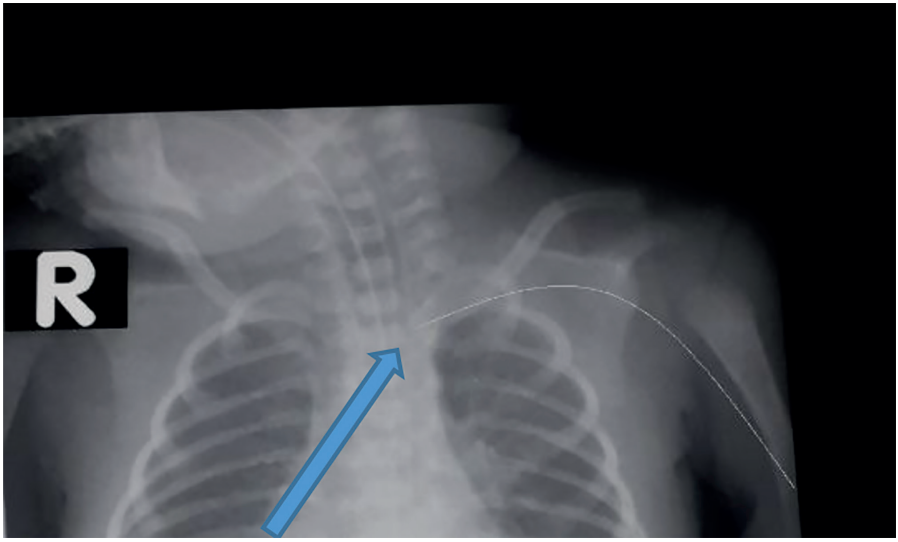

Figure 4: PICC line inserted froma medial vein in left upper limb, and tip is appropriately placed (arrow)

However, if it was inserted from a lateral vein, (This will be seen in the Xray as the line passing over the outside of the humeral head), the tip must lie beyond the mid clavicular point. This is because, lines traversing the cephalic vein can get stuck at the clavipectoral fascia, leading to extravasation injury.

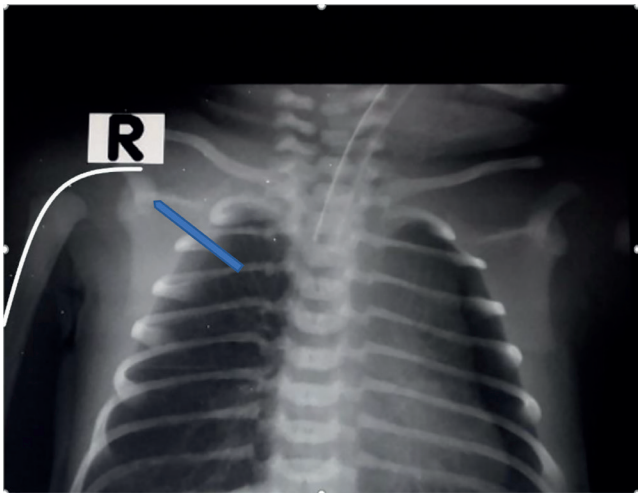

Figure 5: unacceptable position: PICC line inserted from lateral veins of right upper limb; the tip of the catheter does not pass beyond mid clavicular point.

(NB: color and thickness of the line have been enhanced to improve clarity)

Lower limb: PICC should cross the midline at L4/5 and run to the right side of the vertebral column in the IVC with the tip outside the heart. Rarely, the line can run in to the lumbar plexus, in which case it will not cross the midline or show a tortuous course (figures 6 & 7).

