# Chapter 8

# Asphyxia Neonatorum

## Anatomical Considerations

The head of a new-born baby of an average weight of 6 to 8 pounds (2700 to 3600 grams) is about the size of a small grape-fruit and weighs approximately as much. It is attached to the body by a relatively long, relatively thin neck which in the state of complete relaxation gives no support to the head. The normal baby's mouth will readily admit one finger, occasionally two. The pharynx in relaxation will admit the tip of the finger up to the attachment of the epiglottis. The distance from the gums to the glottis is about 2 inches, a relatively short distance. The distance between the epiglottis and the glottis is often so short that when the lip of the laryngoscope is placed against the epiglottis, it impinges against the glottis itself and obscures it. In complete relaxation, the soft parts of the airway are collapsed and as soft and adherent as the finger of a rubber glove or a collapsed toy balloon. While insufflation tends to open these passages, suction immediately causes them to collapse still further, simulating the phenomenon seen when one attempts to use a soft rubber tube on a suction instrument. The trachea is about 2 inches, from the glottis to the bifurcation. The tracheal rings are soft and easily compressible, but they maintain the lumen of the trachea under ordinary conditions. The chest wall with its intercostal muscles, accessory muscles, and the diaphragm, offer little resistance to interpulmonary gas pressure when the lungs are inflatable.

Asphyxia Neonatorum is of the greatest possible interest to the pneumatologist, for it offers an ever-present working model by which all other types of asphyxia may be approached.

Although the anatomical structures of the new-born are delicate and easily traumatized, this tissue fragility is more than counterbalanced by a resilience and a tolerance to asphyxia far beyond that which the child or the adult can endure and survive.

Furthermore, the location and the conditions under which asphyxia of the new-born occurs are under better control than is any other type of asphyxial accident. Not only are the conditions under which asphyxia neonatorum occur subject to anticipation and control, but the predisposing pathology presented by the mother issues a clear warning of the asphyxial accident about to occur.

Correct and non-traumatic treatment of the asphyxiated baby will prepare the physician to treat any other type of asphyxia with understanding and success. A swimmer pulled out of the surf in a condition of complete asphyxial flaccidity presents a condition practically identical with that of the new-born baby drowned in amniotic fluid. The attempted suicide who has taken an overdose of sodium amytal is closely akin to the asphyxiated baby whose mother has received excessive premedication. The Caesarian about to perish from an overdose of anaesthetic resembles the asphyxiated baby just delivered and about to die from the same cause.

For these reasons, State Health Commissioners will do well to encourage the use of material available for the study of asphyxia of the new-born (new-born cadaver) by the pediatricians and the general practitioners of the territory, in order that these may acquire the valuable and basic material which will permit them to take their rightful place as directors of all First-aid emergency resuscitation groups.

Asphyxia of the new-born, the most frequent cause of asphyxial death, complicates approximately one-half of the 4–5 per cent of new-born deaths.

The intensive development of the specialty of obstetrics, pediatrics and internal medicine has divided the human species into infant, child and adult groups which are so sharply circumscribed that we are inclined to forget that the infant is nothing more nor less than a very small man, that his anatomical structures are and should be in a general proportion to his size as compared to that of his mother. For example, given a woman's height and a new-born baby's length, we should by this ratio be able to form a general estimate of the size of his anatomical structures, the variations due to excessive function which occur in early life being admitted as exceptions. For example, the heart of the infant is 0.76 per cent of the body weight; that of the adult is 0.46 per cent of the body weight.

Structures having no excessive physiological activity follow a remarkably constant proportion. For example, the average length of the white baby is 50 cm (20 in); the average height of the white woman is 63 inches. The ratio of 1:3 applies to anatomical structures as generally unfamiliar as the subglottic tracheal diameter. Chevalier Jackson gives the average adult tracheal diameter as 18 mm. Gabriel Tucker states that the average full-term child presents a subglottic tracheal diameter of 6 mm, or 1:3. Jackson gives the distance from the teeth to the glottis as 15 cm or six inches, the distance from the glottis to the bifurcation of the trachea as 12 cm. One-third of these distances, namely five and four cm, would constitute a fair measurement for the average baby.

Jackson bronchoscopic tube, infant size: $3\frac{1}{2}$ mm = 6 by $4\frac{1}{2}$ mm, o.d.
4 " = 9 " 5 " "

Velvet end bronchoscopic suction tube, 3 mm.

Infant subglottic diameter, 6 mm.

Flagg infant insufflator tube, 4 mm.

Suction tube used for insufflation in prematures, 3 mm.

The ordinary respiratory rate of the sleeping new-born baby varies from 36 to 60, average 43 (Douglas P. Murphy and Edward S. Thorp). The tidal capacity varies from 17 cc at birth to 36 cc six hours after birth (Von Reus). The anterior border and apices of the lungs are the first portions to become aereated. The right ventricle of the heart is unusually large and strong. The pulse rate varies from 130 to 150. The blood pressure varies from 40–60 systolic and from 20–40 diastolic.

