cent oxygen. The color became pale, blood pressure dropped to 120/72, and pulse volume weakened. Coramine 5 cc. was given intravenously, and pulse volume improved. The blood pressure at closure was 130/80. Time of operation 48 minutes. The patient reacted quietly in 40 minutes, and had no nausea or vomiting.

Conclusion: Despite the fact that early clinical reports warned against the use of pentothal sodium in patients having low blood pressure, anemia, circulatory diseases, hepatic or renal diseases, organic or obstructive respiratory diseases, diabetes or hypertension; poor surgical risks; for long and major operations, and in both extremes of life, we have found after careful study, and with cautious administration of the drug in five thousand consecutive anesthesias embracing all types of operations, that when administered skillfully and cautiously, pentothal sodium is a safe and pleasant anesthetic. It gives the least postanesthetic disturbance and affords the surgeon sufficient relaxation for any operative procedure that may be desired.

Reference:

THE MEASURED ADMINISTRATION OF ANESTHETIC AND AUXILIARY GASES

HELEN LAMB

Barnes Hospital, St. Louis, Mo.

With the acceptance of the newer anesthetic and auxiliary gases into the anesthetist’s armamentarium, special interest attaches to the mechanisms by means of which these modern agents are administered in accordance with progressively developed up-to-date techniques; and in speaking on this subject, I first emphasize the specific individual merit of, and definite place for, each one of the four great general anesthetic agents—nitrous oxide, ethylene, cyclopropane and ether—either alone or in combination with one of the others, for its own specifically preferred procedure or patient. As very brief illustrations of the basis for this general pronouncement, I cite the following practical clinical instances.

Nitrous oxide

As a characteristic preferential indication for nitrous oxide (with basal rectal supplement if necessary), I point out the cases in which the use of a cautery in the field eliminates the use of inflammable ethylene, cyclopropane or ether, and where the selection of the anesthetic agent is therefore necessarily limited to the non-inflammable agents nitrous oxide or chloroform; of which nitrous oxide becomes the anesthetic of choice because of contraindicating pharmacological characteristics of chloroform.

Cyclopropane

As a typical indication for cyclopropane, I call attention to intrapulmonary procedures wherein ether is contraindicated because of its inherent property of respiratory irritation, and where neither nitrous oxide nor ethylene is sufficiently potent to provide adequate
narcosis with proper accompanying full oxygenation of patient.

Ethylene

Ethylene evidences its own specific advantage for certain of those same intrapulmonary cases, where the reaction of the individual patient to cyclopropane renders continuance of that agent undesirable, but wherein unsupplemented low potency nitrous oxide would be ineffective (a basal supplement being contraindicated because of its depressant effect upon the cough reflex).

I start then from the premise that all three of the anesthetic gases, nitrous oxide, cyclopropane and ethylene, have specific individual preferential indications in surgical anesthesia and should therefore be provided for on an inhalation anesthesia apparatus which is to be regarded as completely adequate for the servicing of the broad range of surgical procedures of the active, progressive, general surgery clinic.

Oxygen

In addition to the anesthetic gases themselves, each "gas anesthesia" mechanism must necessarily be equipped to deliver accurately measured volumes of oxygen, and should also be equipped to deliver a similarly accurately metered supply of carbon dioxide; although in view of differences of opinion regarding the method of use of this agent, my simple statement on that point requires amplification.

Carbon dioxide

Physiologists agree that carbon dioxide is the most effective respiratory stimulant available. Whether this carbon dioxide is accumulated from re-breathed exhalations, or whether it be administered from an independent cylinder supply, the pharmacological effect in similar concentrations is the same. In the first instance (from re-breathing) the accumulation is slow and erratic, whereas in the second instance (from cylinder supply) it is promptly available to exactly the required degree.

Experience amply demonstrates that by the skillful use of carbon dioxide during the administration of nitrous oxide and ether, a smooth, progressive induction to narcosis is effected without the intervening "hesitant, shallow-respiration, vomitus-threatening phase" that otherwise often characterizes the late stage of induction by those agents. Clinical experience also shows that the use of an independent supply of carbon dioxide when needed during surgical anesthesia, assists in the maintenance of a smooth, controlled level plane of narcosis, which may be promptly changed to a different zone if required by a change in the surgical procedure.

