PULMONARY VENTILATION IN INFANTS AND CHILDREN *

H. M. SLATER, M. D.
Director, Department of Anaesthesia, Children's Memorial Hospital.
Assistant Professor, Department of Anaesthesia, McGill University.
Montreal, Canada.
and
R. H. FERGUSON, M. D.
Assistant Director

Why is paediatric anaesthesia frought with difficulties and dangers ? Why does the average anaesthesiologist usually shy away from anything other than a minor procedure in children ? Why is there a mental block created at the mention of infant anaesthesia ? Why ? The answers are simple. The average anaesthesiologist may not be aware of the differences between the child and the adult either anatomically, physiologically or bio-chemically. He may be obsessed with the idea that adult techniques are directly applicable to children without regard to actual margin of safety of the drugs and equipment employed. Or perhaps someplace in his training, paediatric anaesthesia was not stressed sufficiently to acquaint him with the details which are paramount in the management of children either before, during or after surgical interventions. Now, pulmonary ventilation is one of these major details which forms an intrical part of any anaesthetic procedure, be it long or short, major or minor. The term ventilation in anaesthesia automatically brings to one's mind the terms, rebreathing bag, absorption, cyanosis, carbon dioxide, lack of oxygen, airways, etc. In other words, pulmonary ventilation implies the understanding of the existing anatomical and physiological circumstances to which are applied the knowledge of pharmacology and anaesthesiology.

---

* Presented before the Second Latin-American Congress of Anaesthesiology, São Paulo, Brazil, September 1954.

Anatomy

One is reminded that an infant or child is not a true miniature of the adult anatomy. Although everything appears to be smaller it is the relative proportions which vary. Because of the small size of the lungs, heart, abdominal organs, immaturely developed nervous systems, we cannot assume that techniques of anaesthesia applicable to adults, are also applicable to infants and children on a smaller scale.

Anatomically, pulmonary ventilation includes the breathing apparatus beginning at the tip of the nose and lips and ending in the alveolar sacs. Any part of the system may have abnormalities which can affect the course of anaesthesia in the matter of proper ventilation on the part of the machines and patients. In most cases, the infant's nasal passageway and also that of the small child is sufficiently large to admit tubes of the same calibre as would be admitted orally. The infant's tongue in relation to that of the adult is much larger and occupies a greater space within the oral cavity. This is due to the fact that the infant must have a strong sucking action shortly after birth for feeding purposes. Farther down in the pharynx is the epiglottis which not infrequently can interfere with graceful intubation due to its close proximity to the larynx. Intubation under very light or no anaesthesia then becomes a matter of skill. The adult's epiglottis is actually some distance from the larynx, and therefore on laryngoscopy in the older age groupe it is easily lifted of view, whereas in the infant it is much easier to use the laryngoscope MacIntosh-fashion and displace the tiny structure without displacing the larynx. The outstanding difference between the child's or infant's larynx as compared to that of the adult is that is is located more superiorly and anteriorly. Hence, once again upon attempting to intubate it is advisable to have the head slightly hyperextended on a pillow for better vision of the larynx. This prevents unnecessary prying and injury to gums and teeth. Just beyond the vocal cords is the short trachea which tapers to branch off to the two bronchi and so on. The tracheo-broncheal mucosa is extremely sensitive to any undue trauma and is more likely to swell causing blockage to the airway.

The lungs themselves are essentially no different than those of the adult except in size and the ease with which alveolar rupture can occur. The mechanisms which activate the lungs in the thoracic cage are less well developed. The thoracic cage, consisting of the delicate ribs which are not fixed to the spine posteriorly and the sternum anteriorly offers no real resistance to interfering external forces. Due to the great flexibility of the ribs, very often we mistakenly believe that the infant's chest does not move very much during respiration. Much of this movement is in all directions rather than just anteriorly and therefore seems to be small as com-

pared to abdominal respiration. As the child grows, the thoracic cage becomes more fixed so that the adult type of thoracic breathing becomes more apparent. The young infant's thoracic musculature is indeed very weak an does not have the driving forces as do the muscles of the developed chest. This is probably the reason for the many instances of atelectasis in this age group. The child does not have the extra force to expand the chest and the lungs in the presence of adverse conditions. It is true that the greatest ventilation in babies is created by the abdominal action on the diaphragm and any interferences to this seriously effect the breathing.

Before leaving the anatomical discussion, one should not fail to mention the adenoid and tonsiller tissues. When enlarged, these tissues create difficulties in the maintenance of patent airways. Large adenoids are easily traumatized during nasal intubation and predisposing to haemmorrhage.

Anatomical abnormalities affecting ventilation

To add confusion to normal difficulties in anaesthesia of infants and children, there are anatomical and pathological situations which complicate the pulmonary ventilation in the patient under anaesthesia. These complications can be due to deformities of the spinal column, thoracic cage, as for exemple in the instance of pectus excavatum or fused spine due to old tuberculous lesions affecting proper thoracic movement. These patients often require extra assistance by the anaesthetist in order to prevent the hypoxia which may occur during long operations because of the decreased respiratory excursion on the part of the patient. One must also take into consideration any afflictions of the lung tissue itself such as abscesses, tuberculosis, bronchiectasis, emphysema, pneumonia and atelectasis. These serve to reduce the aerating surface and again increase the possibility of hypoxia. In children the aerating area is small as compared to that of an adult and any reduction of this renders the child incapable of extra respiratory efforts for long periods .

