RESUSCITATION OF THE NEWBORN*

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STATISTICS from the Department of Health for the City of Hamilton reveal the mortality rates for resident births for the year 1955 to be as follows:

	No	Per thousand live births
Stillbirths	89	14.9
Within 24 hr	82	13.8
Within 1 wk	106	17.8
Neonatal	114	19.6
Within 1 yr	146	24.0

Should all deaths within the first 24 hours be considered together, then the rate reaches 28.8/1000 live births or about 72 per cent of the mortality in the first year of life. Thus the greatest infant loss occurs at a time when the mother and especially the child have come under the influence of depressant sedative drugs, anaesthetic agents, and manipulative procedures. It cannot be disputed that a large percentage of this loss has to be attributed to immaturity, anomalies and malformations, Rh incompatibilities, disease of the mother incompatible with continued foetal life, these are inevitable. Neither can it be denied that many of these deaths result from errors in judgment or technique on the part of the obstetrician or the anaesthetist in regard to sedative or anaesthetic agents, the conduct of the delivery or the anaesthesia, and the inadequate resuscitation of the depressed or apnoeic newborn, these deaths are preventable. Modern medicine has appreciably reduced maternal and infant mortality but has succeeded in introducing newer aetiological factors in neonatal mortality.

To discuss properly all the factors responsible for this preventable foetal loss and to evaluate the prophylactic measures necessary to reduce it would require much more time than is available at the present. In this paper discussion will be limited to an outline of the principles of proper and adequate resuscitation of the newborn who is experiencing difficulty in initiating or maintaining respiratory function essential for continued life. To do so, it is necessary to review foetal circulation and respiration as it pertains to this discussion.

Many investigators have attempted to ascertain whether the human foetus carries on respiratory movements *in utero*. The studies have been on animals which, many believe, are analogous to the human foetus in regard to such a primitive and essential system. Barcroft (2) has shown that, in the sheep, the foetus responds with respiration-like movements to sensory stimulation early in development and later to chemical stimulation produced by clamping the umbilical cord. This response is not normally elicited during the gestational period, but readies the foetus for the onset of respirations at birth. It is assumed

*Presented at a joint meeting of Ontario Division, Canadian Anaesthetists' Society and the Sections of Anaesthesia and General Practice of the Ontario Medical Association at Kingston, Ontario, October 20, 1956.

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that in the human foetal respiratory movements do occur, as amniotic fluid has been found in the lung of the newborn and, also, radio-opaque dye has been seen in the lung following its introduction into the amniotic sac prior to birth. These observations are not universally accepted, as a smaller percentage of full-term newborns show positive results; some investigators maintain that the normal environment has been disturbed or that the amniotic fluid may have been aspirated during the birth process. It may be that the respiratory movements are a response to either sensory or chemical stimulation of the foetus by the investigators, similar to that shown by Barcroft in the sheep.

Clinical observations of the onset of respirations in the newborn show that the responses to stimulation approach in sequence those observed in the animal. That is, the normal newborn who has not been unduly depressed by drugs, and who has been delivered without the use of excessive inhalation anaesthesia, invariably will cry while being delivered from the birth canal or shortly thereafter without stimulation from the obstetrician. In other newborns, some mild form of sensory stimulation will often suffice to initiate respiration. This corresponds to the early response of the sheep to sensory stimuli as observed by Barcroft. The breathing has a definite inspiratory and expiratory phase. It is the desirable onset of respiration.

The newborn who has been depressed by drugs, excessive anaesthesia, or trauma of birth does not cry readily nor does he respond to sensory stimuli. This infant depends upon chemical stimulation for the initial gasp. His gasp is an inspiratory effort which, if repeated, may be sufficient to enrich the alveolar air and the circulation with oxygen. The increased oxygen supply to the higher centres will aid in their recovery and the establishment of the normal respiratory movements. Should this gasp not occur because of prolonged depression, the newborn does not achieve the resuscitation of the vital centres, the impulses are reduced, and the infant will succumb to anoxia. This infant could be salvaged by prompt and adequate resuscitative measures.