For resuscitative procedures, when necessitated by hemorrhage, shock, et cetera, a quickly available definite supply of carbon dioxide, plus oxygen and helium, with fluids (blood), is the technique par excellence for improving blood pressure, pulse volume and tissue oxygenation.

Postoperative hyperventilation, which is considered of great prophylactic value by many surgeons, and definitely demanded by them, is impossible to conduct properly with the necessary open exhaling valve to speed elimination of the anesthetic gases, excepting by the incorporation of a definite concentration of carbon dioxide; which under those circumstances can be obtained only from an independent cylinder supply, since rebreathing is then no longer in effect or available without defeating one of the objects of the procedure, viz., "rapid deanesthetization."

Helium

In considering this latest addition to our group of auxiliary gases (helium),
it is to be noted that the clinical use of
this increasingly important agent am-
ply justifies its use (1) as an alleviant
to stridor and allied respiratory diffi-
culties during anesthesia, (2) as a reg-
ular component part of both the sur-
gical-anesthetic mixture and the hy-
perventilating mixture and (3) as a
calculated part of the gas mixture ad-
ministered in resuscitative procedures.

These clinical techniques are based
upon the comprehensive research work
of painstaking investigators, who have
demonstrated human reactions to heli-
um which assign to it a specific and
distinct place in the anesthetist's arma-
mentarium of administrative agents.

For instance, Barach in 1934, by ad-
ministering experimentally to human sub-
jects a calculated mixture of helium and
oxygen in place of the mixture of
nitrogen and oxygen which constitutes
ordinary atmospheric air, demonstrated
that while all of the oxygenating prop-
erties of the mixture were defended
and maintained, there was a reduction
in the resistance to breathing amount-
ing to from 25 per cent to 50 per cent.
This fact of "reduction of breathing ef-
fort," is one of the reasons for using
helium as a part of anesthetic tech-
nique.

A second reason for the use of this
gas as a calculated part of the anes-
thetic mixture, is its extremely low
density ("thinness," "ease of flow," "rapid
diffusibility"), which causes it to
carry its mixed companion gases (cy-
lpropane and oxygen) to the distant
alveolar areas, thereby increasing anes-
thetic effectiveness and aeration.

A third reason for the use of helium,
both as a part of the anesthetizing and
hyperventilating mixtures, arises from
the fact of its very slow absorption in
the pulmonary endothelial structures,
through which all gases must diffuse
which pass from the lung alveoli to the
circulating blood. This important fact,
the specifically slow solubility of heli-
um in the endothelial tissues, was es-
blished by Coryllos and Birnbaum in
1932, when they demonstrated (upon
dogs) that helium took something like
forty times as long to completely em-
pty from an occluded lung lobule, as did
oxygen, nitrous oxide or ethylene—and
while cyclopropane was not includ-
ed in those experiments (not having at
that time come into clinical usage) its
known physical constants indicate that
it would follow the pattern of the other
gases experimented with, particularly
ethylene.

The significance of the slow passing
of helium from lungs to blood, was in-
corporated into a postulate by Burford
in 1938, that atelectasis may in some
cases be due to rapid passing of gases
from poorly ventilated lung alveoli to
circulating blood, thereby leaving the
alveolar structure uninflated or col-
apsed—a condition which might be
prevented by incorporating into the
breathed mixture an inert gas with a
characteristic of slow tissue solubility,
by reason of which it would retard the
emptying (into the blood) of poorly
supplied or partially occluded alveoli;
thereby inhibiting or reducing the in-
cidence of atelectasis.

As a result of the work of the inves-
tigators named in this paper, it is pro-
posed to administer helium with and
as a part of the anesthetic mixture, one
volume of helium to two volumes of
cyclopropane. We ourselves are work-
ning with a technique employing equal
parts of helium and cyclopropane but
await further laboratory and clinical
confirmation.