There are also extra thoracic conditions which can affect ventilation. Probably one of the most frequent difficulties is that of the ingestion of gases into the stomach particularly following accidents . The dilated stomach presses against the diaphragm and interfere with its regular movement thereby producing a gasp-like breathing. The judicious use of a stomach tube will relieve the condition and permit an uneventful maintenance of anaesthesia. Any abdominal pathology, such as peritonitis, acute appendicitis, enlarged spleen of liver, also to interfere with the normal breathing pattern.

One is constantly reminded of the possibilities of the presence of congenital anomalies occurring in lips, palates, chins, larynx,

hearts and lungs which can interfere with proper ventilation. The careful application of technique, drugs, positioning, etc., will preclude any possibility to interference of the patient's aeration.

Physiology

As we observe the breathing in infants we note that the respiratory rate is much greater than that of the adults. Oft times it reaches the rate of 60-80 per minute. This is due to the proportional size of lungs as compared to that of the body. The average is in the neighborhood of 40 breaths per minute, and during quiet respiration under anaesthesia it can be lowered to 30 per minute. In order to consume enough oxygen in a given time, the tiny lungs must be activated at a greater rate in order to have a better exchange through the alveolar walls. In other words the minute volume of respiration in infants on the basis of their surface areas comes close to that of the adult but the rate of breathing must be greater, a penalty due to the decreased volume of lung in the baby. The respiratory rate is not lowered soon after birth but is gradually reduced from infancy to childhood. On the average, the minute volume and the respiratory rate of the newborn infant are three times that of the average adult, by weight.

Alterations in the regular rhythm appear quite often in the breathing patterns of newborn children and young infants. This should not cause any undue apprehension to the anaesthesiologist, providing he is fully cognizant of the possibilities and treats them accordingly. Firstly, there is the *gasping type* of breathing in which the inspiratory phases are short, followed by slight pauses. Next, there is the type characterized by long expiratory pauses or *periodic breathing*. These are particularly worrisome in the premature age groups when anything can happen to the child during a pause of respiration. Frequently, the *sobbing type* is noted in the toddler age group. In most cases it is brought on by emotional disturbances preoperatively, and persists throughout induction and maintenance of anaesthesia. It is annoying to say the least, but not detrimental to the patient's well-being. The *cog-wheel type* of respiration is observed less frequently. Here the expiration is prolonged and even slightly jerky and then is followed by a pause. In addition to the types mentioned, one should also be mindful of the rapid *shallow panting* respiration or to the *breath holding* which appears so often during inductions, particularly stormy ones. Where there is irregularity of pattern it then becomes necessary for the anaesthetist to use all his tricks to interpolate respirations and to assure proper ventilation from minute to minute. Recently it has been shown that the premature child with the irregular breathing can be exposed to high atmospheres of oxygen, resulting in a regular rhythm and increase in minute volume. One should not assume

that so long as there is the presence of irregular patterns, there is also a coexisting state of hypoxia in the child. With a strong cardiovascular system the colour will remain good and there will be no evidence of anoxemia. However, one should not preclude the possibility of difficulties occurring during the frequent irregular pauses and should make every effort to assure the patient sufficient supplies of oxygen or mechanical means for artificial respiration.

Although infants can withstand periods of hypoxia we are quite aware that any surgical intervention superimposed in the face of such circumstances would add greatly to the risk of the patient. These children become candidates for acidosis due to increased carbon dioxide in the blood and in the tissues. Because of the associated heat accumulation there is an increased metabolism, a factor which a child will not tolerate for long. His reaction to this will be one of surrender. Such a state can be prevented by the proper assistance to his basic needs and by the employment of proper anaesthetic equipment and management. The dead space in an average adult is in the neighborhood of 150 cc. and that in a newborn infant about 8 cc. Therefore it is obvious that any equipment utilized for maintaining anaesthesia should have a minimum of dead space in order to prohibit carbon dioxide accumulation. An adult is better equipped to move gases in any breathing system, whereas it is not so with a baby. The infant soon tires, perspires, has tachypnoea and tachycardia and finally quits.

The matter of how much carbon dioxide a child or infant can withstand over a period of time is still questionable. We do know that during his periods of apnoea the newborn infant must build up higher levels of carbon dioxide than would normally occur in the adult, and after these seemingly long periods of hypoxia the child can be ressuscitated and appears normal with no ill after-effects. However, from an anaesthesiologist's point of view, excess carbon dioxide seems to be a liability rather than an asset. There are those who feel that small amounts of carbon dioxide are not harmful and act as stimulants to latent breathers. While, on the other hand there is a group which feels that additional carbon dioxide is harmful. We know that in the young age group they are always on the brink of acidosis and therefore adding gaseous carbon dioxide allowing it to build up metabolically will create a non-physiologic status. Permitting carbon dioxide to accumulate in any breathing system leads to a patient with a very rapid laboured breathing, a high pulse and blood pressure, resulting in fatigue and collapse. From clinical observations one would then assume that carbon dioxide is of no use to the tiny patient. On the other hand, one should not make extreme efforts at washing out the last bit of carbon dioxide in the patient's system. As a matter of fact this is impossible. There is always a certain amount which is in the tissues due to metabolic processes. The addition of carbon

dioxide in oxygen mixtures for the purpose of stimulating breathing in depressed patients seems to be an erroneous technique. Depressed patients already have higher levels of carbon dioxide so that any extra carbon dioxide serves only as a further depressant after initial stimulation. As a matter of fact, there is a level reached where any excess carbon dioxide has no effect on the patient whatsoever. In these cases, 100 % oxygen is all that is needed.

