### Neonatal anthropometry – measurement and reporting of newborn size and growth

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Neonatal anthropometry – measurement and reporting of newborn size and growth

1. Introduction

All newborn infants should have size at birth and subsequent growth measured to document normal size and growth, and to diagnose and document disorders of growth and nutrition. Size and growth should be recorded on an appropriate validated growth chart.

Size at birth and subsequent postnatal growth velocity are critically related to long-term neurological and metabolic outcomes. Preterm infants and neonates are more vulnerable in the first months of life to nutritional deficits than any other time of the life cycle. Indicators are required to diagnose and document growth disorders and malnutrition related to undernutrition in preterm and neonatal populations. However, neonatal anthropometry is characterized by a lack of validation and consensus of available indexes. There is little harmonization between the different criteria to assess pre- and postnatal nutritional status for constant and continuous growth monitoring in the different stages of development.

2. The Aims / Expected Outcome of this Guideline

- Indicators are required to diagnose and document growth disorders as well as malnutrition related to undernutrition in preterm and newborn populations.

3. Risk Statement

SLHD Enterprise Risk Management System (ERMS) Risk # 1: Unwarranted Deviations from standards of clinical care:

- Preterm infants and neonates are more vulnerable to nutritional deficits than any other time of the life cycle.

4. Scope

This guideline applies only to clinical staff providing newborn care in the Neonatal Intensive Care Unit (NICU) and Special Care Nursery (SCN) in SLHD.

5. Implementation

- Notification and distribution of this guideline via management and clinical stream meetings, ward meetings, group email and SLHD Intranet.

6. Service Measures

- Complete anthropometry (weight, length and head circumference) will be collected on all NICU enrolled infants at birth, 28 days, 36 weeks postmenstrual age, discharge from hospital and/or discharge to home.
- Incidents are reported and managed in ims+.
### 7. Summary of Practice Guidelines

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
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<tbody>
<tr>
<td>Within 24 hours of birth</td>
<td>All infants should have weight, length and head circumference measured at birth.</td>
</tr>
<tr>
<td>Weight</td>
<td>Weight should be assessed using a calibrated electronic scale with 10 g resolution and tared to zero.</td>
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<tr>
<td></td>
<td>Average weight gain for infants &lt;34 weeks gestation is approximately 17 g/kg/day and for term infants 10 g/kg/day.</td>
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<td></td>
<td>- Term or late preterm infants with &gt;10% weight loss day 3 should have a lactation / feeding consult.</td>
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<td>- Term or late preterm infants with &gt;12% weight loss day 3 or 10% on day 5 should have a medical review.</td>
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<tr>
<td></td>
<td>- Term or late preterm infants with &lt;7g/kg/day weight gain after 2 weeks age should have a medical review.</td>
</tr>
<tr>
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<td>Preterm infants &lt;34 weeks gestation with &lt;12g/kg/day weight gain after 2 weeks age should have a medical review.</td>
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<td>Length</td>
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<td>The Newborn Stadiometer 35-70 cm is preferred for measurement of term infants.</td>
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<td>- All infants should have length measured at birth, 28 days, 36 weeks postmenstrual age, discharge from admitting hospital and discharge to home.</td>
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<td>Head circumference</td>
<td>Use a non-stretchable, disposable paper 1–2 cm wide marked in 0.1 cm increments.</td>
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<td>- To measure the head circumference, securely wrap the tape measure around the widest possible circumference of the infant’s head (typically 1 to 2 finger-widths above the eyebrow (supraorbital ridges) on the forehead, above the ears, to the most prominent part of the back of the head (occiput). Repeat the measurement three times and select the largest measurement to the nearest 0.1 cm</td>
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<td>- All infants with growth in head circumference ≥1.0 cm per week must have a senior medical review.</td>
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<tr>
<td>Referral or Escalation</td>
<td>The Resident Medical Officer/neonatal Nurse Practitioner should be notified and review infants with excess weight loss or head circumference gain according to specified criteria.</td>
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<td></td>
<td>The first on call neonatal senior Staff Specialist should be notified of infants with excess gain in head circumference according to specified criteria.</td>
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<tr>
<td>Documentation</td>
<td>Document in PowerChart.</td>
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<tr>
<td></td>
<td>Use the Fenton Chart to monitor growth to 42 weeks postmenstrual age (PMA) and the WHO chart for term infants and preterm infants after 42 weeks PMA.</td>
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8. Background

8.1 Size versus growth:
A single weight, length or head circumference measurement is an assessment of ‘size’. Longitudinal measurements over time document ‘growth’ which may be linear (along centile lines) or non-linear (crossing centile regions).