On the basis of the same investiga-
tions, and consequent to clinical expe-
rience, helium is definitely indicated as
a component of the hyperventilating
mixture. We use it regularly, the tech-
nique being to inaugurate the hyper-
ventilation by administration of a mix-

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ture composed of 50 per cent oxygen, 41 per cent helium, and 9 per cent carbon dioxide, with open expiratory valve to facilitate elimination of the anesthetic. The length of time required to secure the desired depth of breathing varies with the patient, but is always brief — usually requiring only from eight to ten inspirations. At reaching the desired depth of respiratory exchange, the carbon dioxide is discontinued and the patient permitted to respire the flowing oxygen-helium mixture for five full inspirations with the exhaling valve still open, after which all gas flows are discontinued and the mask removed.

From the foregoing it is obvious that the modern anesthetizing machine should be provided to deliver accurately calibrated volumes of this increasingly important auxiliary gas helium, thus removing its administration from the earlier “spurt” or “flood” techniques, and instead enabling its administration as a precisely calculated component of an anesthetic, a prophylactic or a resuscitative mixture.

Machine Calibrations

Since the up-to-date anesthetizing machine is to be equipped to deliver the now discussed six anesthetic and auxiliary gases, I approach the very practical detail of what calibration shall be considered specifically suitable for each of those six gases—and here it is to be noted that considerable variation of opinion is reflected in the several groups of calibrations that have been heretofore specified by both anesthetists and manufacturers of the equipment. My feeling is, however, that many of these variations can be assessed to the fact that the particular mechanisms have been calibrated for restricted fields or for particular purposes; and that such variations are not at all irreconcilable with a recommend-
ed “general purpose” calibration for those machines which are intended to serve a broad, active, general surgery service, where from time to time each one of the agents will be required for administration by modern techniques particularly suited to the surgical procedure at hand.

Cyclopropane. There is very little difference of opinion regarding a calibration suitable for cyclopropane administration, where the potency and restricted method of administration of the agent (closed circuit entirely, both as a matter of economy and of reducing ignition hazard) brings a universal calibration of 1,000 cc. per minute well within the range of every usage.

Ethylene. The next older agent, ethylene, also lends itself reasonably well to agreement on calibrations, although in view of its lesser potency and therefore open-exhaling-valve during induction (to establish its tension in the place of systemic nitrogen) its volume of delivery is necessarily scaled considerably higher. A calibration of 6 liters per minute services satisfactorily both “open valve” induction and “closed circuit” administration of this agent.

Nitrous oxide. While currently functioning anesthetizing machines show quite varied calibrations for the administration of our oldest and longest used anesthetic gas, nitrous oxide, these differences again seem to be due to the limitation of certain machines to restricted usage, and are not at all at variance with a “universal” calibration for mechanisms which are to be used for administering this agent in “general service,” where it will be called upon to function in both “open exhaling valve” and “closed system” anesthesias.

As an illustration of circumstances in which non-inflammable nitrous oxide will be administered by the equivalent
of an "open valve" method, I point out (1) a group of procedures such as laryngectomy, esophagoscopy, et cetera, in which the volume of insufflated nitrous oxide will reach 7 liters per minute in adult cases, and (2) cauter y pneumectomy with frequent bronchial fistula (also change of chest packs in bronchial fistula), in which the flow of nitrous oxide not infrequently rises 7 liters per minute. In these and allied circumstances a calibration of 7½ liters per minute is necessary, if the administration is to be removed from a "bubble and guess" technique, with no knowledge of either anesthetizing or oxygenating concentration being actually delivered.

Oxygen. In turning from the anesthetic agents to our auxiliary gases, I feel it desirable to state what I think is fundamental, that is, that every calibration on an anesthetizing machine should be proportioned to and based upon the other agents on the same machine, with which it will be administered either continuously or intermittently. For instance, assuming a nitrous oxide calibration of 7½ liters, the oxygen calibration to service that agent should read 1,900 cc., in order that at the maximum flow of nitrous oxide, the administered mixture may definitely contain 20 per cent oxygen. I therefore recommend 1,900 cc. per minute as the "fine flow" oxygen calibration, clinical evidence having clearly demonstrated that such calibration may also be satisfactorily used for regulation of the finer "metabolic" flow utilized in closed circuit administration.