Experimentally it has been shown that infants will withstand fairly high interpulmonary pressures. Contrary to the popular belief a child can withstand a pressure up to 60 cm. of water, if such pressures are given intermittently in short sharp administrations, but this is not advocated since there is the great possibility of abuse in inexperienced hands. It has been shown recently that at the time of birth, the pulmonary pressures during the first gasps are in the order of 40-60 cm. of water. Therefore to expand an atelectatic lung at birth or at a later period requires far more than just 8-10 cm. of water as is permitted by certain resuscitator machines. At the Children's Memorial Hospital, in cases of repair of diaphragmatic hernia where the chest is opened, we have noted that the congenitally collapsed lung required pressures upwards of 30 cm. of water in order to expand it to normally. This expansion of the lung, under direct vision, should be carried out in a definite fashion. Enough pressure is applied so that the lung expands gently and without sudden force. When full expansion is accomplished, the pressures then should be returned to zero. From that time on, short sharp applications of pressure, returning in between to zero, should be maintained to keep the lung expanded and healthy. If positive pressure is maintained over prolonged periods there is then a direct effect to the right side of the heart with a resulting lowered blood pressure and a blanching of the patient's skin. The average useful intermittent interpulmonary pressure during anaesthesia is in the neighborhood of 8-12 cm. of water for the infants, and 12-20 for the older children. During long operations, premature infants tolerate pressures of 6-8 cm. of water without difficulty so long as there is no residual positive pressure between compressions of the rebreathing bag.

Anaesthesia and pulmonary ventilation

Proper pulmonary ventilation is the essence of good anaesthesia management. This axiom serves to help prevent catastrophes to patients in the operating room. A close watch of the breathing tells us the depth of anaesthesia. It warns us of any evidence of obstruction. It tells us very quickly that the patient is alive. The strict attention to detail in the choice of equipment, drugs, positioning and general management, serve to assure children of all ages a successful outcome after any surgical procedure.

AGENTS — Some agents such as those of the ether groups enhance pulmonary ventilation by virtue of their irritating effects on the pulmonary system. This is true of the lighter planes but as deeper planes of anaesthesia are reached, there is a depression and of course a hypo ventilation. However, during induction ether frequently causes breath holding, cyanosis and possibly convulsions from increased carbon dioxide. Cyclopropane on the other hand, offers an extremely smooth induction, quiet breathing, and a rapid transit into the deeper planes of anaesthesia without excessive effort on the part of the patient. The difference between these two commonly used anaesthetics is that the margin of safety is far greater with with the ether than it is with the cyclopropane. In paediatric anaesthesia, the danger of breath holding is overcome by using rapidly acting agents, such as divinyl ether or pentothal followed by a balanced anaesthesia. The greatest majority of surgical procedures can be carried out in the light planes any place from planes one to lower two, during which time the patient is able to maintain a respectable blood pressure, pulse and respiratory activity. As long as the child breathes actively himself, there is less chance for hypoxia or hypercarbia to occur. His own efforts will draw in the fresh gases containing at least 20 % oxygen and at the same time, he will be able to eliminate much of the Waste carbon dioxide. Rectally administered anaesthetics are prone to cause hypoventilation unless precautionary measures are instituted.

Sodium pentothal has already caused much grief through careless management, and should be treated with the greatest of respect. With the advent of curare and curare-like agents combined with barbiturates or inhalation anaesthetics, the danger to respiration has been increased manifold. In spite of the dangerous possibilities, the drugs can be administered safely and usefully as long as proper ventilation is maintained, either by the patient or by artificial means.

PREMEDICATION — Narcotic premedicants and barbiturates may depress a patient preoperatively and influence the subsequent conduct of anaesthesia to a great extent. As a rule, babies up to 4 months of age are not premedicated with morphine because it causes a prolongation of induction time. The respiratory centre is depressed and the anaesthetic agent is not absorbed in sufficient concentrations from the alveoli. Even if the plane of surgical anaesthesia is reached it is nearly always necessary to assist the breathing because of the inadequate efforts on the part of the baby. Post operatively, there may be enough depression to cause concern until such time that the premedication and anaesthetics have worn off sufficiently. We have found that scopolamine or atropine alone are adequate for these children. Beyond four months of age, a combination of barbiturates, morphine and scopolamine, preopera-

tively, in the dosage as prescribed by Dr. Digby Leigh, have aided us in reducing emotional upsets and in providing for smooth inductions without undue breath-holding and possibility of convulsions. Preoperative premedication enables one to use less anaesthetic, thereby shortening the recovery period . Once again this contributes to better pulmonary ventilation during the operation as well as post-operatively.

AIRWAY — The maintenance of an airway is fundamental. Here one should consider the advisability of endotracheal anaesthesia as opposed to other methods. The endotracheal method offers one some assurance in the feasability of being able to control the patient's breathing at all times. The advantages far outweigh the disadvantages. In our hospital, approximately 65 % of the inhalation anaesthetics are administered endotracheally. Any obstruction to the airway is manifested by the indrawing suprasternally and also by the accentuation of Harrison's Sulcus; that is, a flaring of the lower ribs . No child can withstand this for any long period of time even in the mildest form, much less an infant. As was mentioned before the infant will react to this situation by refusing to breathe any more; he just gives up from fatigue.

