

VARIATIONS IN THE GAG, COUGH, AND SWALLOW
REFLEXES AND TONE OF THE VOCAL CORDS AS
DETERMINED BY DIRECT LARYNGOSCOPY
IN NEWBORN INFANTS*

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This investigation is part of a comprehensive effort to determine the degree of vagal function in newborn infants. No particular attention has been given to this problem previously, but in the light of recent experimental work in animals there is a clear indication for such a survey in newborn infants.

The presence of an effective vagal mechanism is essential to the life of newborn kittens and puppies, but the adults of these species can survive vagal deprivation indefinitely, such as results when the vagi are cut in the midcervical region.⁸ Vagotomy in rabbits performed in the above manner results in pulmonary edema and death within a few hours. Recently it has been shown that in addition to the pulmonary edema, hyaline membranes are formed in the alveoli and alveolar ducts of the lungs of rabbits¹⁰ and puppies,¹ the only species examined to the present time. These pulmonary hyaline membranes are similar in appearance and have the same histochemical properties as those found in the lungs of newborn infants dying in the first few hours and days after birth.⁹ It was this observation which led us to investigate the rôle of the vagus in newborn infants.

Some evidence already exists for believing that vagal function is not fully developed in newborn infants. Wiggers has stated: "To judge from the rapid [heart] rate in infancy, its gradual decrease during childhood, and the fact that atropin does not accelerate it in children, the vagus influence has not developed in early life, but is acquired gradually."¹² Hoff writes: "In infancy and in old age (man), vagal 'tone' is at a minimum, while it is at a maximum during adolescence and early adulthood."¹³ Vagal influence on the gastrointestinal tract also appears to be minimal at this age, as indicated by the relatively reduced peristaltic activity⁹ and the low output of hydrochloric acid by the stomach when compared to older infants.⁴ Miller and Behrle have shown that vagal control of respiration apparently is not fully developed, particularly in premature infants.¹¹ In view of these observations it seemed important to obtain additional information concerning vagal function in the newborn period.

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One of the important rôles of the vagus nerves is to help maintain the reflexes in the pharynx and larynx which produce coughing, swallowing, and gagging. While there are generalized statements in most pediatric texts to the effect that these reflexes are sometimes diminished or even absent in some newborn infants, particularly premature infants, no record could be found of any systematic study of them. The nearest approach to an evaluation was that made by Flagg on the action of the vocal cords in newborn infants. He described a loss of tone and a failure of the vocal cords to go into spasm on direct laryngoscopy in asphyxiated newborn infants.⁵ He stated that reflex spasm of the glottis was a more sensitive reflex than that of the cornea in the dying infant, but did not extend his observations

TABLE 1
INCIDENCE OF COUGH REFLEX DETERMINED BY DIRECT LARYNGOSCOPY
IN INFANTS ACCORDING TO AGE

<i>Group</i>	<i>Age of infants</i>				<i>Total</i>
	<i>0-4 days</i>	<i>5-9 days</i>	<i>10-30 days</i>	<i>Over 1 month</i>	
Premature	17	5	3	4	29
Cough reflex	7	0	0	1	8
%	41	0	0	25	27
Full-term	63	33	8	21	125
Cough reflex	17	19	6	19	61
%	27	57	75	90	49

to include other reflexes.⁶ Consequently, in the present study a routine examination of a series of newborn and older infants was made by means of direct laryngoscopy, with particular attention being paid to the position of the vocal cords and their action and to the presence or absence of the gag, swallow, and cough reflexes. All the laryngoscopies were done by one of us (G.O.P.) by direct visualization. The gag and swallow reflexes were noted with the introduction of the laryngoscope into the pharynx. After the position and action of the vocal cords were determined, the presence or absence of the cough reflex was ascertained by squirting a few drops of normal saline on to the vocal cords by means of a syringe and needle while the laryngoscope was in place. Any cough resulting from either the introduction of the scope or following the squirting of saline on the vocal cords was considered as a positive result.

RESULTS

Direct laryngoscopies were done on 154 infants. All but two of these had gag and swallow reflexes. The histories and findings in these two infants will be detailed later, along with those of a third infant who was laryngoscoped on five different occasions during the first 63 days of life.

