

The Intergrowth standards for Hadlock's estimation of fetal weight

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Running Head: The Intergrowth standard for Hadlock's EFW

Keywords: EFW, biometry, Intergrowth, Reference chart, screening, ultrasound

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1002/uog.22000

Establishing an estimated fetal weight (EFW) percentile involves two distinct steps: first, calculating the fetal weight based on one or more fetal biometric variables (such as head circumference (HC), abdominal circumference (AC) and femur length (FL)); and second, plotting the EFW at the gestational age on an EFW standard, to derive a percentile.

A recent publication of a systematic review has suggested that Hadlock's 3-parameters formula (HC, AC and FL) is associated with least error in estimating EFW^{1,2} and may perform better in fetal weight estimation than the 2-parameter formula we developed recently³. Because our commitment is to base our recommendations on the results of systematic reviews, we present herein a newly developed prescriptive standard for EFW based upon this formula of estimating fetal weight ($EFW = 10^{(1.326 + 0.0107 \times HC + 0.0438 \times AC + 0.158 \times FL - 0.00326 \times AC \times FL)}$). This formula was applied to fetal biometric measures from our original study of optimally grown fetuses⁴.

After calculating the estimated weight for each fetus using this method, we applied a second-degree fractional polynomial functional form and found the best fit using a 3-parameter Box-Cox Gaussian distribution (i.e. the LMS method) for the response variable, defining three distributional functions of gestational age ($\lambda(GA)$, $\mu(GA)$ and $\sigma(GA)$). All analyses were carried out in R statistical software (<https://www.r-project.org>) using the Generalised Additive Models for Location, Scale and Shape (GAMLSS) framework⁵. The gestational age-specific centiles for EFW are presented in Figure 1 in comparison with the one published previously based on the 2-parameter only based EFW. The corresponding equations for $\lambda(GA)$, $\mu(GA)$ and $\sigma(GA)$, are presented in Table S1 and the main centiles are shown in Table S2.

It must be highlighted that discrepancies - and more generally the controversies about which equation or chart to use when evaluating fetal weight - illustrate the fact that the use of ultrasound to estimate fetal weight at the time of making delivery decisions and interacting with neonatologists is a practice that needs to be challenged. Both obstetricians and neonatologists apply the information, often in conjunction with other parameters, to make important decisions about the need to deliver a baby or whether to transfer an undelivered mother to a facility with a higher-level neonatal unit. However, using in this context an estimate of fetal weight, as a proxy for newborn viability, on a summary of ultrasound

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measures of the fetal head, abdomen and femur, each with their own individual technical errors, is questionable, especially given the wide confidence intervals of such estimates: the mean percentage error can range from -6.9% to 22.2%⁶. There are other pathophysiological problems with using EFW to estimate neonatal risk. Indeed, each of the biometric parameters summarized in the EFW value has different risk implications. For example, in a recent systematic review and meta-analysis, third-trimester ultrasound screening for late-onset fetal growth restriction (FGR) performed better when based on AC than EFW, and there is a close association between AC in the third trimester and neonatal morbidity⁷. On the other hand, an isolated, mid-trimester, short FL is associated with an increased risk of FGR and preterm birth, in the absence of aneuploidy, congenital anomalies, skeletal dysplasias, and early-onset FGR⁸. To complicate matters further, neonatal mortality, although strongly associated with gestational age at birth, was best predicted in a systematic review by multivariable models rather than birth weight or gestational age alone in very preterm infants, the priority group for this clinical dilemma⁹.

Finally, the neonatologist has to decide which chart to use to judge the implications of the EFW provided by the obstetrician. We strongly believe that for risk assessment of the newborn, the same chart that assesses weight for gestational age should logically be used by obstetricians and neonatologists. On the one hand, because FGR is over-represented in premature deliveries, the use of birth weight curves to interpret EFW may miss the diagnosis of FGR¹⁰ (preterm infants are known to be somewhat smaller than are fetuses of the same gestational age while still in utero)¹¹. Figure 2 illustrates the difference in interpretation according to the use of EFW or BW standards. On the other hand, if the ultimate objective of estimating fetal weight is for the neonatologist to assess risk, to refine the infant's clinical management and to communicate the likelihood of death or disability to the parents, then the same chart should be used by obstetricians and neonatologists - otherwise, the same pregnancy may be evaluated on the same day using two different tools, resulting in two separate risk assessments being made. Hence, there should be no need for EFW charts in this context of immediate neonatal risk assessment.

In summary, we recommend:

- 1) That fetal growth should not be evaluated using a single summary measure. Rather fetal growth should be assessed over time based on the trajectory of individual parameters, plotted separately against the INTERGROWTH-21st Fetal Growth Standards to enable growth/size to be

evaluated for each gestational period.

