Rapid assessment of gestational age at birth

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Parkin, J. M., Hey, E. N., and Clowes, J. S. (1976). *Archives of Disease in Childhood*, 51, 259. **Rapid assessment of gestational age at birth.** A simple scoring system based on skin colour, skin texture, breast development, and ear firmness that can be performed even in an ill baby without manipulation or movement enables gestational age to be estimated to within ± 15 days (95% confidence limits) at any time in the first 2 days of life. More complex techniques only marginally improve this estimate.

Knowledge of the gestational age of newborn babies may modify the details of their care. Though gestational age usually is calculated from the date of the mother's last menstrual period this date is not known with certainty in a large minority of pregnancies (Baird, Thomson, and Billewicz, 1957; Neligan, 1965). In others it gives misleading information, for example when menses are very irregular or have continued after conception, or when the mother was taking oral contraceptives shortly before conception. There clearly is a need in clinical practice for a method of estimating gestational age, and, as most practical problems arise in ill and low birthweight babies, any method should be applicable to these types of babies. In particular it should not upset ill babies, and in order to distinguish between preterm and light-for-dates babies it should not be affected significantly by the quality of intrauterine growth. Of the many methods that have been explored (Casaer and Akiyama, 1970) the clinical ones appear to give the best prediction of gestational age (Finnström, 1972b) and clearly only these are likely to be of wide-spread value in newborn nurseries.

An estimate of gestational age with 95% confidence limits of 2.4 weeks may be made by scoring 11 external physical characteristics (Farr, Kerridge, and Mitchell, 1966a) and the 95% confidence limits may be improved to 2 weeks by combining 10 neurological measures with these external characteristics (Dubowitz, Dubowitz, and Goldberg, 1970). The use of such a large number of measures diminishes the value of the method as the necessary skills for examination are more difficult

to acquire, the examination becomes time consuming and is more disturbing for an ill baby. We explore the possibility of reducing the number of variables scored without seriously diminishing the accuracy of the prediction of gestational age.

Methods

Selection of babies. Two groups of babies were examined. The first, a group of 210 babies, were selected during the antenatal period by an obstetrician, the essential criteria being that the mother had previously had regular menstrual periods, had kept a written record of them, and that at examination during the first 20 weeks of pregnancy the uterine size had been consistent with the gestational age as calculated from the last menstrual period.

The second group, examined 2 years later, was selected by a paediatrician after birth using strict criteria; the mothers were sure of the dates of their last menstrual period, had previously had a regular cycle of 26–30 days, and had not received oral contraceptives during the 6 months before conception. All had had a vaginal examination during the first 12 weeks of pregnancy with findings compatible with the calculated stage of pregnancy. There were 182 babies in this second group. The gestational ages of all the babies were calculated from the first day of the last menstrual period.

Examination technique. The external physical characteristics, skin colour, skin texture, ear firmness, breast size, plantar skin creases, skull hardness, oedema, lanugo hair, and development of the genitalia, were scored using the definitions of Farr *et al.* (1966b), and in addition nail length and texture were recorded on a three-point score as defined by Lind and Parkin (1976). The 10 neurological measures, posture, square window, ankle dorsiflexion, arm recoil, leg recoil, popliteal angle,

heel-to-ear, scarf sign, head lag, and posture in ventral suspension, were examined and recorded as defined by Dubowitz *et al.* (1970).

In the first group of babies, all of whom were examined by one observer between 12 and 36 hours after birth, only the external characteristics were recorded. In the second group both external and neurological characteristics were measured except in a few ill babies whose neurological examinations were omitted. In addition, many of the babies in the second group were examined by two different observers at different times during the first 48 hours after birth.

Results

Altogether 205 male and 187 female babies were examined, their gestational ages ranging from 177 to 317 days (Table I). The weights of 36 of the

TABLE I
Age range of babies studied

Gestational age (d)	Preterm			Term		Post-term
	≤230	231-244	245-258	259-279	≥280	
No. of babies	15	12	19	146	168	32

term babies were below the 10th centile for gestational age and 38 were above the 90th centile, using local sex specific standards (Neligan, Prudham, and Steiner, 1974). There were no systematic differences in findings between male and female babies and so in all analyses they have been considered together.

Choice of criteria.

Predictive power. Correlation coefficients of the scores for each characteristic with gestational age were calculated on data from 182 babies in the second group on most of whom all 22 characteristics had been scored. The six characteristics with the highest correlations are marked with an asterisk in Table II. An additional two characteristics used by Dubowitz *et al.*, (1970), nipple formation and ear form, had poor predictive value ($r=0.55$ and 0.51 , respectively) and are not considered further in this paper.

Effect of weight for gestation at birth. The 211 babies whose gestational ages were 273-287 days inclusive were divided into five categories on the basis of their birthweight for gestational age. The correlation coefficients of the scores for the physical characteristics and the birthweight for gestational age category are shown in Table II. Those least affected by the quality of intrauterine growth have

the lowest coefficient. The characteristics most affected by intrauterine growth are skull hardness and development of the genitalia.