Needless to say, the best airway is the endotracheal tube which reduces the dead space in the breathing system and allows better control over the patient's breathing. It also offers a route by which one is able to aspirate the chest, and provides for clean, healthy lungs post-operatively. It prevents or reduces the possibility of aspiration of foreign material into the lungs. Though an endotracheal tube be in place, do not rest assured that there is bound to be a patent airway at all times. Because of the thin-walled tubes employed, due attention must be given to the position of the head, the fitting of connectors and the location of packs in the oropharynx which will avoid unnecessary kinking and obstructed airway.

EQUIPMENT — The careful choice of anaesthetic equipment aids in the elimination or at least in the reduction of dead space and resistance to which the child is exposed. Any resistance inherent in the machine as for exemple, springloaded valves, gravity activated directional valves, etc., demands that the baby increases his respiratory efforts and thereby brings on early fatigue. There is also the problem of dead space present in over-sized equipment applied to children. Very often as much as 25 times the infant's anatomical dead space is added by means of improper face masks and ether masks. This serves only to increase the carbon dioxide and bring on the possibility of respiratory acidosis and convulsions. Therefore, keep resistance and dead space to a minimum by selecting the proper sized face masks and attachments,

the proper lengths and diameters of endotracheal tubes with appropriate connectors, and wherever possible, apply assisted respiration.

Posture — Oft times difficulties in pulmonary ventilation arise from improper posturing on the operating table. The greatest excursions of the chest during breathing occur while lying in the supine position with the arms at the side of the body. If the arms are maintained extended over the head, there is then some interference with the thoracic movement. This is actually minimal as compared to the other factors which can be detrimental to respiratory effort. It is preferable, wherever possible, to have both chests moving and unhundered by pressure from the operating table, screens or trays. However there are times when it is necessary to posture the patient to facilitate surgery. Anything which can be done to shorten the overall time that the tiny patient is on the operating table should be considered. As for exemple, a semi-posterior approach to the tracheoesophageal fistula problem is better for the surgeon, although the infant is lying on one good lung, with the upper lung exposed through the open chest. Assisted or controlled respiration then becomes mandatory and can be carried on indefinitely. The same applies to all other operations in the lateral position, where the liberal use of assisted breathing assures proper expansion of both lungs. The clinical use of the oximeter demonstrates the presence of hypoxia states whenever a patient is in an unnatural position causing poor ventilation. Sometimes a compromise can be made with the surgeon by placing the patient in a semi-lateral position which allows the down-most side to expand more than it would otherwise. Orthopaedic operations of the spine and extremeties require that the patient be in a prone position. One fully realizes the difficulty in breathing here. The use of kidney shaped pads resting under the shoulders and iliac crests permits freedom of chest and abdominal movement. However, on occasion, we have noted that respiratory rates seem to rise well over the normal level without any apparent reason, and return to normal as soon as the patient is turned on his back. This is probably due to the encroachment of the aforementioned pads upon the sides of the chest and abdomen or the change in position of the endotracheal tube or airway as the patient was turned in the prone position. In these instances, one should not make the mistake of attempting to subdue the respiratory rate by undue deepening of anaesthesia and the liberal use of intravenous barbiturates and narcotics, because the patient may remain depressed long after being turned on his back. In the face of an elevated rate, one can assist the breathing at frequent intervals on condition that the operation is not prolonged. If the operation is long and the patient begins to show signs of fatigue as evidenced by perspiration, faster pulse and elevated blood pressure, consider then the advisability of dee-

pening the anaesthetic compatible with the surgery and the patient's overall condition. As a rule, in the majority of our cases in the prone position, we have not been unduly concerned with elevated respiratory rates as long as assisted respiration is maintained. These patients are usually in a light plane of anaesthesia and offer a quick recovery postoperatively. Any change in position of the table itself, such as extreme trendelenburg or kidney position interferes with the tidal exchange. Spontaneous atelectasis is a definite entity and does occur on the operating room table, particularly when prompted by poor positioning, unassisted respiration and the weight of a heavy tired surgeon's arm. As mentioned before, the smaller the child, the less is its resistance to external forces applied to the thorax and he simply refuses to breathe against great odds. Any undue flexion of the head can cause obstruction to airways. This is obviated by maintaining the head in a normal natural sniffing position in slight extension thereby straightening the airway.

SURGERY — Surgical intervention in itself does affect the pulmonary ventilation in patients. The smaller the patient the greater the effect. With the cooperation of a gentle operator, there is less likelihood for the occasion of undue reflex stimulation from mesentaries, bowel and peritoneum. It is not uncommon to see the tremendous differences in respiratory rates during a herniorrhaphy at the time of dissection of the peritoneal sac. Here, if the patient is an infant, there can be evidence of palor, fast pulse and exceedingly high shallow respirations. This should not be corrected by deeper anaesthesia, but rather by tactful advice to the surgeon, for no infant will tolerate this too long. Reflex stimulation also occurs during proctoscopy, circumcisions, cystoscopies and even incision and drainage of abscesses. These last mentioned are all characterized by the lightness of the anaesthetic administred where without the extra reflex stimulation, the respiratory rate would remain within normal limits.

