

Single-step gastric aspirate shake test

Bedside predictor of neonatal pulmonary morbidity

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SUMMARY A simplified, single-step shake test has been performed on gastric aspirate samples from 85 preterm infants and a control group of 214 term infants. Respiratory symptoms were seen in 25 of 30 preterm infants with a negative or intermediate test, but in only 2 of 55 infants with a positive test ($P < 0.001$). No infant with a positive test developed respiratory distress syndrome (RDS) while RDS developed in 66% of those preterm infants with a negative test. False-negative results were not seen in the preterm group. The gastric aspirate shake test had better sensitivity and selectivity in prediction of clinical outcome than did the amniotic fluid lecithin/sphingomyelin ratio in 37 preterm infants in whom both results were available. Serial shake tests were performed on samples from a number of infants with RDS and the results were seen to change in parallel with clinical recovery. This and other observations suggest that the result of the gastric aspirate shake test depends more upon direct swallowing of fetal lung liquid than on swallowing of amniotic fluid.

Estimation of the lecithin/sphingomyelin (L/S) ratio in amniotic fluid (Gluck *et al.*, 1971) had made prediction of fetal lung maturity a reality. However, the equipment required to estimate the L/S ratio is not universally available and this test is not immediately available to all patients. The development of the foam stability test, or 'shake test', for use with amniotic fluid (Clements *et al.*, 1972) provided expediency, simplicity, and economy yet preserved sensitivity and selectivity, but could only be performed in centres where amniocentesis was available. Sefton *et al.* (1972) assumed that the fluid in the newborn infant's stomach was amniotic fluid swallowed immediately before delivery and showed that the L/S ratio could be performed on this fluid with results comparable to analysis of maternal amniotic fluid. Evans (1975) and Cowett *et al.* (1975) showed that this was also true of the shake test used with gastric aspirate.

Why then has the shake test not become widely used when it has been shown to be a satisfactory clinical tool for prediction of neonatal pulmonary morbidity? Firstly, previous studies have used a seemingly complex series of dilutions (Cowett *et al.*, 1975) or interpretations (Evans, 1975) in describing the test, which may have detracted from its acceptance. Secondly, reports of false-negative results in

term babies as a source of error (Gebhart and Ruys, 1976) may have cast doubt on the specificity of the test.

We have therefore prospectively assessed the gastric aspirate shake test performed at a single dilution in 85 preterm infants. In addition, the results have been compared to amniotic fluid L/S ratios obtained within 24 hours of delivery in 37 preterm infants in whom both indices were assessed.

Materials and methods

Gastric aspirate samples were obtained within one hour of birth from 92 consecutive infants, of 37 weeks' gestation or less, admitted to the neonatal intensive care unit, by passage of a no. 10 Fr polyethylene suction catheter with a mucus trap.* Seven samples were discarded either because of inadequacy of sample (<0.71 ml) or because of contamination with blood or meconium, as recommended by Clements *et al.* (1972).

The 85 infants included in this study had a mean (\pm SD) weight of 2348 ± 640 g and a mean (\pm SD) gestation of 35.3 ± 1.8 weeks. The male : female ratio was 1.45 : 1 and 16% were delivered by caesarean section. As a control, shake tests were

*Argyle HR1 8888-257527 DeLee Suction Catheter with mucus trap.

performed on 214 term infants (38–42 weeks' gestation). Gestational ages were assessed from menstrual data and confirmed by clinical assessment (Dubowitz *et al.*, 1970).

Gastric aspirate 0.5 ml was pipetted into new 10 mm × 110 mm test tubes containing 0.5 ml saline and 1 ml 95% ethyl alcohol. The tube was corked and shaken for 15 seconds and left to stand for 15 minutes before reading. Bubbles covering greater than two-thirds of the liquid surface was interpreted as a positive test, covering one-third to two-thirds an intermediate test, and one-third or less a negative test. The method and interpretation are shown in Fig. 1.

PREPARATION

Gastric Aspirate	0.5 cc
Saline	0.5 cc
95% Alcohol	1.0 cc

Shake — 15 seconds
Read — 15 minutes

INTERPRETATION

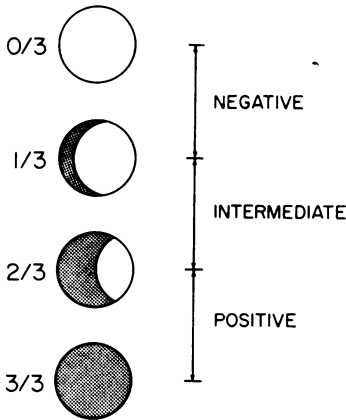


Fig. 1 Single-dilution shake test. Method and interpretation.