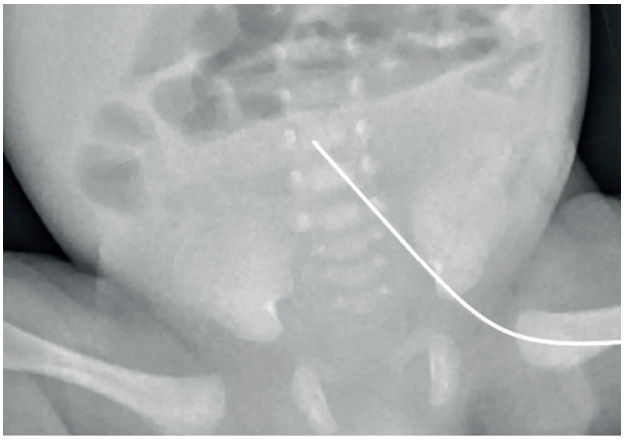

Figure 6 : AP view of a PICC line entering into the vertebral column; inappropriate position.

(NB: line has been enhanced in the picture to improve the clarity)

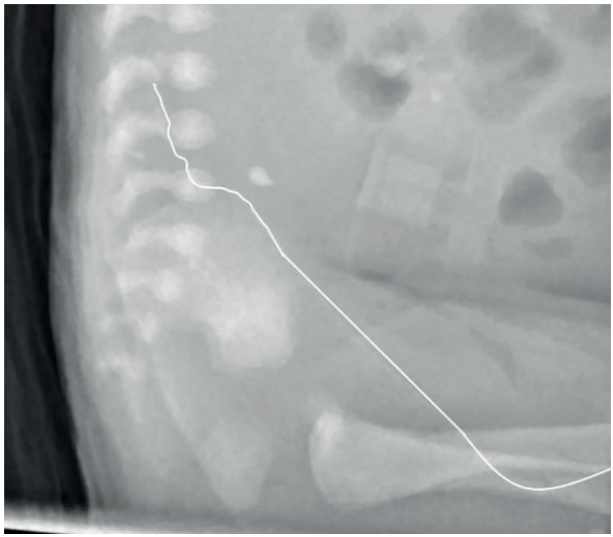

Figure 7: Lateral view of the same patient: A line having a tortuous course, and entering into the vertebral canal is seen. (NB: line has been enhanced in the picture to improve the clarity)

7. For Fr 1 PICC lines, contrast must be injected just before the X ray to facilitate visualization of the line in the X ray. (omnipaque : Dose 0.3 ml)
8. If catheter tip lies beyond the desired location, using aseptic technique, pull out the desired length through the diamond shaped hole in the Tegardem. Confirm new position with repeat X ray.
9. **A short line must never be advanced, as this breaches the sterility.**
10. **Line tip must not lie within heart as there is a risk perforation and tamponade.**
11. Document the date, time, insertion length and the final position of the catheter tip in X ray patient notes.
12. **PICC lines must only be used for infusions like parenteral nutrition. Avoid using it for antibiotics, to minimize line breaks. Maintaining strict sterility while handling the line is extremely important.**

Insertion of umbilical lines

Measurement of length:

Umbilical venous catheter (UVC) length in cm = (weight x 1.5) + 4.5 + length of umbilical stump

Umbilical Arterial Catheter (UAC) length in cm = (weight x 3) + 9 + length of umbilical stump

Choosing the correct size

- UVC: Fr 5 (ideally double lumen or triple lumen)
- UAC : single lumen umbilical catheter
  - < 1500g : 3.5 Fr
  - >1500g : 5 Fr

Maintaining sterility during insertion of the umbilical lines is extremely important.

Monitor the vital parameters and temperature of the baby during the procedure.

Procedure:

1. Follow steps 1-5 as stated in PICC line insertion
2. Required equipment:
   - 2x sterile drapes
   - 3-way taps
   - 2x 3ml syringes
   - Drawing up needles
   - 4/0 silk curved needle
   - Size 22 scalpel
   - Appropriately sized catheters
   - Heparinised saline for UAC. (50 units per 100 ml)
   - non-toothed forceps