**Pathological Physiology**

We may consider the fetus as a fish, suspended in fluid, exerting an equal pressure over the surface of its body and within its open body cavities. Respiratory movement takes place, causing a gentle circulation of fluid from the amniotic bath in which the child is suspended, through the mouth and into the trachea. These movements, the precursors of those to occur in extra-uterine life, tend to maintain the patency of the airway to fluid as well as to synchronize and develop the respiratory musculature. Adequate oxygenation is provided by the placental circulation. Reifferscheidt is of the opinion that respiratory movements take place with the glottis closed, and the power of suction is so slight that the liquor amnii reaches at the utmost the nasal cavity or the entrance of the larynx. Under normal conditions the respiratory tract is always free of liquor amnii. At birth, by vertex delivery, intrauterine pressure compresses the chest and upper airway, squeezing much of the fluid present out of the mouth and nostrils. This preparation for an atmospheric environment is accompanied by varying degrees of respiratory obstruction. If the baby is vigorous and awake, as it were, that is, if he is not under the influence of an anaesthetic which has been administered to produce general anaesthesia, basal anaesthesia or asphyxiation (profound anesthesia), muscle tone and active reflexes help to keep open and clear the airway for the extrauterine respiratory effort. This effort, the accumulative effect of many repressed efforts, finally breaks through the existing obstruction and initiates subsequent rhythm. If the baby presents profound relaxation, obstruction and respiratory depression, these complications must be relieved or he will die.

Johnson and Meyers* reported a series of 500 autopsies of which 19.4 per cent showed evidence of pneumonia, 13.6 per cent of which were infected before birth. The great majority showed aspiration of amniotic material. These investigators state that autopsies should include examination of the placenta, cord and membranes. They urge that prophylaxis against infection by amniotic fluid be practiced by studying the condition of the cervix and vagina before labor. While amniotic fluid is normally present in the nose, mouth and trachea, it is not usually found in the lung. The presence of epithelial cells in the lungs indicates that aspiration has taken place as the result of intrauterine respiratory movements. Aspiration of uncontaminated amniotic fluid is not expected to produce inflammatory effects.

* *Am. J. Obst. Gyn.*, **9**, #2, Feb. 1925.

A new-born baby presents one of two extremes of reflex activity and muscle tone. It is extremely important to recognize these variations, as they form the criteria of treatment. There is no excuse to attempt to intubate a new-born baby whose head is moving about from the action of the muscles of the neck, or whose gums close upon the gloved finger of the operator. Asphyxia produces progressive relaxation and loss of the reflexes of the airway. In extreme asphyxia the gums separate without resistance, the tongue is completely relaxed, the soft palate and the pillars of the fauces are perfectly flaccid, the epiglottis drops into view, the glottis appears beneath the lip of the laryngoscope, with cords which are silent and which are separated or in contact with one another. The mucous membranes of the field are cyanotic and injected to a degree which varies directly with the vigor of the baby's circulation. A vigorous circulation gives rise to the well known asphyxia livida; a depressed circulation, on the other hand, results in the so-called asphyxia pallida.

Between the two extremes of active reflexes and muscle tone on the one hand, and complete disappearance of the reflexes and complete relaxation on the other, appears every variation. These variations depend upon the viability of the baby.

It is, therefore, practical and reasonable to make an immediate prognosis of the baby's condition by the state of the reflexes and muscle tone found upon the initial examination. If a baby permits the introduction of the finger into the mouth without resistance, exposure of the pharynx by the laryngoscope is indicated, which will be entirely non-traumatic. If upon laryngoscopy, active swallowing reflexes and spasm of the glottis occur, it will be unnecessary to intubate, for the viability present indicates that central activity will promptly result in a respiratory effort. The act of opening the mouth, lifting the tongue out of the field, and removing detritus in the airway provides adequate immediate treatment for the baby.

On the other hand, if laryngoscopy reveals the pharyngeal reflex to be in abeyance and the cords inactive, the indications are to introduce a suction tube between them, to practice endotracheal suction, and to follow this by re-intubation and insufflation of oxygen and carbon dioxide. In the presence of an active circulation, cyanosis, which may be present upon intubation and which is seen as lividity in the mucous membranes, ecchymosis of the skin or cyanosis of the extremities will promptly disappear upon insufflation of oxygen. It will be replaced by a pink color, and the reflexes which were in abeyance will reappear.

In asphyxia due to obstetrical manipulation without cerebral hemorrhage, or in respiratory obstruction from fluid in the airway, the reflexes return very promptly. However, if the asphyxia is the result of prolonged anaesthesia or of medication to the mother, a longer period will elapse before

the reflexes return. A vigorous circulation will promptly pick up oxygen available in the trachea and in the bronchi. A depressed circulation will react more slowly. Care must be exercised, therefore, to provide surface heat as an initial circulatory stimulation.

The rhythm of respiration is the result of a highly complex biochemical reaction which is complicated by asphyxial factors. It will vary in accordance with the freedom with which each individual respiratory effort takes place. If the airway is absolutely unobstructed, as is the case when the endotracheal insufflation tube is in place, returning respiratory effort will be noted as an extremely shallow, but regular, effort occurring as rapidly as, or more rapidly than the pulse rate. As the vigor of the respiratory effort increases, the depth of each respiration will increase and the rate will be diminished; if the respiration is obstructed, these initial efforts will be obscured until the summation results in a forceful gasp, a final effort to overcome existing obstruction. When it is realized that adequate oxygenation of the circulation may readily be carried on for hours by means of endotracheal oxygen without any respiratory efforts whatsoever, the effort to establish an artificial respiratory rate and rhythm will be of secondary importance. The objective in every case is to support the returning voluntary respiration without in any way interfering with it by attempting to supplant an artificial rate and rhythm. The operator attempts, as it were, to feed the returning respiration with the oxygen which is required to resuscitate the respiratory center.