These depressed newborns can be salvaged because they are capable of withstanding severe degrees of hypoxia which would be lethal to the adult. This is brought about by increased utilization of the available oxygen; the anaerobic phase is more pronounced the more immature the foetus, but is lost soon after birth. Thus the premature infant withstands hypoxia better than the full term, the full term better than the newborn of a few days who is rapidly losing this ability as he assumes the adult dependency on oxygen.

The physical state of the lungs prior to birth is that of a soggy, more or less collapsed structure whose alveoli contain fluid. This state is shown by placing them in water as a test of original expansion. The lungs lie within a slightly collapsed and atonic thorax with its walls hollowed inwardly and the diaphragm pulled high into the chest. Inflation of the lungs comes about by the initial inspiratory force of the expanding thorax and descending diaphragm which, by creating a negative intrapleural pressure, will fill the alveoli with air provided there is no obstruction between the alveoli and the atmospheric air. The distension of the unobstructed lung is opposed by the cohesive force of the moist surfaces of the alveoli and the elasticity of the lung tissue. The sum of these

forces approaches 20 to 30 cm. of water, the distension has been found to be the greater of the two forces, as a pressure of 3 to 9 cm. of water is sufficient to keep the lung inflated once it is expanded. It becomes necessary, therefore, to produce an equivalent pressure to expand the collapsed lung parenchyma of the depressed newborn who cannot initiate the inspiratory effort to produce this pressure. This need must be borne in mind for the proper understanding of the variations in pressures required for the resuscitation of the depressed newborn. Most full-term infants are capable of exerting a negative or positive pressure of 40 to 50 cm. of water. This pressure cannot be repeated by successive respirations as the newborn easily becomes enfeebled under clinical conditions imposing similar difficulties.

Complete aeration does not occur immediately when the child begins normal respiration. It may be several days or weeks before all the alveoli have become filled with air. Thus it cannot be definitely proven by radiological means whether patches of atelectasis are physiological or pathological. The distinction must be made on clinical evidence of other signs and symptoms.

As the foetus is dependent upon the mother for its oxygen and nutrition, there are certain circulatory variations. When a circulation of independent function is achieved, nature quickly obliterates these now unnecessary circulatory by-passes.

The normal foetal haemoglobin content is 17 gm. It is a mixture of a foetal and an adult type. The foetal haemoglobin is present in a percentage which is decreasing as full term approaches, and has disappeared about the 120th day of extra-uterine existence. In the premature infant it persists for a longer period.

The foetal haemoglobin as found in blood has an oxygen dissociation curve which lies to the left of that of the mother at the same pH. This permits greater saturation for the same oxygen tension. As the curve rises steeply at the beginning, the haemoglobin gives up a greater percentage of its oxygen under small variations in oxygen tension. This faculty is an important asset in a rapidly developing foetus whose oxygen tension is of necessity low as a result of the decreasing oxygen tension as it passed from the maternal circulation through the placenta to the umbilical vein, where oxygen tension is 40 mm. Hg. The oxygen saturation of arterial blood is 50–55 per cent and of the venous 20 per cent. There must be more than 5 gm. of reduced haemoglobin present, so the foetus lives in a state of constant cyanosis. In this state it is born, as is evident at Caesarean section.

The poor oxygenation of the blood may have a part in the rapid cardiac rate which is present up to birth. The rate is influenced *in utero* by hypoxia produced by uterine contractions and also by tight loops of cord. Following birth this rate is reduced by 20–30 beats. Under normal conditions the cardiac rate of the newborn may drop below 100 or rise to 180 for short periods.

The carbon dioxide tension in the foetal blood is normally 32 mm. Hg. In the hypoxic state this may increase more than twofold. At the same time the lactic acid content will rise to 85 to 90 mg. per cent from a normal of 35 mg. per cent. The pH will fall to 7.05 from the usual 7.35. In severe asphyxia it has fallen below 7.00, a level which proves fatal to the newborn.