- 5–10 mL syringe
- sterile scissors
- umbilical tie

3. Attach to 3 way taps to the lines
4. Prime the catheters through the three way taps with saline
5. Work through incubator port holes only.
6. Clean the umbilical stump and surrounding abdominal wall with antiseptic solution.
7. Cover abdomen with sterile drapes.
8. Apply the umbilical tie around the stump to prevent bleeding.
9. Cut the umbilical cord, to obtain an even sharply cut surface.
10. Identify the vein and 2 arteries. Arteries appear small in diameter but thick walled. Vein is larger and thin walled. Vein is usually located in the 12-o'clock position. *(Figure 8)*

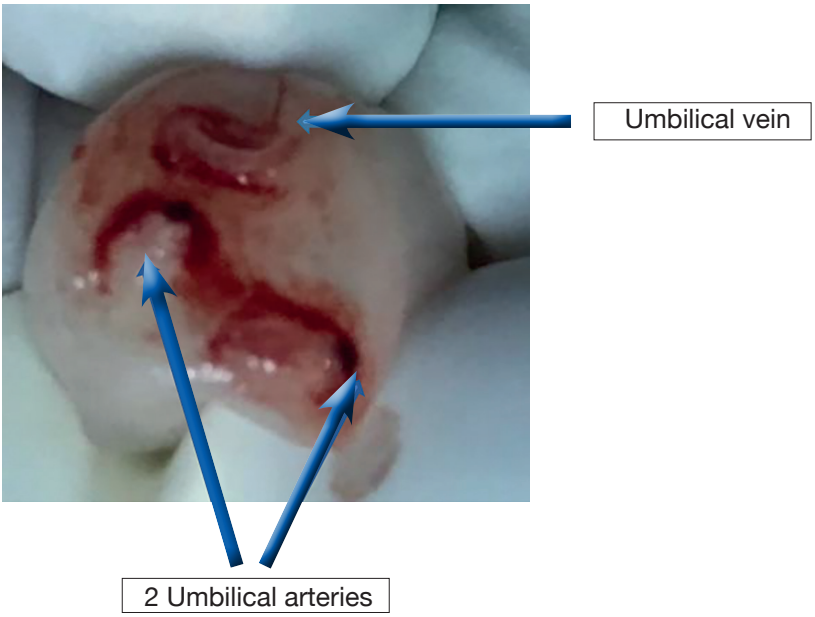

Figure 8: Identifying the vessels

11. If inserting both lines insert the UAC before UVC.
12. UAC:
    a. Dilate the artery gently with a dilator. (if the arteries protrude out, cut them to the level of the cord using a scalpel or a pair of scissors)
    b. Insert the catheter in to the artery lumen. If resistance is felt at any point, maintain some pressure on the catheter for several minutes and then advance.
    c. Once inserted in to predetermined length, aspirate blood and check for pulsatility of the blood flow, to confirm it is the artery.
    d. Suture the artery in to the umbilical stump separately.
13. Next, insert the UVC to the predetermined length.
14. UVC must aspirate blood freely, if it is in the in the inferior vena cava. If it does not aspirate blood, it is not in the right place, eg: in a hepatic vein. Withdraw the UVC for about 2 cm and reinsert.

    (NB if you simply withdraw until it bleeds back it will be in a low position, even though this can be used for infusions, there is a high risk of extravasation).
15. Suture the UVC in to umbilical stump separately *(figure 9)*.

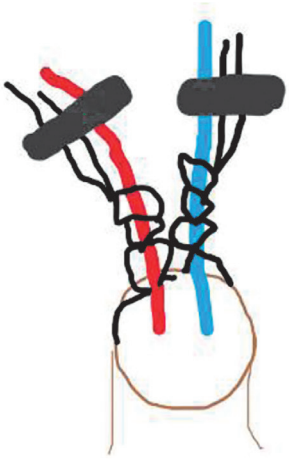

Figure 9: UVC and UAC must be sutured to the cord separately,
to allow them to be removed/ adjusted independently.