- 2) If an EFW value is added to complement the individual parameter during fetal growth monitoring, the most evidence-based strategy is to use the EFW we have presented here; these standards match methodologically the INTERGROWTH 21ST Fetal Growth Standards
- 3) If we are interacting with the neonatologist to decide clinical actions, the INTERGROWTH-21ST Newborn Birth Weight Standards (33-43 weeks' gestation) ¹⁴ or Very Preterm Reference Charts (<33 weeks' gestation)⁹ allow evaluation of neonatal size and risk by week of gestation. This change of standards is required, even if it complicates the process, because neonatal size at birth and risk is different from EFW (Figure 2)
- 4) The responsible next step is always to provide the parents with the specific centiles or z-scores of the error range of the birthweight estimation. If the newborn is to be delivered prematurely, postnatal growth can then be monitored on the neonatal unit and in the pediatric follow-up clinic using the INTERGROWTH-21ST Preterm Postnatal Growth Standards¹⁵ that were constructed specifically to ensure continuity of care, using the same pregnant cohort as the fetal and newborn standards.

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FIGURE LEGENDS

Figure 1: Gestational age-specific centiles for EFW presented in in comparison with the one published previously based on the 2-parameter only.

Figure 2: Comparison of the EFW standards based on the Hadlock formula with the INTERGROWTH-21st Newborn Birth Weight Standards (33-43 weeks' gestation) ¹⁴ or Very Preterm Reference Charts (<33 weeks' gestation)⁹

Figure 1.

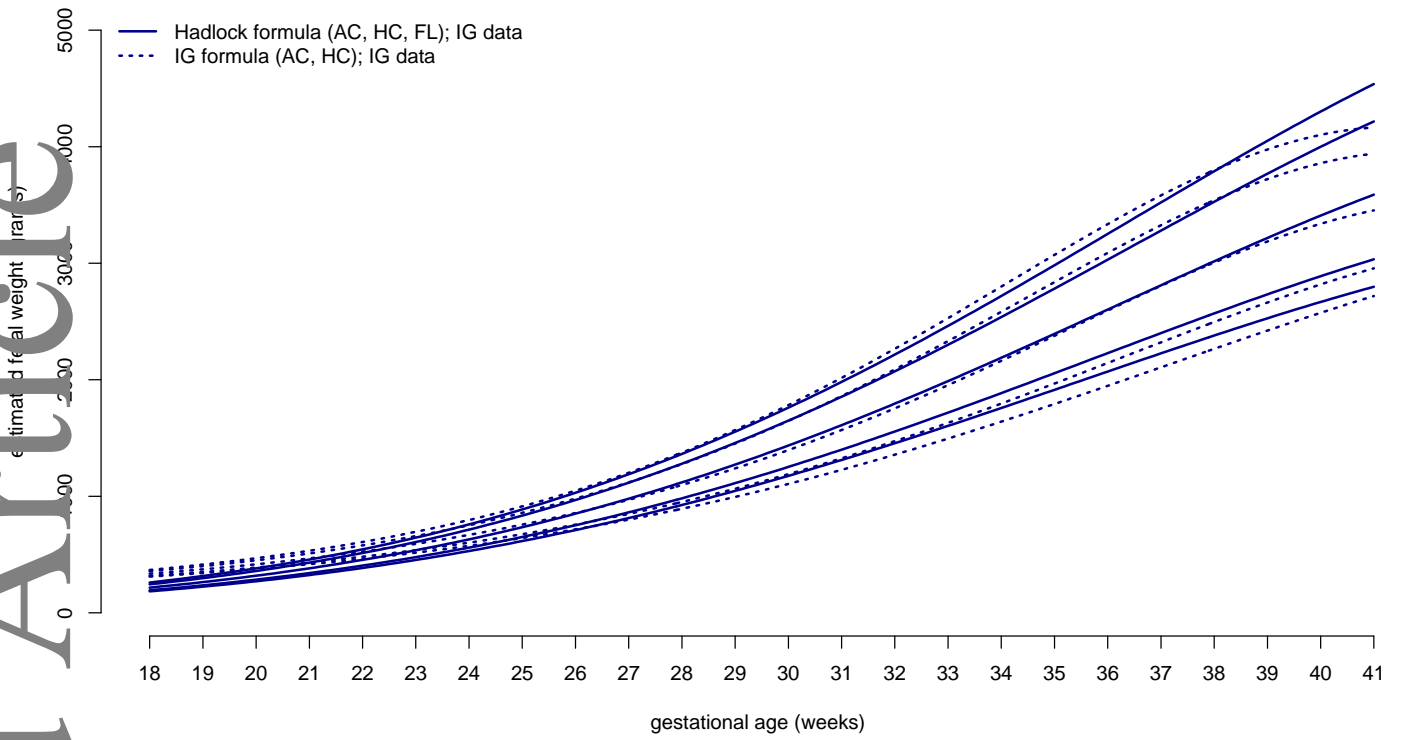


Figure 2.