In the resuscitation of the newborn it is important to initiate the measures within as short a time as possible. The method of evaluation proposed by Apgar (5) is excellent, but it should be used in resuscitation only in the role for which it was designed, as a means of assessment for comparison.

The prime consideration in the resuscitation of the newborn is to get sufficient oxygen into the circulation and to the vital centres before irreparable neurological degenerative change dooms the newborn to a life of varying degrees of mental deficiency, or to death.

The trachea, stomach, or skin may absorb some oxygen, but the respiratory alveoli are still the main organ for oxygen transfer from the air to the bloodstream. The patency of the conductive passage must be assured before air can reach the alveoli. This, then, is the first consideration. The pharynx is cleared by gentle suctioning. The vigorous to-and-fro and side-to-side pharyngeal stimulation with the suction catheter accomplishes nothing. The catheter is better introduced into the pharynx and the suction applied prior to and as it is being withdrawn. In a flaccid infant, aspiration of gastric contents will safeguard against their aspiration into the trachea while oxygen is given under pressure. This is important where the infant is placed in a 15° to 30° Trendelenburg position, as is advised for added drainage of the trachea. The tongue should be elevated with a small pharyngeal airway. Where it is necessary in the flaccid infant, a pliable endotracheal tube of proper size should be inserted under direct vision by the laryngoscope with the premature blade.

Certain types of external stimulation should be mentioned only to be condemned as useless and harmful. The practice of acutely flexing the thighs upon the abdomen pushes the abdominal contents and the diaphragm into the chest, thereby expelling any air which may have expanded some of the alveoli, and returning the lung to the unexpanded state. To re-expand this lung requires a greater intrapulmonary pressure. How many doctors would treat the apnoeic adult patient with splashes of ether, dunking into hot and cold water, giant swings in large circles, sudden tossing into the air and lowering to the floor, pounding of the buttocks, loin or back, digital dilatation of the rectal sphincter, or reducing the chest to half of its anterior-posterior diameter? Why, then, subject the newborn to these methods? If the newborn is still capable of appreciating sensory stimuli, as shown by Barcroft, then gently massaging the back of the upturned infant will suffice to initiate respirations or even an inspiratory effort which may be repeated to elevate the oxygen tension in the blood and aid in recovery of the higher centres and re-establishment of normal respirations. If this manoeuvre does not achieve the desired response within a reasonable time, artificial respiration is the only solution.

The use of carbon dioxide as a stimulus has been shown to be of no avail in establishing respirations in an asphyxiated infant. Thus, there are dangers in the practice of increasing the maternal carbon dioxide tension by exclusion of the soda lime in the hope of establishing respirations in the infant by hypercapnia. Instead his existence is jeopardized by the lowering of the pH which will be further lowered by asphyxia. Survival may become an impossibility.

Should the cardiac rate slow down, then all other methods should be abandoned in favour of artificial respiration with an oxygen-rich atmosphere. Often a few inhalations will give a better response to gentle sensory stimulation. Again, the recovery of the higher centres by oxygen permits establishment of respirations.

In the newborn who remains apnoeic without any attempt on its own to initiate respirations, it becomes mandatory that artificial respiration be used in order to expand the atelectatic lung. Every known method of artificial respiration has been tried, including all the various mechanical means of creating positive or negative pressure or a combination of the two. There has been no infallible method of carrying out this procedure without disadvantages.

All of the mechanical resuscitators have been in use at some time. Some have been discarded as useless and even dangerous. Perhaps there are still some being used which belong in the same category. There are models with which anaesthetists and obstetricians have become proficient and are obtaining excellent results in resuscitating the asphyxiated newborn. The individuals have adjusted their technique to compensate for some of the shortcomings. To the novice it is suggested that he master the use of one of the simpler machines which will produce the required ranges of pressure that have been shown to apply in the proper and safe method of expanding the atelectatic lung. A machine which is set by the manufacturers at a definite and unchangeable pressure may not serve the purpose for every case that requires resuscitation.