A cough reflex could not be obtained in over half the infants tested. The lowest incidence was found in the more immature infants and younger infants. As shown in Table 1, there were only 8 out of 29 premature infants, or 27 per cent, with cough reflexes, while 61 out of 125 full-term infants, or 49 per cent, had cough reflexes. The incidence in full-term infants rose from 27 per cent in the first 5 days of life to 57 per cent in the second 5 days, 75 per cent in infants 10 to 30 days of age, and 90 per cent in infants 2 to 11 months old.

The failure to obtain a cough in a large group of infants led us to determine the incidence of a spontaneous cough reflex immediately following delivery. The obstetrician was asked to record the presence or absence of a cough while the baby remained in the delivery room. The results are shown in Table 2. There were 167 infants observed and 72 or 43 per cent of these coughed spontaneously. Six of 18 premature infants and 66 of 149

TABLE 2
INCIDENCE OF SPONTANEOUS COUGH IN NEWBORN INFANTS

	<i>Infants no.</i>	<i>Birth weight</i>	
		<i>2,500 gm. or less</i>	<i>2,501 gm. or more</i>
Total infants	167	18	149
Cough present	72	6	66
%	43	33	44

full-term infants had a spontaneous cough at birth. A higher incidence of spontaneous coughing was obtained at birth than was found by direct laryngoscopy in the first 10 days of life, suggesting that possibly the test situations were not valid. Consequently, 40 of the infants on whom observations had been made for the presence or absence of a spontaneous cough reflex at birth were also examined with the laryngoscope during the first 7 days of life. Five infants who coughed spontaneously at birth responded with a cough when laryngoscoped; 17 infants who did not have a spontaneous cough at birth did not respond with a cough when tested later; 2 infants who did not cough spontaneously at birth responded positively to the laryngoscopic examination; 16 infants who had a spontaneous cough at birth did not cough when tested after birth by laryngoscopy, 15 of the 16 negative responses occurring within the first 4 days after birth. During this same period there was a high degree of correlation between the cough response obtained when the laryngoscope was introduced into the throat and to the saline squirted onto the vocal cords (Table 3). It can be seen that the responses were similar in 41 of the 45 infants who were under five days of age. Among the infants 5 to 9 days of age the number of agreements dropped to 12 out of 21 tests; this was at a time when the incidence of positive responses was increasing. A further change occurred among the

infants 10 to 30 days old, for the number of agreements increased to 9 out of 12 infants. These data do not permit a conclusion concerning the cause of the higher incidence of spontaneous cough immediately following birth as compared to that found in the first four days of life.

The position and action of the vocal cords was noted in all but two of the 154 infants examined with the laryngoscope. The response in 146 infants to the introduction of the laryngoscope was a quick and vigorous snapping together of the vocal cords, as described by Flagg. In the six remaining infants the vocal cords were bowed, lacked tone, or adducted poorly. The cough reflex was absent in five of the six infants. Four of the six infants appeared to be healthy in all respects; one was a premature infant whose birth weight was 2,150 grams and who was examined on the day of birth;

TABLE 3
COUGH RESPONSE TO LARYNGOSCOPE COMPARED TO THAT WITH
SALINE ACCORDING TO AGE OF THE FULL-TERM INFANTS

<i>Infants responding to</i>		<i>Number of infants by age</i>		
<i>Laryngoscope</i>	<i>Saline</i>	<i>0-4 days</i>	<i>5-9 days</i>	<i>10-30 days</i>
0	0	39	6	3
+	+	2	6	6
+	0	2	4	3
0	+	2	5	0
		—	—	—
TOTAL		45	21	12

the other three infants had birth weights of 2,540, 3,500 and 3,250 gms., respectively, and were 1, 2, and 4 days of age when examined. The absent cough reflex was the only other significant finding in these four infants. A fifth infant was born prematurely and died on the second day; the history and findings are recorded in detail in Case 2. The sixth infant with bowed vocal cords was four months old and had laryngeal stridor and a meningococle; the cough reflex was present in this infant.

Three infants had findings on laryngoscopic examination which were sufficiently different from the others as to warrant a more detailed description of their courses and findings. All were premature infants. Two of these infants died on the second day of life and the third survived. Their case summaries are given below.