If, however, there is no respiratory effort whatever, one is justified in attempting to initiate such effort by stimulating the Hering-Breuer reflex by the use of maximum pressure (25 mm Hg). Following this initial stimulation, the technique described may be followed to advantage.

The return of normal vigorous respiration will be accompanied by muscular movement of the extremities and movement of the muscles of the face. The baby's head will begin to move from side to side. After normal respiration through the tracheal tube is permitted for a short period, the tube may be removed, whereupon the baby will begin to cry.

Prolonged postoperative treatment of the new-born due to drug depression or other causes when the respiration has been demonstrated to be free, is best accomplished by means of an oxygen chamber suited to the baby's size and equipped with the necessary heating and ventilating devices.

### Prognostic Signs of Impending Asphyxia during Delivery

The heart is slowed; bradycardia occurs between pains during labor. There is irregularity of the heart sounds, loud umbilical souffle, and excessive movements of the baby in utero. Mecomium is seen as a result of increased peristalsis due to asphyxia. There is twitching of the visible and palpable scalp covering the skull (spastic contractions).

Fig. 89. Complete atelectasis of left lung in infant 61 lbs. 15 oz.

Fig. 90. Diaphragmatic hernia, left. Intestines in left chest. Infant, 6 lbs. 4 oz.

**Causes of Asphyxia of the New-Born**

*Anoxic:*

Aspiration of amniotic fluid and debris
Atelectasis
Enlarged thymus
Tracheo-bronchial fistula
Pathologic abnormalities of glottis, web, exaggerated infantile type
Pneumonia (Fig. 93)
Diaphragmatic hernia (Figs. 90 and 91)

*Stagnant Anoxia:*

Cerebral hemorrhage
Cardio-vascular congenital lesions (Fig. 92)
From analgesics and anaesthetics
Intrauterine pressure interfering with placental circulation
Premature rupture of membranes (causing a disturbance in the ordinary intrauterine hydrostatic pressure resulting in a disproportionate pressure on the presenting vertex)
Premature and excessive use of pituitrin
Post-delivery exposure

*Anemic Anoxia:*

Maternal hemorrhage
Cord pressure
Premature separation of placenta

* Illustrations from Dennen, E. H., "Cyanosis of the new-born," *Am. J. Abs. Gyn.*, **30**, No. 1, p. 147 (1933).

Fig. 91. Diaphragmatic hernia after operation. Patient recovered.

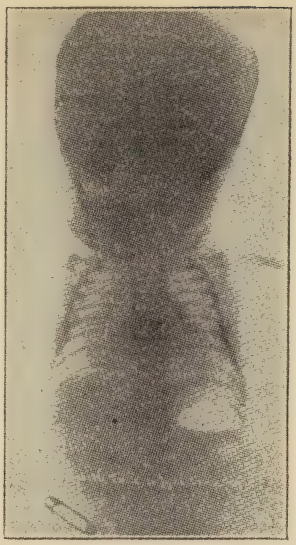

Fig. 92. Congenital cardiac lesion in 6-lb. infant. Post mortem showed three chambers in right heart, rudimentary pulmonary artery, patient foramen ovale.

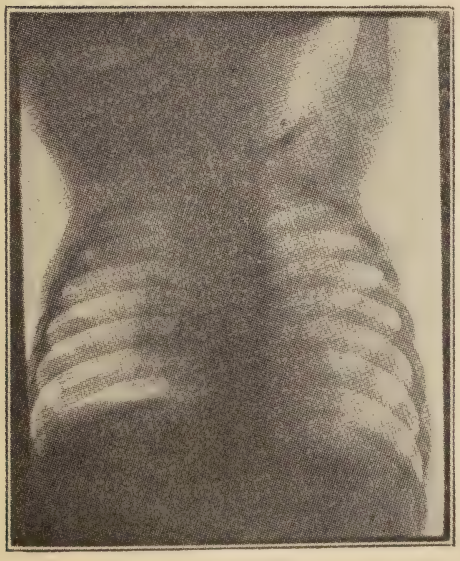

Fig. 93. Pneumonia in 8-lb. infant. Consolidation in upper right lobe; patchy consolidation in right root.

**Differential Diagnosis**

A definite diagnosis of congenital cardiac lesions or gross lesions of the circulatory system may be made by the infant's reaction to the endotracheal insufflation of oxygen. The cyanotic baby is insufflated and intubated in the usual manner. If the color remains constantly dusky, or fails to clear completely in the presence of endotracheal oxygen upon pressure, a portion of the circulation leaving the right heart is finding its way directly into the arterial system. We see this in a patent foramen ovale and in a congenital short-circuting of the large blood vessels. The reason for this phenomenon is that a definite portion of the circulating blood has failed to pass through the lungs and is contaminating the oxygenated stream. Neonatal atelectasis, cerebral trauma, as well as persistent thymus and even the rare, tracheo-esophageal fistula, fail to give this unique reaction. In each case, adequate oxygen insufflation temporarily but completely clears the color of the circulating blood. A tracheo-esophageal fistula may be suspected when there is a persistent discharge of fluid or froth through the glottis following satisfactory initial intubation, suction and an apparently clear respiratory tree.

Fluid within the pulmonary airway may be expected in Caesarean sections and in breech deliveries as the compression action of the uterus upon the flexed chest has not functioned to squeeze out fluid contained therein. It is therefore desirable to practice immediate oral, pharyngeal, and, if relaxation permits, endotracheal suction of babies delivered by these two procedures.