The terms intrauterine growth restriction (IUGR) and small for gestational age (SGA), although often used as synonyms, are not interchangeable. SGA infants have not necessarily experienced IUGR and, conversely, infants with documented IUGR are not inevitably born SGA. Unlike SGA, IUGR always refers to a pathological process that results in decelerating fetal growth velocity. Serial ultrasound assessment (of fetal anthropometric traits, umbilical cord flow, and amniotic fluid) is necessary to confirm IUGR.

A recent consensus defined growth restriction as: birth weight less than the third percentile, or 3 out of the following: birth weight <10th percentile; head circumference <10th percentile; length <10th percentile; prenatal diagnosis of fetal growth restriction; and maternal pregnancy information.

Numerical methods used to describe weight, length, and head circumference growth velocity in preterm infants include grams/kilogram/day (g/kg/d), grams/day (g/d), centimetres/week (cm/week), and change in z scores.

8.2 Small for gestational age (SGA)
The definition of SGA requires:
   a. Accurate knowledge of gestational age (ideally based on first trimester ultrasound exam);
   b. Accurate measurements at birth of weight, length, and head circumference; and,
   c. A cut-off against reference data from a relevant population. This cut-off has been variably set at the 10th centile, 3rd centile, or > 2 standard deviations below the mean (~2nd centile).

Babies can then be sub-classified into SGA for weight, SGA for length, or SGA for both weight and length. Additionally, those SGA babies who have small head circumference should be recognized.

Infants born small for gestational age are defined by the WHO Expert Committee and the American College of Obstetrics and Gynaecology as those weighing below the 10th centile of birth weight by sex for a specific completed gestational age of a given reference population, which identifies infants at increased risk of perinatal morbidities. In low and middle income countries, infants born SGA defined as weight < 10th centile are at increased risk of mortality.

A Paediatric Endocrine Consensus recommended SGA be defined as weight and/or length more than 2 standard deviations below the mean as this identifies the majority of those in whom ongoing growth assessment is required.

8.3 Postnatal growth failure (extrauterine growth restriction - EUGR) and failure to thrive
Underweight at a given gestational age may result from stunting or wasting, or both phenotypes:
• **Wasting**: low weight for length, or low body mass index [BMI] for age, often reflecting recent weight loss.

• **Stunting**: short length for age, reflecting linear growth restriction.

Postnatal growth failure is commonly considered as weigh <10th centile at 36 weeks postmenstrual age or at discharge from hospital. However, a large proportion of healthy preterm infants have weights < 10th centile after the extracellular water loss early in postnatal life, thus this definition may not be appropriate. Postnatal growth trajectory in healthy preterm infants was reported to be adjusted to −0.8 z-scores below intrauterine percentiles after infants had completed postnatal adaptation.

Failure to thrive is defined as a faltering of growth from a previously established pattern of growth. Diagnostic certainty is provided by a documented birth date, weights obtained using an electronic scale, at least 2 weights measured at least 4 weeks apart, and weight for age deceleration through at least 2 centile spaces on a growth chart.

### 8.4 Large for gestational age (LGA) and macrosomia

Large-for-gestational-age is usually defined as weight > 90th centile compared with the size of infants of the same gestation at the time of birth. However, this cut-off is physiologically arbitrary, based on statistics rather than health status, and does not assess whether the infants are large relative to their individual genetic potential. Being born LGA (birth weight >90th centile) is a risk factor for prolonged first stage of labour, shoulder dystocia, caesarean, hypoglycaemia and jaundice.

The term macrosomia is used to describe an individual who is considerably larger than average. Fetal macrosomia is defined as birth weight >4000 g (or 4500 g) and is associated with maternal and fetal complications including maternal birth canal trauma, shoulder dystocia, and perinatal asphyxia.

Constitutional (large parents), diabetes in pregnancy and genetic syndromes are causes of LGA and macrosomic infants.

### 8.5 Microcephaly

Microcephaly is usually defined by the measurement of occipitofrontal circumference (head circumference) that is more than 2 standard deviations below the mean for age and sex or < 3rd centile for age and sex. Severe microcephaly is defined as head circumference > 3 standard deviations below the mean for age and sex.

### 8.6 Macrocephaly

Macrocephaly is defined as an abnormally large head with an occipitofrontal circumference greater than 2 standard deviations above the mean for a given age and sex.