High abdominal laparotomies for subphrenic abscesses, liver, stomach, and spleen operations is nearly always associated with some changes in the breathing pattern. Any irritation of the diaphragm could elicit uncontrollable hicupping. Various means have been tried to eliminate this nuisance. Of these, one can mention the use of relaxants, atropine, controlled breathing and deep anaesthesia. In all instance, the anaesthesiologist is and should be master of the situation, for at his fingertips is the rebreathing bag.

It is fundamental that the anaesthetist have the patient's chest exposed whenever possible, and in full view so that he may observe the breathing. At the same time he must not bury himself behind the anaesthetic screen, forgetting to note that a tired sur-

gical assistant might be leaning on the baby's abdomen or chest, or that the surgeons may have collected all their tools and placed them conveniently on the thorax or upper abdomen. It is enough to ask the infant and child to breathe through resistant machines without his having extra work in lifting these external objects.

The greatest upset to pulmonary ventilation occurs during intrathoracic surgery. Of necessity, one side of the thoracic cage is open and due to the increased extrapulmonary pressure, the lung collapses. During long operations, older children are capable of tolerating complete atelectasis of one lung and maintain good ventilation with the other. However, infants must use both lungs at best, to aerate the blood sufficiently so that any infringement of this invites complications. We have come to the conclusion that it is better, whenever possible, to maintain the affected lung partially open by continuous assistance. With a little persistance, the surgeon soon lerns how to pack off the lung and refrain it from interfering with his field of operation. Periodic expansion of the lungs (every 20-30 minutes) assures an elimination of carbon dioxide and prevents post-operative atelectasis which is due to the sticky secretions collecting within the pulmonary tree. The intermittent positive pressure applied to the lung should be sufficient to expand it reasonably well without interfering in the return flow to the right side of the heart. In infants this pressure is in the order of 10-12 cm. of water. Also, the pressure is applied sharply and released quickly to prevent accumulation of residual positive pressure. The rate for assisted or controlled breathing is governed by the patient's normal respiratory rate. In other words, if a baby breathes normally 40-60 times a minute, it should be the same under artificial conditions.

ANAESTHETIC TECHNIQUES — Any technique employed in paediatric Anaesthesia, should have ideally, (a) unobstructed airways, (b) minimal resistance to expiration and inspiration, (c) reduction of mechanical dead space, (d) facilities for immediate assistance or artificial respiration, and (e) adequate means for elimination of the exhaled carbon dioxide, either into the outside atmosphere directly, or by an absorbing mechanism.

The *open drop technique* is probably the oldest method in anaesthesia. It is still the safest in experienced hands, providing that it is carried out properly. It has the main disadvantage however, that carbon dioxide can accumulate under the mask and some means for its elimination becomes necessary. It can be done by raising the mask slightly from the face to allow air to circulate underneath, or by flowing oxygen underneath at the rate of 1-2 litres per minute. The other main disadvantage to open-drop method is that there is no means for active artificial respiration. One is dependent on a plane of anaesthesia, which is compatible with good

pulmonary ventilation, not too much depression due to heavy premedications and also upon unobstructed airways. Fortunately ether itself is a wonderful stimulant for pulmonary respiration.

In frequent use today is a *partial rebreathing technique*, sometimes called a *semi-closed* or *fractional method*. Our practice is to employ a bag and mask through which are passed the anaesthetic gases at high flows, assuring the patient at all times, a mixture containing no less than 25 % oxygen. The size of rebreathing bag and flow rates are dependent on the patient's tidal exchange and vital capacity. It is obvious that a 5-litre rebreathing bag is not only wasteful when applied to an infant, but also cumbersome and can cause an accumulation of carbon dioxide. The larger rebreathing bag is usually thick and heavy, creating a mechanical resistance to the child's exhalation efforts . This can be shown quite adequately by placing a pressure gauge in the breathing system and observing the results. We are now more inclined to utilize the light weight 2 ½ litre bags for most children, and the smaller lighter ½ litre and ¾ litre bags for the premature and infant group. One great advantage of the partial rebreathing technique is that no resistance is offered by valves, and that the sufficiently high flow of gases reasonably assure the adequate elimination of excess carbon dioxide. It might also be mentioned at this point that no time should the rebreathing bag be distended, else a positive pressure is built up in the breathing system. On the other hand, inadequate flows may result in a collapsing bag and inspiration against negative pressure.

Ever since the *closed absorption methods* have been employed in anaesthesia, many attempts have been made to use them consistently for paediatrics. Until recently these have not been satisfactory, for most adult circle absorption machines have resistant directional valves which are activated by gravity, springs or the patient's breath force, in addition to which there is the resistance of soda lime. The younger the child, the more difficult is it for him to move gases through systems. In the last few years, several workers have been thinking seriously about this problem. Some have placed the directional valves in close approximation to the child's mouth and nose in an attempt to reduce respiratory effort and prevent diffusion of gases; others have tried various styles and shapes of valves to reduce resistance, and still others have though along the lines of decreasing the transverse diameter of the conducting anaesthetic tubes. It seems that none of these have been very efficient. The latest effort is to assist the child in circulating the gases through any circle filtering machine. Ideally, a suck-and-blow method would be preferable whereby gases can be passed into the patient's lungs with assistance and withdrawn upon exhalation with a minimum effort. At the moment there are three or four types of absorption units, specially designed for paediatric anaesthesia. Firstly, the Adriani type which consists of two