Effect of postnatal age. This was assessed in 96 babies who were examined at two different ages by two different observers, the scores obtained between 12 and 36 hours being compared with those before 12 hours and after 36 hours. In order to eliminate any interobserver differences each examiner assessed equal numbers of babies in each group. The numerical expression of the effect of age from delivery (Table II) was calculated as the sum of the net differences between scores at two different times divided by $n-1$ and expressed as a percentage of the range of possible scores for that characteristic. As the findings of both comparisons were similar they were combined in the final analysis. The characteristics that changed least during the first 48 hours of life are marked (*) in Table II. The only characteristics that are greatly affected by postnatal age are oedema which increases in amount, and leg recoil which decreases with age.

Interobserver agreement. 101 babies were examined independently by two observers when they were between 12 and 36 hours old and from these observations two measures of interobserver reliability for each characteristic were calculated. Score consistency (random interobserver differences) was derived from the root mean square differences of the scores recorded by the two observers, expressed as a percentage of the range of possible scores; interobserver bias (the tendency for the scores of one observer to differ consistently in the same direction from those of the other observer) was the sum of the net differences between the scores of the two observers divided by $n-1$, also expressed as a percentage of the range of possible scores for each characteristic. The characteristics showing best interobserver agreement are marked in Table II.

Cross correlation. In any attempt to reduce the number of characteristics it is necessary to know how the scores of the characteristics correlate with each other. In fact the only characteristics whose cross-correlation coefficients were greater than 0.7 were skin texture and plantar skin creases ($r=0.79$). This suggests that in any assessment of gestational age these characteristics will contribute little independently of each other and therefore only one need be used.

TABLE II

Estimates of predictive value of 11 external and 10 neurological characteristics in assessing gestational age within 48 hours of birth and of the consistency with which these characteristics can be scored

Characteristics	Predictive value	Effect of weight for gestation on score	Effect of postnatal age on score	Interobserver	
				Score consistency	Score bias
1. Skin colour	0.78*	0.099*	1.0*	11.4*	1.6*
2. Ear firmness	0.78*	0.066*	0.3*	17.4	4.7
3. Plantar skin creases	0.76*	0.04*	3.8	15.0	4.7
4. Breast size	0.75*	0.15	0.8*	14.8*	0.9*
5. Skin texture	0.72*	0.076*	2.8	10.9*	1.7*
6. Genitalia	0.66	0.40	1.7*	20.0	3.7
7. Lanugo hair	0.62	0.16	4.6	15.2	2.3*
8. Skull hardness	0.61	0.30	2.3	14.0*	2.3*
9. Oedema	0.59	0.14	11.0	22.5	7.6
10. Nail texture	0.57	0.12*	1.8*	16.4	2.6*
11. Nail length	0.51	0.07*	0.8*	19.9	4.1
12. Posture	0.75*	—	4.5	14.0*	4.8
13. Scarf sign	0.67	—	3.0	19.7	11.9
14. Arm recoil	0.62	—	4.2	22.9	3.0
15. Leg recoil	0.59	—	8.3	25.9	15.6
16. Ventral suspension	0.59	—	4.8	21.9	6.8
17. Heel to ear	0.51	—	3.2	21.3	2.8
18. Popliteal angle	0.48	—	5.4	24.1	13.0
19. Head lag	0.47	—	6.0	25.5	16.4
20. Ankle dorsiflexion	0.37	—	6.7	14.9*	3.9
21. Square window	0.21	—	6.0	24.5	20.8

* The 6 most reliable characteristics in respect of each feature under test. These characteristics have a high predictive score and low scores for the other 4 features under review. The numerical basis of the ranking systems are described in the text.

Development of a predictive score. Assessment of the relative weakness and strengths of the individual characteristics suggests the following.

- The majority of the neurological signs do not correlate as highly with gestational age as do the external characteristics.
- Neurological scores tend to be more affected by postnatal age and to exhibit poorer interobserver agreement than the external characteristics.
- The 'best' physical characteristics are skin colour, ear firmness, breast size, plantar skin creases, and skin texture, the last two correlating closely with each other.

It is clear therefore that several of the characteristics, both external and neurological, are unlikely to contribute much to an assessment of the gestational age of the baby, either because their correlation with gestational age is not great or because of other disadvantages. In order to determine the relative accuracy of estimations of gestational age using different combinations of criteria, multiple linear regressions were calculated for different combinations of characteristics, and the 95% confidence limits of these lines compared (Table III). The use of 21 characteristics results in an estimate of gestational age with 95% confidence limits of 15 days, a figure similar to previous

reports (Dubowitz *et al.*, 1970). Little loss of accuracy occurs when the neurological measures are omitted or when only the four best physical characteristics and the two best neurological measures are used. The use of the four best physical characteristics, skin colour, skin texture, breast size, and ear firmness, results in a regression line with 95% confidence limits of 18 days.