Goddard (7) has shown by experimental studies on the lung of the newborn that patchy aeration occurs with a positive pressure of 30 cm. of water applied for a 0.2 second interval. Uniform expansion is achieved with a pressure of 50 cm. of water for the same time. The application of a low or high pressure for a prolonged time will damage alveolar membranes. From these pressure studies and others of tidal volume, minute volume, respiratory rate, and pattern of breathing evolved the GBL Infant Hand Resuscitator.

Another more recent model has been designed by Mann of Toronto (6). This model is very simple in its construction. The positive and negative pressures are set at 12 and 8 mm. Hg. The apparatus also includes a hand-operated suction, specially designed metal endotracheal tubes, laryngoscope, face mask, and rubber tubing. It is a complete outfit in itself.

Older resuscitators which are in use include the Ericson and Johnson with a positive and negative pressure of 13 and 9 mm. Hg, the Kreiselman with a positive pressure of up to 16 mm. Hg, and the Drinker, adapted in size for the infant, with a negative pressure of 10 cm. of water.

Little (4) states that, "It is an enigma that the mechanical resuscitators for use in the treatment of asphyxia neonatorum provide pressures that are far lower than those estimated to be required to overcome the resistance of the lungs of the apnoeic newborn, and yet those same pressures may produce pulmonary damage in such lungs." This explains the controversy regarding mechanical respirators.

The simplest and most constantly available means of artificially producing a variable positive and negative pressure is the respiratory mechanism of the

anaesthetist or obstetrician Mouth-to-mouth breathing may be replaced by mouth-to-mask and by mouth-to-tube if an endotracheal tube is necessary. In the adult the 150 cc. of dead space or unvitiated air is more than sufficient for the infant's tidal volume of 20 to 24 cc and equal to its vital capacity. The oxygen content of this mass of air can be increased by the inhalation of oxygen prior to inflation of the infant's lungs By this method a proper estimate can be made of the lung resistance and the pressures may be created accordingly. It is rather difficult to produce a pressure exceeding 40 to 50 mm. Hg

The apnoeic newborn has been subjected to the action of analeptics in an effort to initiate or maintain respirations Picrotoxin, coramine, metrazol, strychnine, lobeline, and caffeine have been used These drugs take effect not by acting on the respiratory centre itself, but by creating a generalized cerebral stimulation or by acting reflexly through the carotid body. The range of dosage for effective results in the not too depressed infant is small Over-dosage will readily produce convulsions which would be fatal. The disadvantages would appear to contraindicate the routine use of such drugs in resuscitation

When it can be shown that depression is the result of the use of large doses of one of the narcotics, the injection of N-allylnormorphine (Nalliner) in a dose of 10 mg intravenously to the mother prior to commencement of the second stage of labour or by the umbilical vein of the newborn in a smaller dose will assist greatly in the re-establishment of adequate respiratory movements

It is not definitely accepted now that warmth is a necessity in resuscitative measures Experiments with animals show that a reduction in body temperatures increases the survival rate of the anoxic newborn

SUMMARY

Statistics still show that there has not been too great a reduction in the neonatal mortality from aetiological factors of a preventable nature

Foetal development readies the foetus for an extra-uterine existence by means of a central nervous system which is sensitive to sensory and later to chemical stimulation, a circulatory system with haemoglobin which provides oxygen under low pressures, a respiratory system which can quickly be expanded with air, and an inherent ability to survive under severe degrees of hypoxia Modern analgesia and anaesthesia along with operative obstetrics have depressed this normal change-over to the detriment of the newborn

Resuscitation of the asphyxiated newborn requires sound judgment and moderate skill during the most dangerous minutes of the infant's existence. The application of these necessitates a patent and clear airway, rational use of physical stimulation, administration of an oxygen-rich atmosphere by artificial respiration if indicated, and the avoidance of drugs or treatments which would, in any way, jeopardize the chance of survival