### 8.7 Short stature

Short stature is defined as length or height more than 2 standard deviations below the mean for a given age and sex, which corresponds to approximately 2.3% of the population and usually includes healthy individuals. Stricter classifications define short stature as heights 2.5 to 3 standard deviations less than the given population’s mean height, which represents 0.6 and 0.1% of the general population respectively and is frequently associated with syndromic conditions.
8.8 Tall stature

Tall stature is defined as length or height more than 2 standard deviations above the mean for a given age and sex. Tall stature can also be defined relative to the target height, with height >2 standard deviations above the target height being considered tall. Ideally, both parents should be measured to calculate the target height. Tall stature is usually not a pathological condition and generally does not need treatment.

9. Guidelines

9.1 Routine anthropometry:

Size at birth: All infants should have weight, length and head circumference measured at birth as current charts reflect measurements taken in the first 24 hours after birth.

9.1.1 Routine monitoring:

- All infants should have weight measured at birth and day 3 if stable, then 2nd daily until discharge.
  - Weight should be assessed using a calibrated electronic scale with 10 g resolution and tared to zero.
- All infants should have length measured at birth (or as soon as possible within 7 days if not done at birth), 28 days, 36 weeks postmenstrual age (PMA), discharge from admitting hospital and discharge to home.
  - The Premie Stadiometer 26-50 cm is preferred for measurement of premature infants including within the incubator.
  - The Newborn Stadiometer 35-70 cm is preferred for measurement of term infants.
- All infants should have head circumference measured at birth and every 7 days until discharge.
  - Use a non-stretchable, disposable paper 1–2 cm wide marked in 0.1 cm increments.
  - To measure the head circumference, securely wrap the tape measure around the widest possible circumference of the infant’s head (typically 1 to 2 finger-widths above the eyebrow (supraorbital ridges) on the forehead, above the ears, to the most prominent part of the back of the head (occiput). Repeat the measurement three times and select the largest measurement to the nearest 0.1 cm.
- Document in PowerChart. Use the Fenton Chart to monitor growth to 42 weeks PMA and the WHO chart for term infants and preterm infants after 42 weeks PMA.

9.2 Audit (NICUS and ANZNN):

Growth: All infants should have weight, length and head circumference measured at the following intervals:

- 28 days
- At 36 weeks PMA
- At discharge from admitting hospital
- At discharge to home
9.2.1 Criteria for review

Weight:
Average weight gain for infants <34 weeks gestation is approximately 17 g/kg/day and for term infants 10 g/kg/day.

- Term or late preterm infants with >10% weight loss day 3 should have a lactation / feeding consult.
- Term or late preterm infants with >12% weight loss day 3 or 10% on day 5 should have a medical review.
- Term or late preterm infants with <7g/kg/day weight gain after 2 weeks age should have a medical review.
- Preterm infants <34 weeks gestation with <12g/kg/day weight gain after 2 weeks age should have a medical review.

Head circumference

- Average head growth for preterm infants is approximately 0.7 cm/week and for term infants is 0.5 cm/week.
- All infants with growth in head circumference ≥1.0 cm per week must have a senior medical review.

10. Growth Charts


The Fenton size at birth and growth curves were created from 6 large population-based surveys of size at preterm birth representing 3986456 births (34639 births < 30 weeks) from Germany, United States, Italy, Australia, Scotland, and Canada. Smoothed growth chart curves were developed, while ensuring close agreement with the data between 24 and 36 weeks and at 50 weeks.

The Olsen growth curves are gender-specific weight-, length-, and head circumference-for-age curves created from a USA hospital cohort of 257855 singleton infants born 1998 to 2006 aged 22 to 42 weeks at birth who survived to discharge.

The INTERGROWTH-21 Project assessed fetal, newborn, and postnatal growth in 8 geographically defined populations from 2009 to 2013, in which maternal health care and nutritional needs were met. From these populations, low-risk women starting antenatal care before 14 weeks' gestation were selected and fetal growth monitored by ultrasonography. Preterm postnatal growth standards were selected from live singletons born between 26 and before 37 weeks' gestation without congenital malformations, fetal growth restriction, or severe postnatal morbidity. Only 408 infants born <33 weeks gestation were included.

