The Potential Dangers Attendant on Ethylene-Oxygen Anesthesia

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In the absence of precise data, it has been estimated that ethylene-oxygen anesthesia has been employed in some 50,000 operations. Up to the present, no contraindications to its use have been noted. It has been employed successfully and without deleterious effects not only as an anesthetic agent in all types of general surgery on otherwise healthy subjects,[1] but also in cachectic infants [2] as well as in the aged with marked pulmonary cardiac, vascular and renal pathologic conditions.[3] A favorable report on its use in gynecology and obstetrics is to be published,[4] and within the last month an article was published on its very satisfactory use in exodontia.[5] Its safety and superiority over nitrous oxid have recently been confirmed by several French investigators.[6] Recently, data were published which prove conclusively that ethylene oxygen anesthesia does not influence "the blood reaction so markedly or so rapidly as does ether or chloroform." [7]

In all our published articles, on the other hand, we have called attention in no uncertain terms to the one serious disadvantage of this anesthetic agent; namely, to its inflammability and explosibility.[8] The fact that

* From the Hull Physiological Laboratory of the University of Chicago.

1. Luckhardt, A. B., and Carter, J. B.: Ethylene as a Gas Anesthetic, J. A. M. A. **80**: 765 (March 17) 1923. Luckhardt, A. B., and Lewis, Dean: Clinical Experiences with Ethylene-Oxygen Anesthesia, J. A. M. A. **81**: 1851 (Dec. 1) 1923. Horsley, J. S., Jr.: Ethylene-Oxygen Anesthesia, Virginia M. Month. **50**: 822 (March) 1924.

2. Lundy, J. S.: Ethylene and Oxygen as an Anesthetic for Infants, J. A. M. A. **82**: 448 (Feb. 9) 1924.

3. Kretschmer and Luckhardt: Ethylene Anesthesia in Genito-Urinary Surgery, J. Urol. **11**: 415, 1924.

4. Heaney: Ethylene Anesthesia in Gynecology and Obstetrics, Surg., Gynec. & Obst. **38**: 692, 1924.

5. Christiansen: Ethylene-Oxygen Anesthesia in Exodontia, Dental Cosmos, March, 1924.

6. Papin and Ambard: Presse méd. **32**: 133, 1924.

7. Leake, C. D., and Hertzman, A. B.: Blood Reaction in Ethylene and Nitrous Oxid Anesthesia, J. A. M. A. **82**: 1162 (April 12) 1924.

8. Luckhardt and Carter (Footnote 1). Luckhardt and Lewis (Footnote 1). Kretschmer and Luckhardt (Footnote 3).

ethylene with oxygen gas (or air) in the proper concentration forms a highly explosive mixture precludes its use in the presence of a free flame, thermocautery, or sources of electrical discharges (in the roentgen-ray room or in the presence of an exposed induction coil). This constitutes one of the limitations of ether anesthesia also; and we are quite certain that an ethylene-oxygen mixture is no more dangerous than an ether-oxygen mixture. Parenthetically, it might be pointed out at this point that, contrary to common belief, a nitrous oxid-oxygen mixture may be ignited with an ensuing explosion by means of a thermocautery.[9]

In a recent article, Brown[10] considers the "four places in which ethylene might conceivably explode." He promptly and quite properly excludes as possibilities the explosions of the tanks of pure compressed ethylene as well as the explosibility of pure ethylene itself. In confirmation of previous work, he finds that the ethylene-oxygen mixtures, most commonly used in anesthesia, are too "rich" and, therefore, nonexplosive when subjected to a possible ignition by an electric spark. His calculations on the length of time of continuous anesthesia necessary to fill a small and badly ventilated operating room with a minimum explosive mixture are quite convincing, since some direct experiments[11] failed to reveal detectable traces of ethylene after one and one-half hours' continuous administration of the gas (with oxygen) in a fairly well ventilated operating room.

Such calculations and experiments do not justify, however, the use of the cautery or free flame near the field of operation; for, in the immediate proximity of the patient and even at some distance from the table, the "rich" and nonexplosive mixture exhaled by the patient may have experienced just the proper dilution with air to be most explosive. Similar considerations apply to ether-oxygen or ether-air mixtures as commonly employed.