The practice of postoperative prophylactic hyperventilation, which is demanded by many surgeons, obviously requires provision for a materially greater volume of delivery of gases, but does not modify the necessity that they be delivered in known and controlled concentrations—hence accurate calibration of these greater volumes is equally imperative. When postoperative hyperventilation is conducted by means of oxygen and carbon dioxide alone (without inclusion of helium), the volume of oxygen required sometimes reaches the rate of 15 liters per minute, which calibration for "coarse oxygen" is recommended.

Carbon dioxide. To induce within the required time, the desired increase in tidal exchange during brief postoperative hyperventilation, a concentration of up to 9 per cent of carbon dioxide is demonstrated clinically. Since the coarse oxygen flow during such hyperventilation sometimes reaches 15 liters, a measured delivery up to 1,500 cc. per minute of carbon dioxide must of necessity be provided for; in view of which that calibration is recommended for that agent.

Helium. Helium, like oxygen, requires two quite different rates of flow for different administrative procedures: (1) a "fine flow" for administration as a precise component part of cyclopropane anesthesia, and (2) a "coarse flow" for administration as part of a hyperventilating or resuscitative mixture. Since the volume during cyclopropane anesthesia is based upon and is parallel to that agent, it is recommended that the fine flow of helium be similar, or 1,000 cc. per minute.

When helium is used as a calculated part of the hyperventilating mixture, its proportion may be calculated to constitute as much as 41 per cent of the total mixture—41 per cent helium, 50 per cent oxygen, 9 per cent carbon dioxide) but when used in a succeeding prophylactic deanesthetizing mixture may constitute as much as 75 per cent of the total flow (75 per cent helium, 25 per cent oxygen)—therefore the coarse flow calibration for helium is recommended as 12½ liters per minute.
Summary

In concluding this paper, and to sum up the recommendations made; while recognizing the province of "limited capacity" anesthetizing machines, when their usage is restricted to the special purposes for which they are designed, I feel strongly that the anesthetizing machine which is to be used over the full, broad range of surgical demands that are inherent in the progressive, active surgical clinic (what I term an "all purpose" machine), should be so designed and equipped as to permit the anesthetist to administer the full range of the anesthetic and auxiliary gases (plus ether vapor, of course), and I suggest as calibrations for such equipment the following volumes:

- Cyclopropane .................1,000 cc.
- Nitrous oxide ..................7½ liters
- Ethylene ......................6 liters
- Oxygen (fine) ..................1,900 cc.
- Oxygen (coarse) ..............0.15 liters
- Carbon dioxide ...............1,500 cc.
- Helium (fine) .................1,000 cc.
- Helium (coarse) ..............12½ liters

Each of which is based upon a definite calculation, as set forth in this paper.

References:

GIFT

In the report of the activities of the Missouri Association given at the annual meeting, a letter was read from Miss Anna Gettinger, Secretary of the Missouri Association, stating that the Missouri organization had voted the sum of Fifty Dollars to be given to the National Association, as an expression of gratitude for the support and help that the National organization had given the Missouri group. Miss Gettinger sent best wishes for a successful convention.

In Memoriam

Miss Elsie Mae Palmer, of Children’s Hospital, Pittsburgh, Pa., died Sunday, September 24, 1939. Miss Palmer had been a member of the National Association of Nurse Anesthetists since 1934. She was graduated from the Oil City Hospital School of Nursing and from the Grace Hospital School of Anesthesia in Detroit, Mich.

NOTICE

Miss Alpha Schier, St. Joseph Infirmary, Atlanta, Ga., has been appointed Secretary-Treasurer of the Georgia Association of Nurse Anesthetists to fill the unexpired term, following the resignation of Miss Caroline Hohenschutz.