absorption chambers for alternate use with light weight mushroom type directional valves. This unit is somewhat cumbersome but can be utilized in the administration of closed circuit anaesthetics for short periods of time with assisted or controlled respirations. Dr. Adriani has also devised a scheme for assistance in the to and fro technique. Secondly, there is the Digby Leigh infant circle filter in which the directional valves of rubber flaps are located immediately adjacent to the face mask in order to reduce the diffusion of gases in that area. The gases passe through a small absorption canister, a rebreathing bag, and finally back to the patient. There is less resistance in this system than in the previously mentioned one. It might be said at this point, that the circle filter offers a means for dissipating any body heat and certainly keeps the patient's temperature lower than the to and fro technique. In the last year, Foregger Company had specially designed for our hospital, a model of an infant to and fro absorber, with the O'Shaugnessy by-pass. All parts have been reduced in size to eliminate dead space and excess weight, which was inherent in the adult types of by-pass absorbers. Probably the only great advantage of the to and fro system is that it has no directional valves and the absorber is located quite close to the head of the patient. One must always be alert for evidence of spent soda lime as it increases the dead space in the breathing system. As mentioned before, this is overcome by frequent and regular changes of cooled cannisters. The most recent effort has been made by the Ohio Chemical Company, whose infant absorber has plastic valves which are resistant to moisture and distortion. They are light and rest on a circular knife edge so that there is nothing to hinder their action. Because of the valve disc's lightness, they offer minimal resistance to the baby's breathing. In the circuit is an absorption chamber, partitioned so that gases are passed up one side and down the other for more efficient carbon dioxide absorption. This chamber is easily changed during an operation without the loss of anaesthetic gases. An added feature is a gauge which will advise the anaesthetist of the presence of any increased positive or negative pressure in the system caused by either over-distended rebreathing bags or obstruction any place within the circuit. The face mask chimney piece is divided in an effort to further reduce the dead space. With careful thought towards heat retention, efficient carbon dioxide elimination, assisted or controlled breathing, these absorption units can be utilized successfully.

The preference at the Children's Memorial Hospital is the non-rebreathing non-resistant technique. This form of anaesthesia, first popularized by Dr. Digby Leigh, is the greatest contribution to paediatric anaesthesia. By this method, the smallest infant is capable of withstanding long surgery. It embodies sound physiological principles. Thin rubber valve discs are arranged in such

a fashion as to prevent carbon dioxide accumulation in the reservoir bag, and also enables the child to receive fresh gases with each breath. Assisted or controlled respirations are easily accomplished by compression of the rebreathing bag; the resistance to inhalation and exhalation is minimal, and the dead space within the apparatus is reduced so that it is less than that of the infant mouth and pharynx. It is common to see patients who have been breathing laboriously through circle filter machines, become a picture of quiet effortless breathing when the non-rebreathing technique is instituted . Excess body heat is blown off through the exhalation valve, thereby reducing the body metabolism and necessitating the administration of less anaesthetic agent.

Of interest too, in recent years, is the Carlen's technique for adult anaesthesia, related to thoracic surgery. Unfortunately this method is not applicable to children by virtue of the types and sizes of tubes designed. Dr. Leon Longtin in Montreal, has therefore incorporated the use of two endotracheal tubes, one for the affected lung and one which lies in the trachea. Each tube is cuffed and attached to separate gas machines. In this way, either of the lungs can be inflated independently with the assurance that contaminants are not transferred from one lung to the other. This method seems to have a good future because it does enable the anaesthetist to chose various sizes of tubes and hence can be applicable to the younger children.

Conclusion

Though we continuously strive towards complete knowledge of the fundamentals of physiology, biochemistry, pharmacology and anatomy; though the choice of anaesthetic agents and techniques is ever greater; though mechanical devices are constantly improving — all of these, are of no avail without strict attention to pulmonary ventilation in paediatric anaesthesia.

SEDORGA

A MELHOR COMPOSIÇÃO DE ANALGÉSICOS

AÇÃO TRÍPLICE

- sôbre o sistema nervoso central
- sôbre o sistema nervoso autônomo
- diretamente sôbre as fibras musculares em espasmo.

ATRAVÉS da metil melubrina
da novatropina
da papaverina
do cloridrato de difenil acetil-dietilamino etanol (nospasmina).

