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Review Article

Growth charts in neonates

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ARTICLE INFO

Article history:

Received 16 January 2016

Accepted 17 March 2016

Available online xxx

Keywords:

Growth charts

Neonatal

Fetal

Head circumference

ABSTRACT

There has been a continuous effort to develop standard growth charts for neonates. Reference growth charts based on cross-sectional intrauterine data were developed from measurement of anthropometric parameters of neonates of different gestations at birth. Similarly postnatal charts for preterm neonates were developed based on longitudinal measurements of infant's parameters over intervals. Fetal–infant growth charts were devised by combining cross-sectional intrauterine data and postnatal infant's longitudinal parameters. Revised Fenton 2013 charts incorporating neonatal anthropometric data look to be most adequate for preterm infants of 22 weeks gestation till 50 weeks post-menstrual age. These growth references describe how infants grew in certain time in a defined population. There was a need of developing growth standard defining growth of healthy population in optimal conditions. WHO Multicentre Growth Reference Study charts were developed as growth standards describing the growth of healthy children from term gestation till 5 years of age. Intergrowth 21st growth chart is the new growth standards for preterm infants and looks promising in infants of gestation 33 weeks or more.

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1. Introduction

Growth is described as a net increase in size or mass of tissues as a result of either multiplication of cells or increase in intracellular substance.¹ Fetal growth is the most rapid phase of growth in humans and exponential growth occurs by six folds between 22 and 40 weeks.² It is influenced by fetal, placental and maternal factors. Under normal environment, a fetus grows as per its inherent growth potential to an appropriate size newborn. After birth, baby's growth is

determined by genetic potential and various internal and external factors.¹

Infants are in a continuous process of growth. It is important to monitor the growth of infants to detect any deviation from normal. During hospital stay, a rapid change in weight may occur due to fluid overload or due to catch-up growth. Low gain may be due to inadequate nutrition or concurrent illnesses. Growth faltering in neonatal period can be due to faulty feeding, infections, cold stress, anemia and metabolic disturbances.^{3,4} Growth monitoring also helps in identifying babies at high risk of having poor neurodevelopmental outcome. Higher linear

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<http://dx.doi.org/10.1016/j.cmpr.2016.03.009>

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growth,⁵ weight gain and head growth are associated with better neurodevelopmental outcome including decreased incidence of cerebral palsy especially in extremely low birth weight babies.⁶

An important tool for growth monitoring in neonates is growth charts. Two common types of growth charts are 'growth references' and 'growth standards'. A 'growth reference' is a statistical summary of anthropometry in a reference group of children, whose health status is not taken into consideration.⁷ These charts are descriptive and show how children grow rather than how they should grow.⁸ A 'growth standard' is essentially the same as a growth reference except that the underlying reference sample is selected on health grounds. It is a prescriptive model representing a healthy pattern of growth and shows how the child should grow. Standard charts have the ability to diagnose overweight and obesity early and also avoid over diagnosis of undernutrition.^{7,8}

2. Neonatal growth charts

Historically, the idea of plotting a child's anthropometric parameters on a chart to illustrate the pattern of growth was first conceived by Count Philibert de Montbeillard of France in the 18th century. He plotted his son's height every six month from birth till the age of 18 years. Henry Bowditch was the first to use the centiles to describe the growth of Massachusetts children in 1891.⁷ Lubchenco's chart was amongst the first intrauterine growth chart to be widely used in neonates. It also classified newborns based on size at birth.⁹ Over last five decades, number of standard and reference charts have been developed for monitoring growth of term and preterm neonates.

2.1. Reference growth charts

Reference growth charts used in preterm infants are:

A. *Intrauterine growth charts*: Intrauterine growth charts are those that are derived from data of anthropometric measurements of preterm infants of different gestational age at birth. Available intrauterine charts are Lubchenco (1966), Usher and McLean (1969), Brenner (1976), Arbuckle (1993), Alexander (1996) and Kramer (2001).¹⁰ The drawbacks of these intrauterine charts are that they are based on small sample size and are not gender specific. Most of these charts used last menstrual period (LMP) to estimate gestation age instead of first trimester ultrasound (USG), which is less reliable.¹¹ These charts are cross-sectional and lack the ability to describe longitudinal fetal growth.¹² There are serious concerns about using them as standards, as preterm infants are different from fetus.¹⁰

Lubchenco charts (1948–1961) based on population of around 4700 newborns having gestation age from 26 to 42 weeks was one of the most widely used intrauterine growth charts. It was based on a multi-centric retrospective study, which included both term and preterm infants. Weight, length and head circumference were retrieved and smooth

growth curves were developed. Battaglia and Lubchecho were the first to describe newborns as small for gestation age, appropriate for gestation age and large for gestation age.^{9,13} The drawbacks of these charts are that they are based on population of only one country (USA) and included population of high altitude which are more likely to be growth restricted.^{14,15}

B. *Postnatal growth charts*: These growth charts are based on longitudinal measurements of parameters of infants as they grow and as such provide actual postnatal pattern of infant's growth. Growth chart developed from these data as such cannot be prescriptive, as defining a healthy preterm is not possible.¹⁰ Postnatal growth charts include Dancis 1948, Infant Health and Development Program (IHDP) 1985, Shaffer 1987, Wright 1993, Berry 1997, Ehrenkranz 1999. These charts demonstrated the weight loss pattern after birth, regain of birth weight and subsequent growth.^{16,17}

One of the popularly used postnatal charts was charts by Ehrenkranz (1999). It was based on a multicentric prospective cohort study from 12 centers based in USA and included 1660 infants with birth weights between 501 and 1500 g admitted within 24 h of age. Longitudinal data on weight, length, head circumference and mid-arm circumference were measured from birth until discharge, transfer, death, age 120 days, or a body weight of 2000 g. The strength of these charts is that they consist of a large, heterogeneous population of very low birth weight infants and included infants, who received more advance treatments such as surfactant replacement therapy, antenatal steroid and early aggressive nutritional regimens. These growth curves may be used to understand postnatal growth better and to identify infants developing morbidities affecting growth such as bronchopulmonary dysplasia. Drawbacks are that it is based on a small sample size and derived from population of a single country.¹⁸ Another significant shortcoming of use of this chart in practice is that it only provides a single line trajectory and not major centiles.

C. *Fetal–infant growth charts*: These charts are constructed by merging two sets of reference data: cross-sectional data of anthropometric measurement of preterm infants at birth and postnatal longitudinal anthropometric data of term infants. Therefore, these charts permit growth comparison with fetus first and then to term standards. The advantage of using fetal–infant growth chart is that it allows to assess if a preterm neonate is achieving catch up growth or not.¹⁷ Examples are – Babson and Benda charts 1967, Fenton chart 2003 and Fenton charts 2013.^{2,19,20}

Babson and Benda obtained anthropometric data of infants of mostly Caucasian population, with gestation age 27 to 44 weeks born between 1959 and 1966. It was popularly used but had limitations of not including neonates of lower gestation and had 500 g weight interval increments. This made precise plotting difficult.¹⁹ Fenton in 2003, updated the Babson–Benda charts and created new chart that could be used from gestation 22 weeks to 50 weeks. It allowed comparison of growth of a preterm infant with that of fetus initially starting as low as 22 weeks till 36 weeks and then later with term infants upto

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