16. Request X ray abdomen and chest to confirm the final position

    UAC:

        High- between T6-T10

        Low- at L4 in the abdominal aorta

    UVC: Just below the diaphragm

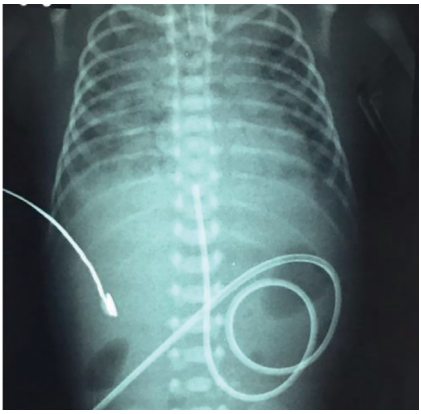

Figure 10: Correctly positioned UVC

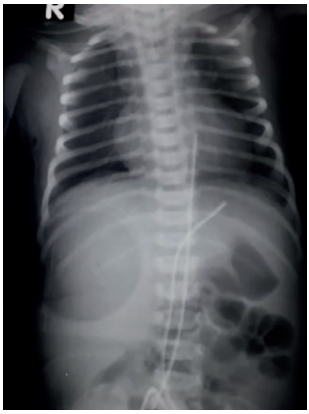

Figure 11: Correctly positioned UAC with mal-positioned UVC

After inserting the lines, while awaiting x ray confirmation,

17. Keep running 0.5 ml/hr of 0.9 % Saline, until the intravenous solutions/ TPN are connected.
18. Document the date and time of insertion, insertion length, any changes made to the length and final tip position in X ray.
19. During each shift check the line position, by checking the insertion length.

Heel prick blood sampling

Heel prick is the recommended method for collecting blood for investigations, as it helps to protect veins. Many investigations like capillary blood gas, full blood count, serum biochemistry, serological tests can be performed with blood collected via heel prick. However, it is not suitable when blood is required for blood culture and coagulation profile.

Equipment required

- A kidney tray
- Sterile gauze
- 70% alcohol
- Sterile lancet
- Tubes to collect blood
- Tape
- Paraffin

Procedure:

1. Attend to pain relief with methods like non-nutritive sucking, swaddling, containment
2. Procedure
3. Wash hands and put on disposable gloves.
4. Warm the foot as it will increases vascularity, making blood collection easier.
5. Choose the area of puncture, as shown in figure.
6. Clean the area with 70% alcohol and let it dry.
7. Make a puncture with a lancet. Choose the area colored red (figure 7).
8. If lancet is not available, use a needle. Make sure that the puncture is not deeper than 2 mm.

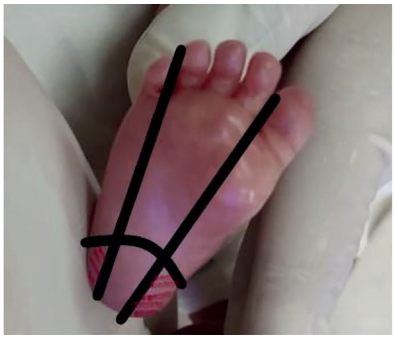

Figure 12: correct sites to puncture the heal are shaded black

Performing heel prick-

- Apply a thin film of Vasline to the area pricked.
- Encircle the heel with the palm of the hand.
- Gently squeeze the heel, and collect blood.
- On completion of blood sampling, apply pressure on the puncture site with a small, dry cotton wool until the bleeding stops.

Insertion of chest drain

Indications

- Pneumothorax
- Pleural effusion
- Post operative haemothorax
- Chylothorax
- Empyema

Small pneumothorax without significant symptoms doesn't usually require drainage. Similarly, spontaneous pneumothorax occurring in the absence of lung disease, is likely to resolve without intervention.

Chest drain must be inserted using either of the following methods.

1. Insertion of chest drain following blunt dissection of the chest wall
2. Insertion of pig tail chest drain using **Seldinger** technique

As pigtail chest drains are not available in Sri Lanka, only the first method will be described in this chapter. Insertion of chest drains with trocar is not recommended due to associated complications.