WHOGS 2006 was a population-based study 1997 to 2003 in Brazil, Ghana, India, Norway, Oman and the USA from birth to 24 months. Study populations had to have socio-economic conditions favourable to growth, low mobility and ≥20% breastfed, no known environmental constraints on growth, adherence to feeding recommendations, no maternal smoking, single term birth and no significant morbidity. About 83% of 13741 subjects screened for the longitudinal component were ineligible and 5% refused to participate. UK Scientific Advisory Committee on Nutrition recommends not switching from preterm charts to the WHOGS until 42 or more weeks.
There were differences in growth velocities at 27-32 weeks PMA between the INTERGROWTH reference and the Fenton and Olsen references. INTERGROWTH standards differ from the size-at-birth derived growth references as they are based on measurements made after the postnatal physiologic weight loss in healthy preterm infants without fetal growth restriction or morbidity. INTERGROWTH postnatal growth charts are based on limited data before 36 weeks so are also less precise and markedly deviate from the Fenton and Olsen curves, especially for weight g/kg/day and length less than 33 weeks (see Figure 1).

For very preterm infants, INTERGROWTH reference and the Fenton charts ascribe SGA and extrauterine growth restriction differently. Several studies have now compared the performance of the INTERGROWTH reference and the Fenton charts for SGA or non-AGA status (SGA or LGA) for detection of neonatal morbidity, but none has compared the performance of the various charts in detecting extrauterine growth restriction (EUGR).

![Figure 1: Weekly median growth velocity of common preterm growth references (Fenton 2013, Olsen 2010, INTERGROWTH 2015, and World Health Organization Growth Standard (WHOGS) 2006) in g/kg/day using a constant gain of 15 g/kg/day superimposed.](image)

In the largest cohort to date in 45505 infants born 33 to 40 weeks gestation, the diagnostic test properties of various charts (WHO, INTERGROWTH, Fenton and GROW) for non-AGA status (SGA or LGA) for composite neonatal morbidity was compared. Similar sensitivity, specificity, positive likelihood ratio, positive predictive value and negative predictive values were reported for the various charts (see Table 1).
Table 1 (for illustration): Diagnostic test properties of various charts (WHO, INTERGROWTH, Fenton and GROW) for non-AGA status (SGA or LGA) for composite neonatal morbidity.

In a cohort of 248 infants born <32 weeks gestation, one out of every four cases assessed as SGA according to the INTERGROWTH-21st standards was within the normal interval according to Fenton charts. One out of every five cases assessed as EUGR according to Fenton standards was within the normal interval according to Intergrowth standards. However, in a cohort of 821 infants born ≤32 weeks, infants identified as IUGR at birth by INTERGROWTH charts and not by Fenton growth charts had higher incidence of morbidities including late onset sepsis and NEC. This report that an INTERGROWTH approach (optimised growth) may be preferable for describing size at birth (i.e. fetal growth). This cannot be extrapolated to the appropriateness of the different charts to measure postnatal growth or detect extrauterine growth restriction.

Given the paucity of data below 33 weeks gestation, INTERGROWTH curves are currently not appropriate / recommended for use in preterm infants.

10.1 Growth goals

Approximations of average growth for preterm infants of 15 to 20 g/kg/day are currently reasonable estimates for infants 23 to 36 weeks’ gestation, but not beyond. There are no clinical trials of different growth goals in newborn infants to inform practice. Fenton charts report size at birth, so approximate (but underestimate) in utero growth. Typically, preterm infants lose weight (extracellular fluid) and follow a growth velocity below the birth centile resulting in a weight centile discrepancy if followed to term corrected age. Suggestions of alternative approaches of targeting the original growth centile for early correction of the postnatal growth profile, or a median of the postnatally adjusted centile and birth centile have been made (see Figure 2), but not evaluated in clinical trial.

Figure 2 (for illustration): Individualized trajectories for preterm infants. (A) Birth-Weight-Percentile Approach; (B) Postnatal-Percentile Approach; (C) Fetal-Median-Growth and Growth-Velocity Approach.
10.2 Anthropometry

10.2.1 When to measure?
Size at birth: All infants should have weight, length and head circumference measured at birth as current charts reflect measurements taken in the first 24 hours after birth.

Growth: All infants should have weight, length and head circumference measured at the following intervals:
- 28 days
- At 36 weeks postmenstrual age
- At discharge from admitting hospital
- At discharge to home.

10.2.2 How to measure weight?
For birth weight the infant should be weighed within 24 hours of birth.

Weight should be assessed using a calibrated electronic scale with 10 g resolution and tared to zero.

The infant should be bare weighed.