Case 1. Baby M. Hosp. no. 51-2570. This male infant was born at 9:00 P.M. on 3/26/51 after an uneventful pregnancy to a mother who was a para two. Immediately after birth the respirations were poor and there was considerable sternal retraction. Fifteen minutes after birth he became apneic, but respirations were re-established within 10 minutes, using oxygen and artificial respiration. A small amount of mucus was suctioned from the pharynx at this time. Sternal retraction became deeper. He was put in an incubator and received added oxygen constantly. The respirations con-

tinued to be regular with deep retractions on each inspiration for the next 9 hours. At 12 hours of age he was apneic and became cyanotic. Following his revival, the baby had a convulsion. A direct laryngoscopy was done at 13 hours of age, at which time the color was improved. It was found that the cords abducted well but did not meet in the midline on phonation. The cords lacked tone and were slightly bowed. No cough, gag, or swallow reflex could be obtained. The epiglottis was normal in size and position. Following the laryngoscopy the baby continued to breathe with deep sternal retraction and remained slightly cyanotic. Death occurred 20 hours after birth and 7 hours after the laryngoscopy. Autopsy revealed atelectasis with light interstitial pneumonitis and a subarachnoid hemorrhage over the inferior surface of the cerebellum and medulla.

Case 2. Baby J. Hosp. no. 51-3170. Baby was born at home after an uneventful pregnancy. He was brought to the hospital one-half hour after birth. The weight of the infant was 1,440 grams. He was dusky in color and respirations were feeble but improved when the pharynx was suctioned. There was moderate subcostal retraction. He was placed in an incubator and given oxygen continuously and penicillin parenterally. At 12 hours of age the breathing was regular and the lower portion of the chest retracted as the upper portion expanded and as the diaphragm contracted. A direct laryngoscopy was done at 18 hours of age when the color was good. No gag reflex was obtained when the laryngoscope was introduced into the pharynx. The swallow reflex was feeble. The vocal cords were not visualized and no cough reflex was elicited. The infant died 36 hours after birth and 18 hours after the laryngoscopy. Autopsy showed atelectasis, hyaline membranes in the lung, and a subdural hemorrhage around the brain stem.

Case 3. Baby R. Hosp. no. 51-25143. This male infant weighing 1,505 gm. was born on 2/21/51 to a gravida 4, para 2, after an uneventful pregnancy and labor. Following its birth, the baby was apneic for a few minutes. There was much mucus aspirated from the nose and throat. Respirations began with use of a respirator which provided alternating positive and negative pressures through a face mask. The color remained dusky for a period of two hours following delivery, but improved gradually thereafter. The infant was placed in an incubator provided with oxygen. Twenty-four hours later the baby's color was good and respirations were adequate. Oxygen was given continuously for the first 10 days of life. The lowest weight was 1,275 gm. on the seventh day. Weight gain was steady and satisfactory from then on, although the baby did not swallow its milk easily at any time during the first six weeks. Laryngoscopy was done on the 28, 44, 46, 55, and 63 days of life. The gag and swallow reflexes were always present, but no cough reflex was obtained except on the 55th day. On the 27th day of life the infant choked and was found to be cyanotic and apneic. What appeared to be milk was removed from the pharynx by suction. Artificial respiration and oxygen were given and the infant began to revive. The infant had choking spells later in the day and again on the 31st and 33d days. A roentgen examination of the chest on the day following the first choking spell showed a complete opacity of the right upper lobe, which had disappeared six days later. No fever was present at any time; there was a temporary weight loss of 2 ounces on the 27th day of life, but a steady weight gain thereafter. The infant was discharged on the 63d day weighing 2,950 gm. in good health.

DISCUSSION

The cough reflex is most commonly initiated by the stimulation of vagal afferent nerve endings in the mucosa of the larynx and trachea, although there are some fibers of the glossopharyngeal nerve in the pharynx which are capable of being stimulated as well as a branch of the vagus (Arnold's

nerve) to the ear. As a result of the sensory stimulation, the vocal cords close and the intrapulmonary pressure is suddenly increased by a spasmodic expiratory effort. The sudden release of the vocal cords and intrapulmonary pressure allows material to be moved cephalad in the respiratory tract. The data obtained by the present investigation do not give any clue as to the explanation for the large number of newborn infants without a cough reflex. The lack of a cough reflex could be accounted for by either an absence of afferent sensory stimuli or a failure to develop a sudden, spasmodic expiratory effort. Recent work by Miller and Behrle on the vagal control of respiration suggests that some newborn infants, particularly premature infants, behave in respect to breathing as though the afferent stimuli were not being transmitted from the lungs to the medullary centers.¹¹ This would tend to support the theory that the major factor in the absence of the cough reflex was the lack of sensory stimulation.