Only by constant attention to the mother and the newborn, proper selection of analgesia and anaesthesia accompanied by sound and safe obstetrical practices, can the neonatal mortality rate be reduced to the minimum in keeping with the achievements of modern medicine

RÉSUMÉ

Les statistiques du service de santé de la ville de Hamilton révèlent que, pour l'année 1955, les morts en-deçà de 24 heures représentent 72 pour cent de la mortalité au cours de la première année de la vie. Ainsi c'est au moment où la mère et l'enfant sont soumis à l'influence dépressive des sédatifs, des agents anesthésiques et des manœuvres d'accouchement que survient le plus grand nombre de pertes de vie chez l'enfant. Un grand nombre de ces pertes de vie sont attribuables à des naissances avant terme, à des anomalies fœtales et à des maladies de la mère, mais il est indéniable que plusieurs morts sont le résultat d'erreurs de jugement ou d'erreurs de technique soit de la part de l'obstétricien, soit de la part de l'anesthésiste ou encore le résultat d'une resuscitation inadéquate chez un nouveau-né déprimé ou en apnée.

Le nouveau-né qui a été déprimé par des médicaments, par une anesthésie profonde ou par le traumatisme de l'accouchement ne crie pas spontanément et ne répond pas aux stimulants sensoriels, mais il doit compter sur la stimulation chimique pour prendre sa première bouffée d'air. Il s'agit d'un effort respiratoire pour augmenter l'apport d'oxygène aux centres respiratoires aidant à leur éveil et à l'établissement de mouvements respiratoires normaux. Puis, si cela n'arrive pas, il faut recourir à des mesures appropriées de resuscitation sans lesquelles l'enfant succomberait par anoxie. Ces nouveau-nés déprimés survivent grâce au fait qu'ils peuvent subir une hypoxie prononcée qui serait mortelle pour un adulte.

La resuscitation du nouveau-né en asphyxie exige du jugement et de la dextérité. En cette occurrence, il faut, d'abord, obtenir des voies respiratoires libres, employer une stimulation physique appropriée, faire respirer une atmosphère riche en oxygène, même artificiellement s'il y a lieu, et éviter l'usage de médicaments ou de traitements qui pourraient compromettre la survie.

Chez l'enfant asphyxié, l'usage du gaz carbonique comme stimulant respiratoire s'est avéré inefficace pour partir la respiration. Le fait d'augmenter la pression CO_2 dans le sang maternel, dans le but d'aider le départ de la respiration de l'enfant en stimulant son centre respiratoire, met en péril la vie de l'enfant en abaissant son pH sanguin qui va continuer à s'abaisser par le manque d'oxygène.

Si le rythme cardiaque ralentit, toutes les autres méthodes doivent être mises de côté et il faut recourir à la respiration artificielle avec une atmosphère riche en oxygène. Quand le nouveau-né ne fait aucune tentative de respirer, il faut, à tout prix, recourir à la ventilation artificielle. On peut faire cette ventilation par la méthode du bouche à bouche, du bouche à tube ou encore en employant un des nombreux ventilateurs mécaniques sur le marché.

Une dépression respiratoire chez l'enfant à la suite de trop fortes doses de narcotiques peut être combattue en injectant de la N-allylnormorphine (Nalline®) à la dose de 10 mgm. par voie intraveineuse et, cela, à la mère, avant le début du deuxième stage du travail ou, encore, on peut l'administrer à l'enfant dans la veine ombilicale, à dose plus petite.

C'est seulement en portant une attention constante à la mère et à l'enfant qu'on peut faire un choix judicieux de l'analgésie et de l'anesthésie, qu'on peut pratiquer l'obstétrique avec sécurité et qu'on peut réduire au minimum la mortalité néonatale selon les standards de la médecine moderne.

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