A diagnosis of cerebral hemorrhage is based upon persistent respiratory depression, regional flaccidity, or blood in the spiral fluid.

Enlarged thymus will give symptoms of tracheal obstruction when the head is extended. In this position the trachea is compressed between the thymus and the sternum. Diagnosis is confirmed by x-ray. Atelectasis may be suspected when there is depression of the lower costal margins during inspiration, intermittent spells of cyanosis, especially in the premature, which clear up with spells of crying, but reappear upon quiet breathing. Diagnosis may be confirmed by x-ray. This is caused by cohesion of soft moist surfaces by obstruction higher up, the left lung being most frequently involved. Post mortem distinction of true atelectasis involves the presence of cylindrical epithelium lining the alveolar spaces. When air has entered these spaces the epithelium becomes flattened. This is characteristic of the premature lung which is atelectatic.* Glottic obstruction is characterized by dysponea, accompanied by a sucking in of the supra-sternal and supra-clavicular regions. Diagnosis is confirmed by endoscopy and intubation.

The foregoing anatomical considerations and pathologic physiology are common knowledge included in the curriculum of the medical schools of this country and abroad. It is therefore of the greatest importance and

* Forbes and Wilson, *Am. J. Diseases Children*, **46**, 590 (1933).

interest to try to determine common practices flowing from this common knowledge. Just how are the medical schools dealing with the problem of asphyxia neonatorum?

To this end, in accordance with the recommendation of the Committee on Asphyxia of the American Medical Association, a survey was begun in 1938 to determine the policy and the practice which the obstetrical teaching centers of the United States and Canada employ in the treatment of asphyxia neonatorum. Contact was made, carried on and completed as follows:

A copy of the last annual report was secured from every medical school.

A personal letter was written to the Professor of Obstetrics of each school requesting the following information:

(a) A review of methods now in use in the treatment of asphyxia neonatorum.

(b) A statement relative to research under way.

(c) A reaction to a suggested outline proposing a new classification of the stages of asphyxia and the treatment indicated (pp. 124, 125) was sent to the Professor of Obstetrics of the following medical schools. On page 122 an outline is suggested for those who wish to assemble accurate information relative to resuscitation.

Albany Medical College
Univ. of Alberta Faculty of Medicine
Baylor Univ. College of Medicine, Texas
Boston Lying-In Hospital
Boston Univ.
Univ. of Buffalo, School of Medicine
Univ. of Cincinnati College of Medicine
Univ. of Colorado School of Medicine
Dalhousie Univ., Faculty of Medicine, Halifax, N. S.
Duke Univ. School of Medicine
Emory Univ. School of Medicine
College of Medical Evangelists
George Washington Univ. School of Medicine
Georgetown Univ. School of Medicine
Univ. of Georgia School of Medicine
Univ. of Illinois College of Medicine
Indiana Univ. School of Medicine
State Univ. of Iowa College of Medicine
John Hopkins Univ. Medical School
Univ. of Kansas
Long Island College of Medicine
Louisiana State Univ. Medical Center
Marquette Univ., School of Medicine, Indiana
Univ. of Maryland, School of Medicine
Meharry Medical College, Tennessee
Univ. of Michigan, Medical School
Univ. of Minnesota, Medical School
Univ. of Mississippi, School of Medicine
Univ. of Montreal Faculty of Medicine
Univ. of Nebraska College of Medicine
New York Hospital
New York Univ., College of Medicine
Univ. of North Dakota School of Medicine
Northwestern Univ. Medical School, Illinois
Ohio State Univ., College of Medicine
Univ. of Oklahoma School
Univ. of Pennsylvania, School of Medicine
Univ. of Pittsburgh (E. S. Magee Hospital)
Jefferson Medical College of Phila. (Penn. Hospital)
Queens Univ., Faculty of Medicine
Univ. of Rochester, School of Medicine
Univ. of Southern California, School of Medicine
Medical College of the State of South Carolina
Univ. of South Dakota, School of Medicine
Stanford Univ., School of Medicine
St. Louis Univ., School of Medicine
Syracuse Univ., College of Medicine

Temple Univ. School of Medicine, Pa.
Univ. of Toronto Faculty of Medicine
Tufts College Medical School, Mass.
Tulane Univ. of Louisiana School of Medicine
Univ. of Utah School of Medicine
Vanderbilt Univ. School of Medicine, Tenn.
Univ. of Vermont College of Medicine
Univ. of Virginia, Dep't of Medicine
Medical College of Virginia
Wake Forest, College School of Medical Sciences
Wayne Univ., College of Medicine
Univ. of Western Ontario, Medical School
Univ. of Manitoba Faculty of Medicine (Winnipeg General Hospital)
Univ. of Wisconsin Medical School
Woman's Medical College of Pennsylvania
Yale Univ. School of Medicine

### Resuscitation Study Report

*Note:* A routine toilet of mechanical suction should be established. Suction should be sterile and should be available for use upon delivery of the head. A velvet-eyed suction tube should be provided for this purpose. Suction should precede attention to the cord, the eyes, etc., and should be applied as soon as the mouth is freely accessible.