★

SEDORGA não deprime

SEDORGA não entorpece

SEDORGA não excita

★

SEDORGA ANTIESPASMÓDICO EFICIENTE
SEDORGA ANALGÉSICO PODEROSO

Apresentação: Gotas e Injetável

LABORTERAPICA S. A.
Santo Amaro - São Paulo

Para facilitar a intubação

Nupercainal

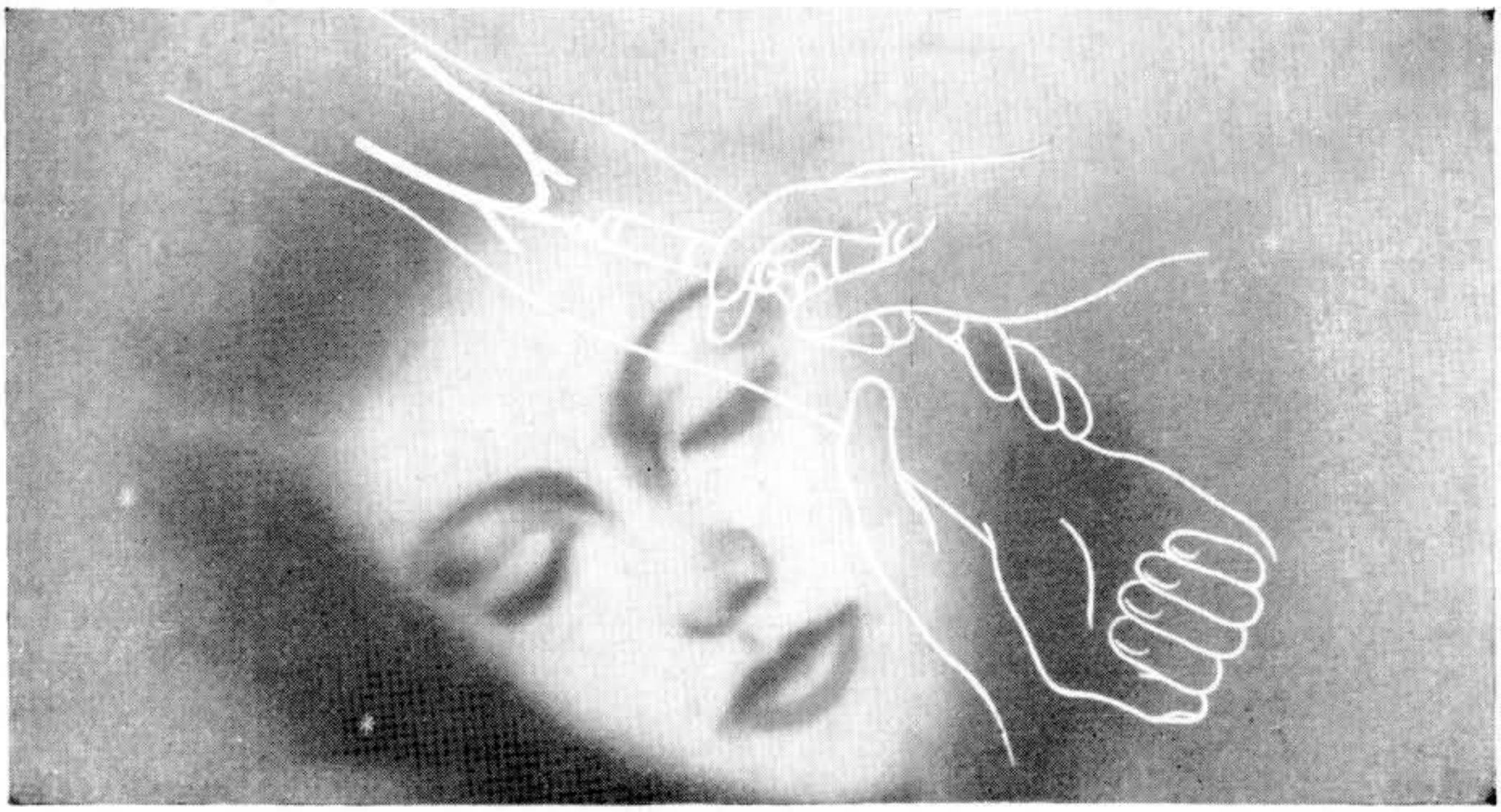
pomada analgésica

a 1 % de Nupercaina "Ciba",
anestésico local de ação prolongada

A aplicação de Nupercainal às cânulas e sondas, além de facilitar a manobra do anestesista, previne, pela supressão de reflexos faringo-laríngeos, a tendência para expulsão dos instrumentos.

Ciba

PRODUTOS QUIMICOS CIBA S. A. — RIO DE JANEIRO



ANESTESIA ENDOVENOSA

com

KEMITHAL

(Tialbarbitona Sódica)

- indução suave e rápida.
- complicações, tais como espirros, tosse, laringospasmo, excitação e tremores, são raras.
- o despertar é rápido e não se observam inconvenientes post-anestésicos.

(*Lancet*, 1946, 1, 768)