Complications of chest drains:

- Perforation of the lung
- Haemorrhage
- Cardiac tamponade

- Phrenic nerve injury
- Infection
- Persistence of pneumothorax if drain is not properly positioned or if air leak is too great to be drained from one tube.

Procedure

1. Analgesia

   Give 50-100mcg/kg morphine as a bolus prior to the procedure.

   Maintain strict asepsis

2. Prepare Equipment
   - Lidocaine 1% solution
   - 2ml syringe
   - 24 – 26Fr (purple / orange / brown) needle to provide local anaesthetic
   - Dressing towel
   - Chlorhexidine solution
   - Sterile gloves
   - Intercostal drain
     - o Size: 12F for infants greater than 1500 grams and 10F for infants less than 1500 grams
   - Vygon green connector
   - Surgical blade
   - Suture material: 4-0 silk suture on cutting needle
   - Transparent dressing
   - Underwater sealed drainage system or a “Heimlich” valve
3. Monitor the patient’s cardiorespiratory status and oxygen saturations throughout the procedure
4. Clean the skin with chlorhexidine.

5. Sterile drapes should be placed on the surface near the baby and to cover the unprepared skin near the incision site
6. Infiltrate skin and the intercostal muscle layers with local anesthetic. 1% Lignocaine 3 mg/kg (0.3 ml/kg) is recommended.
7. Position the patient supine with the affected side slightly elevated and the arm on the affected side restrained superiorly *(figure 13)*.

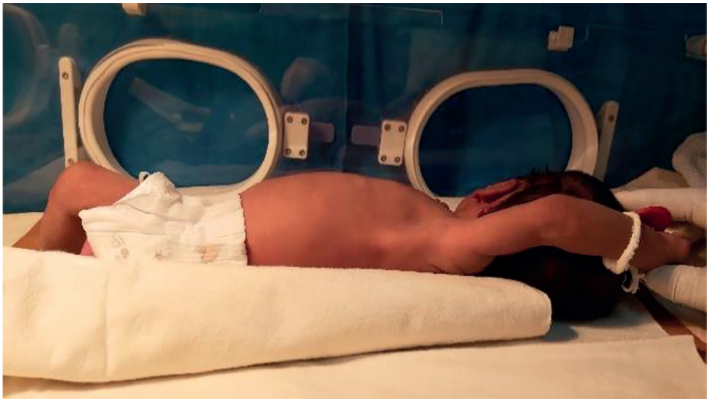

Figure 13: How to position the baby

8. Palpate chest wall with your fingertips to identify anatomical orientation of ribs and select the 4th- 5th intercostal space (level with the nipple, as it usually lies in the fourth intercostal space)
    - For a pneumothorax insert in the anterior axillary line and aim the IC drain anteriorly
    - For a pleural effusion insert in the mid-axillary line and aim the IC drain posteriorly
9. Make a 0.5 cm incision along the line of the intercostal space just above the rib below
10. Using a curved mosquito forceps, bluntly dissect the subcutaneous tissue just over the top of the rib , and puncture the parietal pleura. This entry is recognised by a sudden loss of resistance and is often accompanied by an audible surge of air. The intercostal opening is enlarged slightly by spreading the forceps. The forceps is then removed.

11. Advance the chest drain into the pleural space.
    - The tip of the chest drain is clamped firmly in the curve of the artery forceps with the tip of the artery forceps extending just beyond the tip of the drain.
    - Apply another clamp distal to the openings of the drain as well.
    - The tube is advanced through the previously made tract into the chest. The tube should be directed parallel to the lung surface.
    - Direct the drain towards the apex of thorax.
    - The drain must be inserted approximately 2-3 cm for a small preterm infant and 3-4 cm for a term infant.
    - Ensure that all side holes of the drain are within the thorax
    - Observe for cloudiness, vapor or bubbling in the drain to confirm intrapleural location
12. Immediately connect it to the underwater seal and observe for swinging and / or bubbling.
13. Chest drain is secured by suture and occlusive dressing e.g.Tegaderm
14. To apply suction, use a pressure of 15-20 cm of water

Arterial Blood Sampling

Arterial puncture is not commonly required to obtain blood gases, as a capillary sample provides adequate information. However, radial artery puncture is useful in special circumstances like calculating the Oxygenation Index in babies with severe Pulmonary Hypertension.