In 37 patients amniotic fluid was obtained by amniocentesis within 24 hours of delivery, and the L/S ratio measured according to the method of Borer *et al.* (1971). These measurements were performed for perinatal indications, and the results were retrospectively extracted from the mother's hospital records. A recent review of results obtained over a 1-year period by this method in the obstetric laboratory has shown a predictive capability equal to that originally described.

Table 1 Criteria for diagnosis of respiratory distress syndrome (after Baden *et al.*, 1972)

- (1) Respiratory rate > 60/min
 - (2) Intercostal recession and/or substernal retraction
 - (3) Grunting
 - (4) Pao₂ < 40 mmHg if < 1 h of age
< 60 mmHg if > 1 h of age
 - (5) Paco₂ > 50 mmHg
 - (6) Chest x-ray compatible RDS
 - (7) Cyanosis in room air
- > 4 criteria } RDS
 Not improved at 24 h }
 3 or 4 criteria } mild respiratory disease
 Improving at 24 h }
 < 3 criteria }
 0 criteria aged 4 h } no respiratory disease

Conversion: Traditional units to SI—Pao₂ and Paco₂:
1 mmHg ≈ 0.133 kPa.

Clinical disease was classified after the criteria of Baden *et al.* (1972), as shown in Table 1. Radiological interpretation was by a radiologist experienced in interpretation of neonatal chest x-ray films, and who was unaware that the films would be used for this study. In some infants increases in inspiratory oxygen prevented the Pao₂ values falling below 60 mmHg (7.98 kPa) and in this situation we presumed the criterion to be satisfied if an inspiratory oxygen > 40% did not give a Pao₂ value > 70 mmHg (9.3 kPa).

Results

Fig. 2 shows the single dilution shake test results obtained from 85 newborn infants of ≤ 37 weeks' gestation, plotted according to gestational age and

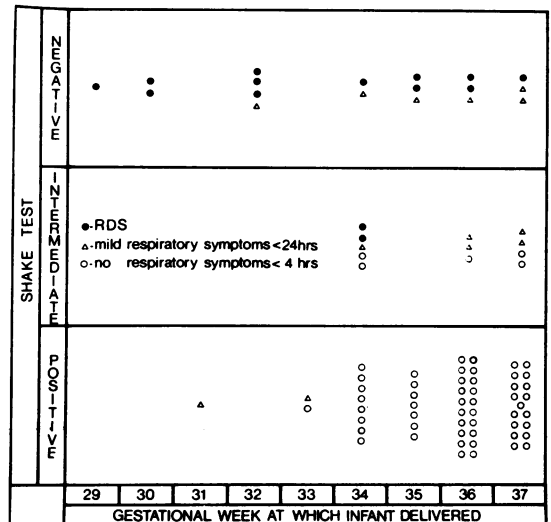


Fig. 2 Shake test results with clinical outcome in 85 newborn infants ≤ 37 weeks' gestation.

clinical outcome. Of 55 infants with a positive shake test, 2 developed mild respiratory symptoms which resolved within 24 hours but none developed the respiratory distress syndrome (RDS); while of the 30 infants with a negative or intermediate shake test, 25 (83%) had respiratory symptoms ($\chi^2 = 53.27$, $P < 0.001$) and of these 14 (47%) had RDS ($\chi^2 = 24.43$, $P < 0.001$). In this study, a preterm infant with a negative shake test had a 66% chance of developing RDS ($\chi^2 = 39.16$, $P < 0.001$). In this group of 85 preterm infants there were no false-negative results.

In our control group of 214 term infants we found a 3% incidence of false-negative results which seemed to be related to the slimy flocculent material described by Gebhardt and Ruys (1976). No such material was seen in samples from the preterm group and no false-negative results occurred in this group.

Fig. 3 relates clinical outcome to both shake test results and L/S ratios from amniotic fluid in the 37 preterm infants in whom both results were available. Interpretation of L/S ratio results is according to the practice of the obstetric perinatology team in this hospital. L/S ratios < 2.0 are regarded as placing the infant 'at risk' of lung immaturity, and results > 2.5 indicative of adequate lung maturation. The intermediate nonspecific zone (2.0–2.5) is shaded in Fig. 3. It can be seen that a negative or intermediate shake test has included all infants developing respiratory symptoms (sensitivity 100%) and that in this group 14 of the 16 infants did develop respiratory symptoms (specificity 87%). L/S ratios below 2.6 failed to identify as 'at risk' 7 of 14 infants who did develop respiratory symptoms (sensitivity 50%) and 7 of 11 infants identified as 'at risk' developed respiratory symptoms (specificity 64%). Those infants not properly identified by having an L/S ratio below 2.6 included 5 infants with RDS, each of whom was correctly identified by a negative shake test. The poor prediction achieved with the L/S ratio in this group is probably a function of sample