*Maternal Record*

Date: Time of delivery: a.m. p.m. Para

Complications of delivery:

Medication:
Delayed labor:
Operation: Type:

Type of delivery:

Vertex:
Breech:
Caesarian:
Miscellaneous:

*Baby Record*

General appearance at instant of delivery:

Respiration:
Color:
Heart action:
Movements:
Extremities:
Face:

*Treatment*

Apparatus or manual methods used:

Indications for treatment:

| | |
|---|---|
| Relaxation: | 1 2 3 |
| Reflexes: | 1 2 3 |
| Apnoea: | 1 2 3 |
| Cyanosis: | 1 2 3 |
| Circulation failing: | 1 2 3 |

Physical signs before treatment:

| | |
|---|---|
| Color: | |
| Lividity: | 1 2 3 |
| Pallor: | 1 2 3 |

Respiration: Respiratory effort:

Present
Frequency
Absent

Is respiratory act effective: Yes No

Reflexes: Is jaw relaxed: Yes No
Are facial muscles relaxed: Yes No

Heart: Apex beat: Present Absent
Cord pulsation: Present Absent
Rate:

*Exposure* (peroral endoscopy and laryngoscopy):
Color of lips:
Spasm of masseters:
Movement of facial muscles:
Fluid in hypo-pharynx:
Appearance of glottis:
open:
closed:
Vocal cords: Not working:
Working:

*Suction* (amount and character of fluid in):
Hypo-pharynx
Trachea
Source of suction: Operator's mouth—hand—electric—water—steam

*Intubation* (instrument used): Suction tube
Insufflation tube
Active
Cord reflex Sluggish
Absent
Do cords close about tube: Yes No
Does glottis remain open on withdrawl of tube: Yes No

*Insufflation:* Yes No
Pressure employed:
mm Hg
Inches of water
Duration of pressure:
Seconds
Tube removed: Tube reintubated
Yes
No
How long
Total time of treatment
Minutes

*Results of treatment:* Sequence of method or treatment used:
Respiration established:
Time in minutes:
Character:
Color:
Muscle tone:
Reflexes:
Crying:

*Remarks*

*Notes:* The interne should differentiate between:

1. Asphyxia from central depression with its tendency to pallor in which the circulation is failing and in which the respiratory act, while complete, is ineffective because of its infrequency and small total volume;
2. Asphyxia from obstruction in which the circulation is well maintained, but owing to fluid in the pharynx and trachea or to a glottis which has failed to open, the respiratory act is spasmodic, incomplete and entirely ineffective because of the mechanical obstruction present.

Artificial respiration must be continued until circulation fails. Gradual failure of the circulation will be noted as the color begins to fade and anoxemia develops in the presence of oxygen insufflation.

The various causes of asphyxia neonatorum should be borne in mind, for example, thymus pressure, central pressure or depression, congenital abnormalities of the heart, aspiration and atelectasis.

One of the best diagnostic signs of cardiac abnormality is the continuation of anoxemia in the presence of intratracheal insufflation of oxygen, the apex beat remaining strong.

When the baby begins to breathe, try to cooperate with his respiratory effort and to fall in with his rhythm. He can breathe very freely through the intratracheal tube and, as he does so, he will inhale oxygen and $CO_2$ even though the pressure vent is wide open.

When the glottic reflexes return, the tube may be withdrawn. The glottic reflexes usually presuppose and are usually accompanied by a functioning respiratory center.

Your report at this time is important since the information which you will gather is pioneering in a new field and will be scrutinized with interest and appreciation.

### Physical Signs Accompanying Stages of Asphyxia

The following stages of asphyxia are recognized as applying to asphyxia of the new-born:

(1) Stage of Depression.
(2) Stage of Spasticity.
(3) Stage of Flaccidity.

*Depressed:*

Baby does not breathe well.

Tendency to duskiness or recurring cyanosis.

Respiration free, but slow and irregular.

*Spastic:*

Irregular, gasping or shallow respiration occurring at long intervals.

Marked cyanosis of mucous membranes, with blotching of skin or general pallor.

The baby's gums close on the gloved finger tip.

Reflex reaction to suction of the pharynx, such as movement of facial muscles or extremities.

If pharynx is exposed, pharyngeal reflex is sluggish or active and the glottic reflex is active.

Froth or fluid is present in the mouth and pharynx.

*Flaccid:*

Respiration occurs at long intervals, or cannot be demonstrated.

Cyanosis or pallor.

Complete flaccidity of the musculature; all muscle tone gone.

Jaw completely relaxed.

No resistance to suction or exposure of the pharynx.

Fluid is found in the hypo-pharynx.

Apex beat may or may not be demonstrable.

### Indications for Relief

On delivery, routine toilet should be practiced, including immediate suction, correct posture, and heat to the body.

*Depression:* Administration of oxygen and $CO_2$ pending confirmation of diagnosis of the cause of depression. Supply heat to the body and maintain correct posture.

*Spasticity:* Relieve obstruction to free respiration by suction and otherwise. Provide oxygen and $CO_2$ so that it may reach the glottis. Apply artificial heat and postural treatment.

*Note:* Artificial respiratory obstruction may be easily induced by the slightest pressure on the baby's face which tends to depress the lower jaw.

*Flaccidity:* Eliminate complete respiratory obstruction which has occurred as the result of flaccidity of airway by lifting the tongue from contact with the soft palate and pharynx. Examine the pharynx, and remove fluid present by suction. Examine the glottis. If the vocal cords are relaxed and silent, introduce suction tube. Follow tracheal suction by insufflation of oxygen and $CO_2$ under controlled pressure for measured periods. On the first appearance of spontaneous respiration, follow this newly established respiratory rhythm with stimulating doses of oxygen and $CO_2$ through a tracheal tube. When reflexes return, discontinue insufflation and provide oxygen and $CO_2$ by inhalation, employing correct posture and heat. Insufflation may be accompanied by hypodermic or intravenous medication, directed to stimulation of the respiratory center.