The assumption that the total score is linearly related to gestational age is however unjustifiable and unnecessary. The relation between the total score for the four most reliable characteristics (skin texture, skin colour, breast development, and ear firmness) and gestational age is shown in the Fig. The relation is clearly nonlinear. 95% of babies assigned any particular score will have gestational

TABLE III

Prediction of gestational age (assuming that the summated score is linearly related to age)

Characteristics utilized	95% confidence limits
All 21 characteristics	15.0 d
Characteristics 1-13	15.2 d
6 best characteristics	
(1, 2, 4, 5, 12, 13)	16.2 d
Characteristics 1-11	16.6 d
4 best external characteristics	
(1, 2, 4, 5)	18.1 d

FIG.—95% confidence limits for prediction of gestational age from the sum of the scores for the 4 most reliable characteristics. Where the confidence limits are based on fewer than 5 points, the number of points is shown in parenthesis.

ages that fall within the limits shown by the black bars. While the confidence with which gestational age can be assessed in a baby who scores two or less is uncertain, there is no evidence that the magnitude of these limits vary with total score. The mean 95% confidence limits for the data summarized in the Fig. is ± 15 days.

There are advantages in limiting the measures used to external characteristics as neurological measures are more disturbing to the baby and more likely to be affected by illness. In view of the evidence, we advocate the use of the sum of the scores of four characteristics only.

Definitions of the four characteristics selected for this rapid method of assessing gestational age have previously been published together with other definitions (Farr *et al.*, 1966b) but are also given in the Appendix to this article, while the mean gestational ages corresponding to total scores taken from the Fig. are set out in Table IV.

TABLE IV

Mean gestational ages derived from the total scores of skin colour, skin texture, ear firmness, breast size

Score	Gestational age (d) (w)	
1	190	27
2	210	30
3	230	33
4	240	34½
5	250	36
6	260	37
7	270	38½
8	276	39½
9	281	40
10	285	41
11	290	41½
12	295	42

Discussion

Several previous workers (Farr *et al.*, 1966a; Finnstrom, 1972a; Locard, 1972; Dubowitz *et al.*, 1970) have described methods of estimating gestational age by scoring characteristics and all have concluded that the most satisfactory technique is simply to sum the scores of the chosen characteristics. We agree with this conclusion and, like Locard and Finnström but unlike Farr *et al.* and Dubowitz *et al.*, have found that the relation between the total score and gestational age is not linear.

We have studied British babies only (the immigrant population on Tyneside is small) but scoring of skin colour in African and Asian babies may cause problems. Unfortunately the replacement of skin colour by another single characteristic is not satisfactory. All the other characteristics have some serious disadvantages and the scores of some, for example skull hardness and lanugo hair, differ in African and British babies of the same gestational age (Parkin, 1971). The alternative in African or Asian babies is to modify the definition of skin colour slightly to allow scoring of this sign and this has proved possible in Nigeria (Brueton, Palit, and Prosser, 1973), or to use a larger number of characteristics with or without skin colour (Locard, 1972; personal observations).

This simple scoring system clearly is least accurate in babies of very low gestational age, a score of less than 2 applying at any age of less than 30 weeks. In such babies repeated examination at about weekly intervals in order to determine the age at which some critical primitive reflexes appear (Robinson, 1966) will enable an estimate of gestational age to be made eventually. Clearly such an estimate is not necessary for clinical reasons, the short score will show such babies to be very pre-term, and therefore the delay inherent in this neurological method does not matter.

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Appendix (Definitions)

Skin texture. Tested by picking up a fold of abdominal skin between finger and thumb, and by inspection.

- 0, very thin with a gelatinous feel.
- 1, thin and smooth.
- 2, smooth and of medium thickness, irritation rash and superficial peeling may be present.

- 3, slight thickening and stiff feeling with superficial cracking and peeling especially evident on the hands and feet.
- 4, thick and parchment-like with superficial or deep cracking.

Skin colour. Estimated by inspection when the baby is quiet.

- 0, dark red.
- 1, uniformly pink.
- 2, pale pink, though the colour may vary over different parts of the body, some parts may be very pale.
- 3, pale, nowhere really pink except on the ears, lips palms, and soles.

Breast size. Measured by picking up the breast tissue between finger and thumb.

- 0, no breast tissue palpable.
- 1, breast tissue palpable on one or both sides, neither being more than 0.5 cm in diameter.
- 2, breast tissue palpable on both sides, one or both being 0.5 cm—1 cm in diameter.
- 3, breast tissue palpable on both sides, one or both being more than 1 cm in diameter.

Ear firmness. Tested by palpation and folding of the upper pinna.

- 0, pinna feels soft and is easily folded into bizarre positions without springing back into position spontaneously.
- 1, pinna feels soft along the edge and is easily folded but returns slowly to the correct position spontaneously.
- 2, cartilage can be felt to the edge of the pinna though it is thin in places and the pinna springs back readily after being folded.
- 3, pinna firm with definite cartilage extending to the periphery, and springs back immediately into position after being folded.