There remains for consideration, as far as we know, the final possibility of explosion, namely, the ignition by a static spark of the ethylene-oxygen mixture in the

9. Injury to Patient from Explosion of Machine Used in Anesthetizing, J. A. M. A. **82**: 329 (Jan. 26) 1924.
10. Brown, W. E.: Explosibility of Ethylene Mixtures, J. A. M. A. **82**: 1039 (March 29) 1924.
11. Luckhardt and Lewis (Footnote 1).

tubing conducting these gases to the mask. On this point, I [12] wrote:

> The possible development of static electricity as the result of the long continued flow of an ethylene-oxygen mixture through the rubber tubing leading to the mask and the sudden ignition of this mixture by a jump spark suggests that there should be an uninterrupted metallic connection from the tank to the face mask and that the tank itself be grounded. Ether-oxygen mixtures administered through insulated rubber tubing have been known to explode with serious violence as the result of a jump spark. Although the instances are rare, every precaution should be taken to avoid their occurrence by the method suggested above. The same precautions apply for the administration of ethylene-oxygen, and should be taken before some serious accident occurs. These potential dangers of ethylene-oxygen anesthesia have been exaggerated, unfortunately, by some and minimized by others.

Brown considers this possibility, but dismisses it finally as an improbability; for he writes, "Such static sparks are rarely of the duration or intensity of those used in testing the explosibility in the experiments reported in the tables, and are hardly likley to produce an explosion."

When I first approached the physicists and chemists several months ago, the theoretical possibility was readily granted but the improbability was emphasized. Subsequent *facts* nullified all *opinions*. The danger is not a theoretical one. Within the last six months, a static spark, arising as indicated above, has to my knowledge twice ignited an ethylene-oxygen mixture with explosive violence, tearing wide open the rubber tubing leading the ethylene-oxygen mixture from the mixing chamber to the mask. Fortunately, both accidents had no serious consequences to the patient, operator or anesthetist; in one instance, the explosion happened just at the conclusion of a prolonged period of anesthesia; in the other, just as the mask was about to be applied to the patient's face. I hasten to add that this potential danger (even if it occurs infrequently) applies equally well to the administration of ether-oxygen or nitrous oxid-ether-oxygen mixtures through the usual type of nitrous oxid-oxygen or combined nitrous oxid-ether-oxygen apparatus. I know of two accidents of this sort.

12. Luckhardt, A. B.: Ethylene Anesthesia, in Gwathmey's book on Anesthesia, to be published.

Because of these facts, I feel the responsibility of frankly calling the attention of the medical profession to this danger (also present in the similar administration of ether-oxygen or nitrous oxid-ether-oxygen anesthesia). The danger can be eliminated by the manufacturers of the various types of gas apparatus by providing their respective machines with flexible metallic tubing. It is particularly important that the tubing conducting the mixed gases (or conducting the ether vapor with or without the nitrous oxid and oxygen) be made of metal, so that there may be direct metallic contact from the mask to the gas machine. If metal tubing connects the gas machine with the tank, and if the tank itself is grounded by means of a conductor, such as a wire attached to a radiator or a water pipe, the last step of known and effective precaution will have been taken. In case conductile rubber tubing can be manufactured, this type of tubing may possibly be preferable to flexible metal tubing, or a closely wound spiral coil of wire may be placed inside the ordinary tubing. The rubber or celluloid mask is less likely to be a source of danger, since expired air is saturated with water moisture, and conduction of the current to the metallic parts is more likely. If the inner surface of the mask were lined with a wire gauze which, in turn, was in contact with the metallic tube conducting the gas mixture to the mask, all possible sources of danger would be eliminated.

Although this advice was first prompted in an endeavor to save ethylene as a meritorious anesthetic agent, the same potential danger applies to the administration of ether-oxygen alone or in combination with nitrous oxid by means of any of the usual types of so-called gas-oxygen apparatus. It therefore behooves the manufacturers of these apparatus to equip their machines so that the lives of those who must use them as well as the lives on whom they must be used are not jeopardized.