The details of this report which will be of particular interest to obstetricians and pediatricians will be found in appendix II.

### Comments

The material in Appendix II is most significant because of the extraordinary educational influence which it represents. The directors of the leading obstetrical services in the United States and Canada have, by their thoughtful response to the queries addressed to them, indicated a nationwide interest in the problem of asphyxia neonatorum. The author, in assembling and presenting the material, is merely correlating the position of leading teaching centers on the subject. He has in this capacity attempted to report the statements of record without unduly emphasizing those factors which might be of particular interest to him.

In commenting upon the conclusions to be drawn, he has attempted to bring to focus points of acceptance and difference which are sharply marked. He has taken the liberty of adding notes based on his clinical experience in this field.

Returning to the general outline as a focal point about which conclusions may conveniently be assembled, the following facts may be noted:

The outline presenting the stages of asphyxiation, including the physical signs characteristic of each stage, has been found acceptable by more than

80 per cent of the universities contacted. In view of this approval and acceptance by the leading medical centers of the country, is it too much to hope that the medical literature dealing with this subject may adopt this classification for common usage?

Turning to the indications for and the specific method employed for the treatment of each stage, we find that the common practice exhibits differences of opinion. The first and the most important point of discussion is in connection with the third stage of asphyxia, flaccidity.

The point is taken by some that the stage of flaccidity formerly referred to as asphyxia pallida is primarily shock, which may have no relation to asphyxiation, but is closely associated with cerebral hemorrhage. Perhaps this point may be illuminated by proposing the question "What physical signs follow the stage of spasticity?" In asphyxia from other etiological causes, the picture presented by the stage described as flaccidity supervenes. We find this in asphyxia from submersion, from anaesthetic accidents, etc. The test of this condition lies in treatment. The writer has personally treated the flaccid new-born infant with nothing but artificial respiration by endotracheal insufflation, relieving the condition and rescuing the child.

Closely allied to this problem is that of cerebral hemorrhage in the newborn. Many schools favor the theory that cerebral hemorrhage is caused by instrumental delivery and antedates asphyxia. Faced with intracranial hemorrhage in the baby delivered by Caesarian section, this theory offers no explanation.

While the clotting time of the blood is noted and checked by lumbar puncture in some clinics, no reference has been submitted concerning a prothrombin deficiency and the use of vitamin K before delivery.*

From the mechanical point of view, the theory that intracranial hemorrhage is merely an expression of increased venous pressure due to asphyxiation provides a reasonable explanation for the intracranial hemorrhage which occurs without trauma, i.e., Caesarian delivery. The frequency of intracranial hemorrhage in the premature, in which the thin-walled blood vessels are more liable to rupture, may also be explained from this point of view. The clinical picture of asphyxia neonatorum in the stage of spasticity requires little imagination to extend the ecchymosis mottling of the skin to a cerebral site where it cannot be seen, but where its effects may prove fatal or appear in later life as mental derangements. The work of Schriber which has been referred to in this connection is of much interest.

Impinging upon the clinical picture of intracranial hemorrhage is that demonstrated by ante- or neonatal atelectasis. This field invites extensive research. Whether the situation is a developmental deficiency or a mechanical failure to distend the air sacks is an open question, particularly in the premature. An infant lung which it was not possible to insufflate endotracheally by a pressure of 25 mm Hg for a period of five seconds *in situ*,

* An inquiry in the fall of 1942 indicated that the respondents desired no change in the views they had expressed. Vitamin K is, however, generally employed.

and which was born atelectatic, was easily insufflated under water at post mortem. The writer has repeatedly emphasized the need of research directed to a series of new-born infants in which endotracheal insufflation could be practiced under fluoroscopic examination, an x-ray record of the progress made kept for record, and a vital capacity tidal volume of air mensuration used as a check. There is an urgent need for an air-conditioned cabinet providing known mixtures of oxygen and $CO_2$ under constant qualitative check and providing adequate heat, humidity and visibility.*

There is a general agreement regarding the necessity of early and thorough aspiration of the infant airway. This seems to be particularly desirable in the breech, podalic, or Caesarian delivery. In these cases the compression effect on the chest occurring in vertex birth, which expresses much of the pulmonary secretion, has failed to operate.

Snyder's demonstration of intra-uterine respiratory movements suggests that amniotic fluid may be a normal condition within the respiratory tree, and that the respiratory efforts may propel a fluid wave instead of the tidal volume of air occurring after birth.

The relief of fluid by suction is carried out by techniques which vary with the individual clinic. Common practice encourages the use of a rubber catheter operated by the surgeon's mouth. This catheter introduced into the mouth and pharynx is useful in removing fluid with which it comes in contact. The method of de Lee, in which the catheter is passed into the glottis by blind intubation, is a source of much satisfaction to many surgeons. Familiarity with the size and the position of the glottis and the strength of the glottic reflex, except in flaccidity, suggests that much of the so-called blind endotracheal suction is in reality esophagal suction.