The radial artery can be accessed easily and puncture is safe. Do not use the femoral artery for obtaining routine blood samples in a neonate.

Equipment needed

- Cleaning solution
- 26 gauged, 1ml syringe coated with heparin/ butterfly catheter

Procedure

1. Hold baby's wrist and hand in your nondominant hand fully supinated with the wrist slightly extended (i.e., dorsiflexed, avoid over extension).
2. Palpate the arterial pulsation just proximal to the transverse wrist creases.
3. Cleanse the area with antiseptic and allow the skin to dry.
4. Measures to relieve pain, as discussed previously must be used.
5. Penetrate the skin at a 30- to 45-degree angle.

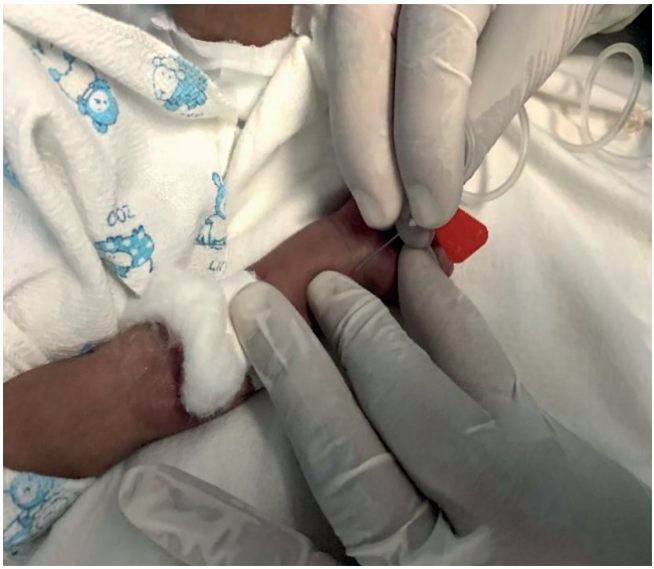

Figure 14: puncturing the radial artery with a butterfly cannula

6. While the plunger of the syringe is gently withdrawn, advance the needle slowly until the radial artery is punctured or resistance (bone) is met

7. Pulsating or rapidly flowing blood that appears in the hub of the needle is a good indication that the radial artery has been punctured.
8. If resistance is met while pushing the needle deeper, withdraw the needle slowly since both walls of the artery may have been punctured but the tip may reenter the lumen on withdrawal.
9. If no blood returns, withdraw the needle slowly to the point at which only the distal tip of the needle remains beneath the skin.
10. Repeat the procedure after checking the location of the pulse. Reorient the needle slightly more laterally or medially if necessary.
11. After the desired amount of blood is obtained, remove the needle and apply pressure for 5 minutes or longer to control the bleeding.

Peripheral Venous Cannulation

The common sites chosen for IV insertion in neonates are the superficial veins of the dorsum of the hand and the dorsum of the foot.

Select the most distal vein that is large enough to accommodate the cannula and leave the larger, more proximal veins in case the initial attempts are unsuccessful or if PICC lines are needed. Avoid cannulating the right hand as much as possible to enable pre ductal saturation monitoring

Equipment required

- Tourniquet
- Alcohol pads or povidone-iodine swabs
- 24 or 26 gauge venous cannula (yellow and purple cannula respectively)
- 0.9% Saline flush
- Tape
- Protective covering (preferably transparent dressing)

  Splint

Procedure

1. Select the appropriate size vein.
2. Clean the area using cleaning solution.
3. Attend to pain management, as described previously.
4. Stabilize the vein *(figure 15)*