Any materials on the infant at the time of weighing should be weighed separately and subtracted from the total weight.

10.2.3 How to measure length?
The Premie Stadiometer 26-50 cm is preferred for measurement of premature infants including within the incubator; whilst the Newborn Stadiometer 35-70 cm is preferred for measurement of term infants [https://www.ellardinstrumentation.com/stadiometers/].

The length-board measurement infantometer has been shown to be the most reliable and accurate measurement of neonatal length. The infantometer should be placed on a flat stable surface.

A rigid infantometer with an offset reading is preferred. For newborns either the ‘two leg’ or ‘one leg’ method may be used. For infants, the ‘two leg’ method has greater accuracy.

The Neorule may be used as an alternative method.

The neonate is placed supine and unclothed on the board and held gently with his or her body aligned and head in a neutral position.

One person stands at the top of the length board and holds the baby’s head in contact with the headboard.

The other person extends the legs by placing the hand over the knees, depressing the knees, straightening the legs and moving the footboard to touch the plantar surface of the feet at a right angle to the legs. Recheck that the head has not moved from the headboard before taking the measurement. The actual reading is marked by an arrow as there is an offset for greater ease of reading and accuracy.

Read the measurement and record the child’s length in centimetres to the last completed 0.1 cm.
Measuring length - Above Left: rigid infantometer placed on stable flat surface. Above Right: Two people using the ‘two leg’ method on a rigid infantometer.

Alternative - the Neorule: Operator 1 holds the head gently with the eyes directly upwards with the lower margin of the orbit in the same vertical plane as the external auditory meatus and gently holds the headboard to the vertex. Operator 2 applies gentle traction to extend the legs without displacing the pelvis and then slides the footplate to meet the heel with just sufficient pressure to cause the skin to blanche; the CHL is then noted to the nearest mm.

10.2.4 How to measure head circumference?

Use a non-stretchable disposable paper 1–2 cm wide marked in 0.1 cm increments.

To measure the head circumference, securely wrap the tape measure around the widest possible circumference of the infant’s head (typically 1 to 2 finger-widths above the eyebrow (supraorbital ridges) on the forehead, above the ears, to the most prominent part of the back of the head (occiput). Repeat the measurement three times and select the largest measurement to the nearest 0.1 cm.
11. Reporting

Numerical methods used to describe weight, length, and head circumference growth velocity in preterm infants include grams/kilogram/day (g/kg/d), centimetres/week (cm/week), and change in z scores reported at 28 days and 36 weeks postmenstrual age.

Z scores should be calculated using a validated size at birth chart and growth chart (e.g. Fenton chart) up to 42 weeks postmenstrual age. Subsequently the INTERGOWTH 21 / WHO growth chart will be used.

12. Definitions

**Excess weight loss:** >12% on day 3 and >10% on day 5.

Primary indicators of neonatal malnutrition (Not appropriate for first 2 weeks of life except for days to regain birth weight)

- **Mild malnutrition:**
  - Days to regain birth weight 15-18
  - Decline in weight-for-age z score 0.8-1.2 SD
  - Weight gain velocity <75% of expected

- **Moderate malnutrition**
  - Days to regain birth weight 19-21
  - Decline in weight-for-age z score >1.2-2 SD
  - Weight gain velocity <50% of expected

- **Severe malnutrition**
  - Days to regain birth weight >21
  - Decline in weight-for-age z score >2 SD
  - Weight gain velocity <25% of expected

- **Mild stunting**
  - Decline in length-for-age z score 0.8-1.2 SD
  - Length gain velocity <75% of expected

Measuring head circumference: Above image reproduced from reference.
Moderate stunting
- Decline in length-for-age z score >1.2-2 SD
- Length gain velocity <50% of expected

Severe stunting
- Decline in length-for-age z score >2 SD
- Length gain velocity <25% of expected

Microcephaly: head circumference >2 standard deviations below the mean for age and sex or <3rd centile for age and sex.

Severe microcephaly: head circumference >3 standard deviations below the mean for age and sex.

Macrocephaly: occipitofrontal circumference >2 standard deviations above the mean for a given age and sex.

13. References


14. **Consultation**

Enterprise Risk Management System Coordinator SLHD
Neonatology Clinical Nurse Consultant RPAH
SLHD Centre for Education and Workforce Policy Committee
SLHD Maternity Policy Committee

15. **National Safety and Quality Standard/s, 2nd ed**

- Clinical Governance Standard
- Comprehensive Care Standard
- Communicating for Safety Standard