The glottis of the new-born baby of seven or eight pounds whose laryngeal reflex is still active presents resistance to a 3-mm smooth metal tube. An attempt to intubate a flexible rubber catheter demonstrates the ease with which the tip of the catheter may be deflected into the esophagus. The finger of the average operator, furthermore, presents a diameter which is larger than the infant laryngoscope. The trauma of manipulation to accomplish blind intubation may very well injure the fauces and the soft palate. During this manipulation the baby's respiration is, of course, completely obstructed by the foreign body presented by the finger and the rubber catheter, which completely fills the glottis. Operators familiar with the use of direct exposure by an illuminated laryngoscope, presenting as it does facilities for the examination of the glottic aperture, amniotic shreds, etc., are inclined to compare the technique of blind intubation with the routine technique advocated by James O'Dwyer fifty years ago for the treatment of diphtheria.

Oral endoscopy in the flaccid new-born can be taught to a student as readily as can blind intubation. The results are those of precision instrumentation as opposed to surgery limited to tactile manipulation.

* The author is now constructing a transparent positive pressure oxygen tent for infants.

**Use of Heat in Treatment of the New-born**

The use of heat in the form of a bath is urged. Avoidance of drafts, avoidance of the heat of an intense light upon the new-born skin, and of the pressure of blankets for protection are to be noted. Blankets heated for the use of the baby should not be put in a warmer which renders them absolutely dry, as the static spark and fire hazard is a common danger where inflammable anaesthetic gases are in use. An understanding of the gesture of skin stimulation as compared with other means of stimulation to provoke respiration would do much to eliminate the hot and cold tubbing, spanking, rubbing of the back, slapping of the soles of the feet, etc.

A profoundly asphyxiated infant can be expected to respond to such form of irritation in just about the same manner as one might expect a patient anaesthetized for a laparotomy to respond. The anaesthesia produced by the asphyxia is certainly as profound. The indications are, as has been noted, to stimulate the respiratory center by carbon dioxide, simultaneously supporting it by oxygen. The vitalization of the respiratory center is immediately followed in orderly sequence by the return of the more superficial reflexes, and recovery ensues.

It is quite immaterial by what apparatus or by what means one introduces oxygen and $CO_2$ into the respiratory tree, provided this actually takes place. Blowing oxygen into the baby's mouth or covering the mouth and nose with an oxygen mask is nothing but an idle gesture if the gas delivered does not actually find its way into the trachea and bronchii. Babies which survive with this treatment do so in spite of it, and because of their inherent vitality, rather than as a result of the treatment. The school which employs direct laryngoscopy and intubation for suction is convinced that the only way to be sure that oxygen is in contact with the respiratory alveolae is to place it past all obstructions directly in the trachea. The immediate results of this treatment have repeatedly confirmed these views.

An important point is brought out in the necessity for close post-operative observation of the baby who has been asphyxiated. He cannot be casually abandoned to nursing care. He should not be placed in an incubator with solid walls where it is difficult for the nurse to see him as she goes about her duties. Adequate illumination of a correct temperature curve (full spectrum)* should be allowed to fall upon the baby. He should not be put in a nursery where daylight is reflected from green walls to his skin. Such illumination destroys the color value and the variations which should be noted.

The position of the baby should be such as to encourage the best possible respiratory ventilation. He should never be placed on his face. If atelectasis is suspected, placing the baby on his right or left side will result in less expansion than if placed flat on his back. The side position is useful, however, in preventing aspiration in very ill babies who regurgitate fluid.

* See page 388.

Respiratory expansion should not be embarrassed by the use of tight umbilical binders, bands or other clothing.

In the absence of mechanical means of artificial respiration, mouth-to-mouth insufflation is commonly practiced and offers relief. The difficulty at once apparent to the operator familiar with the glottis of the newborn infant is the resistance offered by this tiny aperture to the entrance of insufflated air in comparison to the absence of resistance of the wide-open esophagus. There is no doubt but that the greater part of the insufflated breath of the operator distends the baby's stomach instead of the lung. To this, of course, is added the danger of the insufflation of fluid from the baby's pharynx into his airway and contamination from the operator's mouth. However, in the absence of all other means of adequate insufflation, there is no doubt that this method should be practiced.

A number of universities have noted experience with intravenous and other types of medication. There is marked difference of opinion in the case of alpha-lobelin. It may be concluded that the drug selected may be used as an adjutant, certainly never as the sole means of reestablishing the intrauterine respiration of the baby who has just been delivered. The implication that a hypodermic will produce resuscitation *per se* is dangerous, for it may frequently delay the use of methods better calculated to bring about the desired result.

Intracardiac injections are used as a last resort. In this connection it is of interest to refer to the electric Pacemaker of Hyman, by means of which an auricular impulse is stimulated by a bipolar needle activated by an intermittent current which is injected into the right auricle.*

A number of universities urge the popularization of the matter which has been submitted with emphasis upon the prevention rather than the treatment of asphyxia. There is a strong feeling expressed by an important group among our correspondents that sedatives to the mother are responsible for much of the asphyxia neonatorum which occurs, and that the elimination or the reduction of this routine sedation will do much to prevent it. Since this impression has become generally recognized through many press releases it need not be stressed.

In view of the great interest in the subject of asphyxia neonatorum the need for research can scarcely be overemphasized. Research is urgently needed at this time to throw light upon the question of atelectasis, to produce suitable equipment for asphyxia neonatorum in the premature, to throw light upon the problem of intracranial hemorrhage, and to reduce the use of maternal sedation which acts to depress the baby.