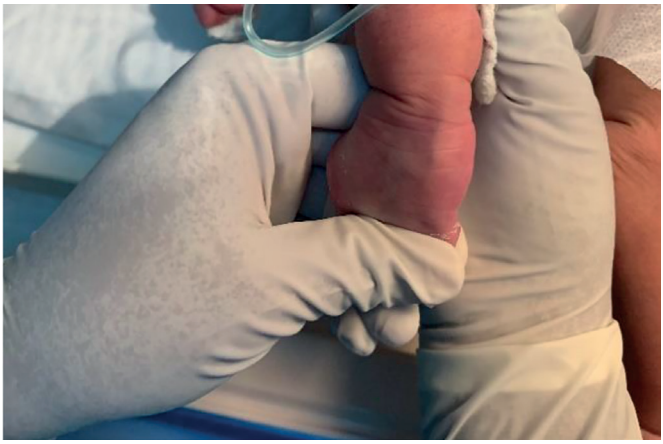

Figure 15: Stabilizing the vein

5. Puncture the skin at 10 – 200 angle at the insertion site and advance until blood return is seen in the cannula hub.(figure 16)

Figure 16: Puncturing the skin

6. Reduce the angle now, and advance the cannula further by 1 mm, without withdrawing the stylet. Now you can observe continuous flow of blood in to the cannula hub.
7. Withdraw the stylet (do not remove it) and advance the cannula in to the vein. When the full length of cannula is inserted, remove the stylet.
8. Attach the T extension set to the catheter hub. (this must have been primed with 0.9% Saline, prior to connecting with cannula). Secure with plasters, making sure that the insertion site is visible. Flush the cannula immediately with saline.
9. Do not encircle the limb while applying the dressing
10. Immobilize the limb with a splint. Make sure that the proximal joint is immobilized *(Figure 17)*

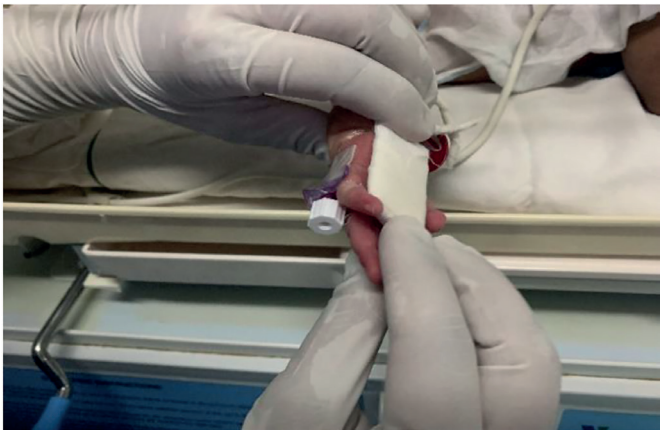

Figure 17: Application of the splint

Obtaining blood for culture

Obtaining blood for culture requires insertion of a venous cannula in neonates, as blood collection via direct venipuncture is extremely difficult and results in unnecessary handling of the baby. (This will further increase the risk of contamination)

Procedure

1. First, identify a suitable vein to cannulate.
2. Wash your hands using 7 steps of hand washing, and dry with sterile towel.
3. Wear 2 pairs of sterile gloves.
4. Place a sterile towel under the selected limb, and clean with 3 swabs containing povidone iodine and alcohol, alternatively.
5. Remove first pair of gloves.
6. Insert the cannula as described previously and obtain blood from a sterile needle and syringe
7. At least 0.5 of blood is required. (1 ml of blood is preferrable)
8. Ask an assistant to remove the cap of the blood culture bottle and clean the top with alcohol.
9. Puncture the top of the culture bottle and transfer the collected blood into it. (Do not attempt to change the needle as it increases the risk of needle prick injury without any benefit)
10. Send the specimen to the lab immediately, or keep in the room temperature, without refrigerating until delivered to the lab.

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