The high degree of correlation between the response to the introduction of the laryngoscope and to the squirting of water on the vocal cords in the first five days of life, and again at a later age when the cough reflex was obtained with high frequency, suggests that the test situation was valid. The relative lack of correlation between the results of these two tests during the age period of five to ten days may be explained by the fact that the incidence of the positive responses was rapidly increasing. There can be no gainsaying the fact that the squirting of saline onto the vocal cords was in itself a severe test. It is almost certain the saline reached beyond the vocal cords to include the mucosa of the trachea and its bifurcation. The higher incidence of spontaneous cough at birth compared to that found in the first five days of life may represent an actual difference rather than merely a change in the test situation. In this connection it is interesting to note that the secretion of HCl acid in the stomach, which is also under vagal influence, is notably greater the first week of life than in the days that follow.¹² Miller and Behrle have also noticed a greater regularity in respiration during the first day of life than is subsequently found, suggesting that perhaps vagal function undergoes some diminution following birth.

It is interesting to speculate about the significance of the absence of the cough reflex at birth. Even in those infants in which it was present, it was notable that the response was brief and weak, amounting to rarely more than one short, slight spasmodic effort. It would seem likely that the cough reflex must be absent or diminished greatly during uterine existence and this might allow amniotic fluid to enter the trachea and other portions of the bronchial tree, especially if ciliary activity and the bechic reflex were unable to cope with the entering fluid. There has been considerable divergence of opinion as to the good or bad effects of amniotic fluid in the lung. Most observers agree that practically all lungs of stillborn and newborn infants contain fluid when examined at autopsy. There is also general agreement that small amounts of amniotic fluid can be of little harmful

consequence. The belief continues that large amounts of amniotic fluid may prevent expansion of the lungs, although the direct evidence to support this theory is lacking. Gruenwald has shown that the lungs of newborn infants and stillborn infants can be expanded with half the pressure if saline is used as compared to air alone.⁷ Behrle, Gibson, and Miller found that lungs which contained large amounts of amniotic fluid required no more pressure and expanded as easily as lungs that were free of foreign materials.⁸ It seems plausible to believe that the admission of fluid to the unexpanded lung may be beneficial in reducing surface tension and hence in making it possible to expand the lung with reduced pressures. It remains to be proven that large amounts of amniotic fluid are harmful. The absent or diminished cough reflex may be significant in permitting access of amniotic fluid to the lung prior to birth.

The long-continued depression or absence of the cough reflex in premature infants, as demonstrated in Case 3, may be the cause of the frequent respiratory difficulties seen in premature infants. Perhaps part of the susceptibility of the premature infant and full-term infant to staphylococcal pneumonia may be related to the absence of the protective influence of the cough reflex in keeping out of the lung the pharyngeal contents, among which pathogenic strains of staphylococci are commonly found.

It is not clear that asphyxia is the only factor controlling the action of the vocal cords in newborn infants as Flagg indicated. Several infants were examined who showed no evidence of asphyxia and yet the tone of the vocal cords was less than expected. The striking absence of the gag, swallow, and cough reflex as well as the atonic condition of the cords in Case 1 and the lack of a gag and cough reflex in Case 2 perhaps were caused by the asphyxia of the infants, but neither of the infants was very cyanotic at the time of the laryngoscopy and neither was in a critical condition. An alternative hypothesis can be made out in the light of the present findings regarding the cough reflex and the increasing awareness that the vagal reflexes controlling other vital functions are not fully developed. It would seem quite possible that the reflexes in these two infants were not obtained because of a failure of development somewhere along the reflex arc. Further observations in which the state of the reflexes are correlated with the clinical conditions and autopsy findings are needed in order to settle this point.

SUMMARY

Direct laryngoscopies were done on 154 infants from birth to eleven months of age. A cough reflex could be obtained in only about one-quarter of the infants during the first five days of life, but in infants over a month of age the cough reflex was present in 90 per cent. One premature infant repeatedly examined developed no cough until the 55th day of life. The gag and swallow reflexes were present in all but two infants, both of whom

were premature and failed to survive the second day of life. The vocal cords were bowed and had diminished tone in six infants, four of whom showed no signs of asphyxia at any time. The relationship between the findings in the present study and a possible immaturity of vagal function has been discussed.

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