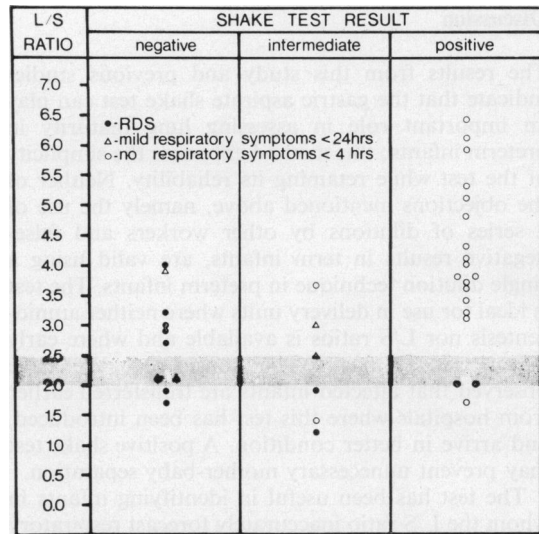


Fig. 3 Clinical outcome in 37 newborn infants ≤ 37 weeks' gestation showing amniotic fluid L/S (lecithin/sphingomyelin) ratio and shake test results.

size, since a recent evaluation of the method within the obstetric laboratory showed good results. This does not, however, detract from the improved identification seen with the gastric aspirate shake test.

During this study we obtained serial gastric aspirate samples from 20 infants. The clinical course of 2 representative infants before milk feeds is given in Table 2 which shows that the shake test converts from negative to positive as respiratory symptoms subside.

Blood or mucus in the gastric aspirate does cause spurious results, and this is also true of milk. We have also noted, in 3 infants, that tracheal intubation caused positive shake tests to become negative, with reversion to a positive result after extubation.

Table 2 Serial gastric aspirate shake test results compared with clinical state in 2 cases

Age (h)	1	6	12	18	24	30	36	42	48
<i>Case 1, male, 35 weeks' gestation</i>									
Inspired oxygen (%)	40	35	38	38	30	30	25	25	25
Respiratory rate/min	40	100	80	80	60	70	70	70	70
Grunt (0-3)	2	2	1-2	1	1	0-1	0-1	0-1	0
Retraction (0-3)	2	2	2	1	1	1	1	1	1
Shake test	neg		neg	int	pos		pos		
<i>Case 2, male, 37 weeks' gestation</i>									
Inspired oxygen (%)	40	35	30	45	55	55	50	45	30
Respiratory rate/min	70	90	100	100	120	120	120	90	75
Grunt (0-3)	3	3	3	3	3	3	2	1	1
Retraction (0-3)	2	2	2	2	2	1	1	1	1
Shake test	neg				neg			pos	

int = intermediate.

Discussion

The results from this study and previous studies indicate that the gastric aspirate shake test can play an important role in assessing lung maturity in preterm infants; this method enhances the simplicity of the test while retaining its reliability. Neither of the objections mentioned above, namely the use of a series of dilutions by other workers and false-negative results in term infants, are valid using a single dilution technique in preterm infants. The test is ideal for use in delivery units where neither amniocentesis nor L/S ratios is available and where early infant transfer has to be considered. We have observed that affected infants are transferred earlier from hospitals where this test has been introduced, and arrive in better condition. A positive shake test may prevent unnecessary mother-baby separation.

The test has been useful in identifying infants in whom the L/S ratio inaccurately forecast respiratory events and infants in whom an L/S ratio is not available. It has been used in making decisions regarding umbilical artery catheterization, and the results used in interviews with parents after initial assessment of their baby. It may have a future role in decisions about starting early distending pressure in the treatment of RDS (Gerard *et al.*, 1975; Mockrin and Bancalari, 1975).

The fact that shake tests have remained positive over several days in serial studies of infants before milk feeds were introduced indicates a persistent source of surface active material entering the stomach. Its disappearance upon tracheal intubation and reappearance after extubation suggests that the surface active material originates in the respiratory tract. The hypothesis that the surface active material in the stomach is swallowed amniotic fluid (Sefton *et al.*, 1972) may be partly correct. However, since fetal lung liquid is known to travel up the trachea *in utero* (Olver and Strang, 1974), and is to a large extent swallowed (Adams *et al.*, 1967), the shake test results in our intubated infants suggest that it is lung-derived fluid which enters the stomach directly and not amniotic fluid. This mechanism might result in a more representative sample of lung-derived surface active material within the stomach than in amniotic fluid and may account for the improved predictive value of the single dilution gastric aspirate shake test for RDS when compared with the amniotic fluid L/S ratio, which we have observed in this study. Our experience with the shake test on amniotic fluid, where the dilution that we use for gastric aspirate samples is too dilute to be consistently useful,

indicates a lesser concentration of surface active material in amniotic fluid.

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