## Summary

It is found that carbon dioxide with oxygen is in general use; that aspiration is regarded as essential to the treatment of the baby; that the use

* See "Resuscitation of the Stopped Heart by Intracardial Therapy," by Albert S. Hyman, U. S. Naval Medical Bulletin, Vol. **33**, No. 2.

of heat is frequently overlooked but should always be applied to protect the baby from exposure.

Sharp differences of opinion exist regarding the use of alpha-lobelin and other drugs as respiratory stimulants.

Where intracranial hemorrhage is suspected, lumbar puncture is advocated and the use of whole blood injected into the buttocks of the baby is recommended.

Mouth-to-mouth insufflation is commonly employed as a method of artificial respiration where mechanical facilities are not available. The position of the baby after delivery is considered important. Intracardiac injections are used as a last resort, but are not popular. The use of blind intubation in accordance with the technique of de Lee is common practice in many clinics. The technique of direct laryngoscopy, intubation, suction and insufflation is not generally understood or applied where indicated. Prochownick's method of artificial respiration is referred to. Confusion exists as to the sequence in which intracranial hemorrhage occurs; it is claimed as both a cause of and a result of asphyxia. It is recommended that the baby who has shown signs of asphyxia be carefully observed after return to the nursery.

The important question of atelectasis is raised and the need of research indicated. There is a strong sentiment in favor of popularizing certain general information relative to asphyxia neonatorum to the profession and to the public, with special reference to the practice of frequent sedation administered to the mother. The danger of respiratory obstruction by the pressure of an inhalator mask on a baby's face is noted.

Experience with the use of mechanical methods, including the Drinker, E & J, Kreiselman and Flagg equipment, are referred to.

The solitary reference to euthenasia in obstetrics is noted for the purpose of condemning it.

Research on the problem of asphyxia neonatorum in the various universities in this country and in Canada is noted and found to be entirely inadequate for the problem confronted.

The work of Schulte and Davis in which pure $CO_2$ was used in cases of extreme asphyxia neonatorum as a means of successful resuscitation would seem to bear out Yandell Henderson's hypothesis of the existence of a non-acidotic acarbia, as opposed to a true acidotic acarbia in asphyxia of the new-born. It would seem that such treatment should certainly have resulted in the death of these babies had the use of $CO_2$ *per se* been as hazardous as proclaimed by those opposed to its use. Henderson's chapter, "The Fallacy of Asphyxial Acidosis" has been greeted by silence. Let us hope that this is the silence of assent. It is unfortunate that those who object to the use of $CO_2$ under certain specific conditions are being regarded as condemning its use in a wider field than they intend to condemn. Aspiration is gaining in popularity. The use of heat continues to be over-

looked. Intravenous drugs are losing their popularity.* Mouth-to-mouth insufflation continues to be recommended as an emergency measure; applied through an intubation tube it becomes effective and more useful.

As pointed out by Dr. Curtis J. Lund,† preoperative maternal oxygen therapy may serve to reduce asphyxia neonatorum at its source.‡ Lund emphasizes that "Just as the mother is evaluated as an obstetric risk, so should the fetus be considered from the standpoint of ASPHYXIAL RISK . . . . The diagnosis of fetal anoxia in utero by fetal heart arythmya and treatment by maternal oxygen administration should be kept in mind.§ Reference to Lund's original work will repay the reader.

Crotty‖, pleading for a wider adoption of intratrachael insufflation concludes that the keynote in the prevention of asphyxia neonatorum is greater caution in the use of drugs for the production of forgetfulness and the relief of pain.

The record form suggested on page 122, if put into practice in institutions interested in the prevention of asphyxial death, may be expected to yield statistics of real value to the art of resuscitation.

* "The treatment of experimental anoxia with certain respiratory and cardiac stimulants," N. J. Eastman and J. Kreiselman, *Surg., Gynec. and Obstet.*, **41,** 260 (Feb. 1941).

† *Am. J. Obstet. and Gynec.*, **43,** 365 (March, 1942).

‡ *Intra-uterine Asphyxia.* Oct. 12, 1943. Para I. Premedication. Nembutal gr. 6. Scopolamine gr. 1/150, between 7 and 9 A.M. Patient first seen by author under anaesthesia gas (oxygen, ether). Slightly anoxic. Moderate respiratory obstruction. Fetal heart 60. Fetal movements active. Free respiratory ventilation was instituted in the mother's anaesthesia. Pure oxygen with rebreathing was practiced, ether being continued. Fetal heart promptly increased in rate. In five minutes it was 100. Baby was delivered by forceps. Cord about neck, slightly cyanosed, mecomium escaping. Within one minute it began to cry lustily.

Comment. Free respiratory ventilation, plus oxygen and $CO_2$, plus reduced intra-uterine pressure from ether relaxation promply relieved a critical intrauterine asphyxia.

§ Ibid., **41,** No. 6 (June 1941).

‖ *Cincinnati J. Med.*, **23,** No. 388 (1942).

NOTE: Live birth following asphyxial death of mother. (Post-mortem Caesarian section.) Patient admitted to St. Vincent's Hospital Jan. 3, 1944, 2 A.M. Diag. Bronchopneumonia: laryngeal stridor, edema of glottis and aryepiglottic folds; cyanosis. Tracheotomy 6.00 P.M. Oxygen administration; condition deteriorated. Expired at 10.14 P.M. Caesarian section done, 35 weeks old, 5 lb. 10 oz. male baby delivered alive. Discharged in good condition 27 days later. (From service of Dr. John Francis McGrath, reported by V. W. Badia.)