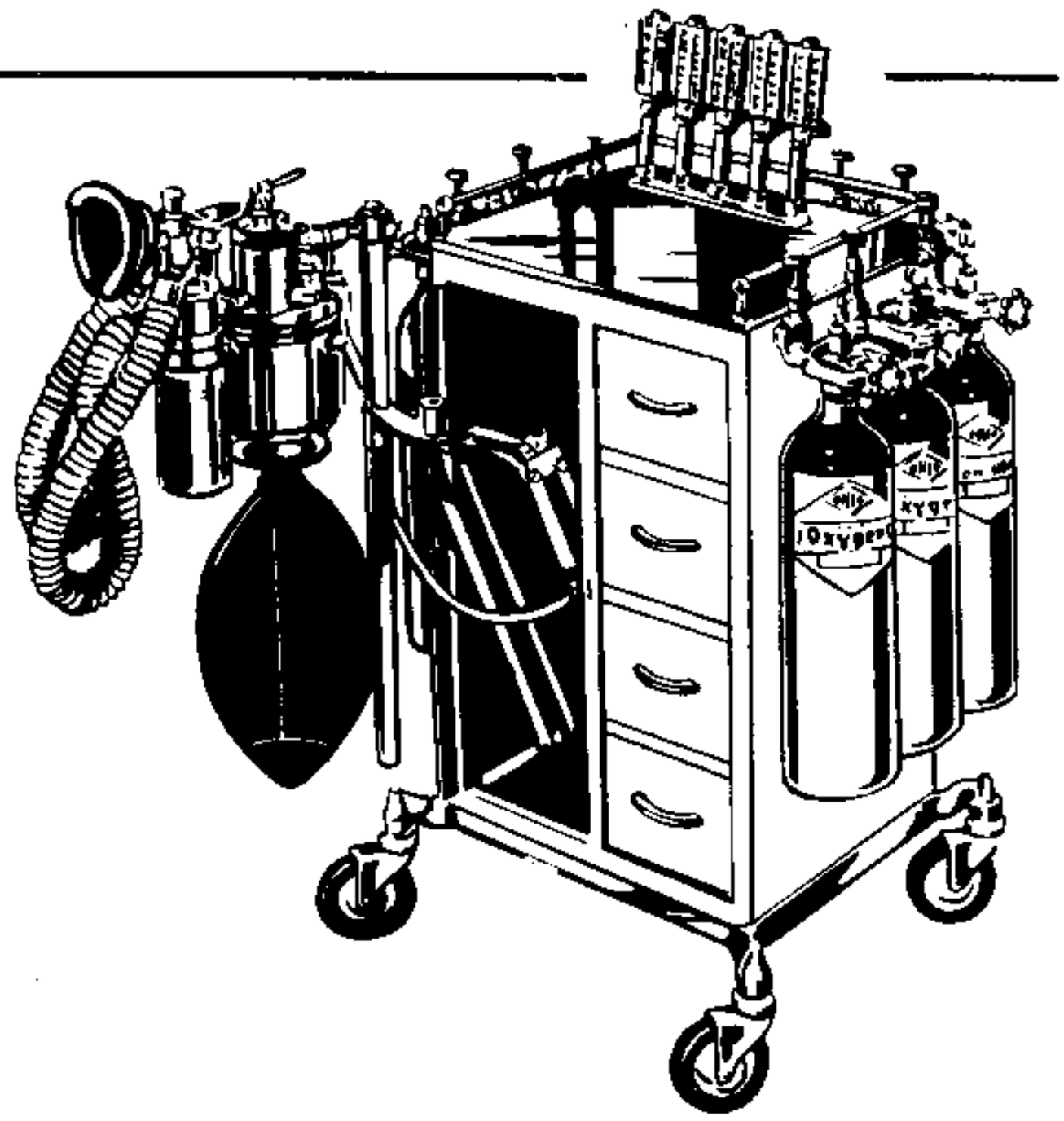
Ampolas de 1 g e 2 g, acompanhadas de ampolas de água bidestilada.

COMPANHIA IMPERIAL DE INDÚSTRIAS QUÍMICAS DO BRASIL

Rio de Janeiro - S. Paulo - P. Alegre - Bahia - Recife

SEGURANÇA **EFICIENCIA**

HEIDBRINK KINET-O-METERS



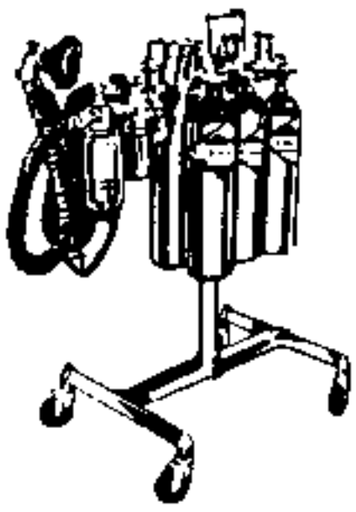
KINET-O-METER
Modelo 550 - Tipo
Armário - 5 Gases

Os KINET-O-METERS, ainda que desenhados especialmente para a utilização do método de grande economia da absorção do CO_2, também permitem o uso do método da reinalação parcial. Os debimetros são construídos e calibrados de maneira apropriada, indicando e medindo com a maior precisão os fluxos necessários ao sucesso de ambas as técnicas. Há sempre um KINET-O-METER que se enquadra a qualquer exigência técnica.

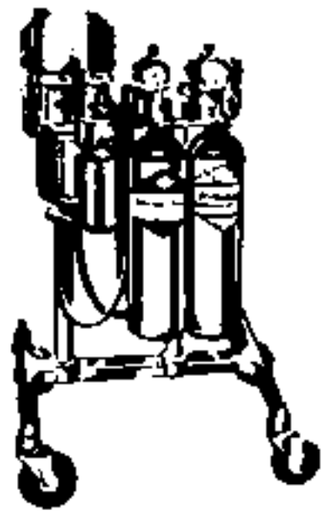
Modelos: Stand, Carro, Gabinete, Carro-Gabinete e Midget.

Peça o novo Catálogo Heidbrink com informações completas sôbre Aparelhos de Anestesia.

KINET-O-METER
Mod. 212A - Stand - Cilindros pequenos - 2 Gases: N2O-O2



KINET-O-METER
Mod. 650 - Midget portátil ou em stand.



KINET-O-METER
Mod. 403A - 4 Gases: N2O e O2 em cilindros grandes - C3H6 e CO2 em cilindros pequenos.

AIRCO COMPANY INTERNATIONAL

DIVISÃO DA "AIR REDUCTION COMPANY, INCORPORATED"

60 East 42nd Street, New York 17, N. Y., U. S. A.

Enderêço Telegráfico "AIRCOCHEM"

OHIO — HEIDBRINK — SCANLAN-MORRIS