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## A HISTORY OF ANESTHESIA

H. R. MATERN, M.D.\*

General Surgery Reviews are teaching conferences for interested surgical residents, regardless of the field of special interest. The material is presented by the resident after a more or less exhaustive study of the assigned subject. This paper on the history of anesthesia by Dr. H. R. Matern was selected for publication in the Henry Ford Hospital Medical Bulletin because it reflects a great deal of study of the subject and, in addition, reflects some thoughts on the matter which have originated with Dr. Matern.

J. L. PONKA, M.D.

"NO DISCOVERY ever made in medicine has proved more beneficial to the human race than the discovery of anesthesia".<sup>1</sup> It opened up medicine as a whole into that burgeoning science it is today. It forced upon medicine the necessity for precision, it liberated surgery from its prison into a world whose horizons are still not yet visible, it gave medicine the impetus and vision for progress that it needed to expand in step with the rest of the scientific world. More than any one thing it won for medicine the interest and favor of modern man, who had actually, in a way, insisted upon its discovery, and whose favor and interest — and insistence — assured, and still assures, the further progress of medicine.

The discovery and development of modern anesthesia falls within the realm of well documented historical record. It is thus a most useful point of reference for the study of modern man, his morals, aspirations, drives, his epistemology, psychology and philosophy. This task, however, still awaits the historians. Nevertheless, if we wish to understand something of the stream of medicine in which we find ourselves today, to understand its currents and directions, its sinkholes and shoals, we must try to lift our heads above that stream in order to see and understand the successes and difficulties of those who have preceded us. We shall then be the better equipped to steer our own course, and to hand on a few hints to those who'll follow us.

To write on the history of anesthesia is to write on the history of humanitarianism, of science, of Christianity, of Western culture; in short, it is to write on what man-

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kind has been and is up to, and how the subject in point, i.e., anesthesia, relates to this. Most authors who write on the history of anesthesia are anesthetists and have little competence for writing history. For example, one often finds in the writings of such authors a parochial concept of pain, according to which all previous ages of man are assumed to have held the same attitudes toward pain that they do. Thus Leake, who was the first to propose the synthesis of a hitherto unknown anesthetic and predict its properties (divinyl ether in 1930), states, "control of pain incident to surgical operation was a pressing problem for centuries".<sup>2</sup> If this had actually been the case, Davison feels anesthesia would have been discovered much sooner than it was.<sup>3</sup> Consider, as a modern example, the Navajo woman in labor. When the writer practiced obstetrics among them a few years ago, it was necessary to give these women a desk bell to tap at the onset of each uterine contraction; otherwise, without a hand constantly on the abdomen the progress of labor would be very difficult to ascertain. Her attitudes toward pain are very different from those of the average Latin parturient, or even from those of the patients of James Simpson, who was the first to use anesthesia in obstetrics. Certainly, it is difficult to conceive how anesthesia might ever have developed *de novo* among a people such as the Navajos.

Thus it seems more true to say that though there may have been individuals in history who felt the pressure of the problem of pain control in surgical operations, it was precisely because the vast majority of people — and doctors — did not feel any such pressure that anesthesia was not discovered before it was.<sup>3</sup> When this pressure finally was felt widely enough, necessity again proved to be the mother of invention, and that through the medium of men who were in other wise little distinguished by greatness.

Nevertheless, throughout history sporadic efforts have been made to alleviate pain, only to be relegated to oblivion again, still later to be revived again. Before one begins to wonder too deeply about the wisdom of our forebears, however, we ought to recall the more recent reintroduction of refrigeration anesthesia (Allen, 1942)<sup>2</sup> and cryotherapy for burns. Although Hippocrates had described the anesthetic action of cold, the first recorded use of cold for surgical anesthesia occurs in the Saxon language in 1050 A.D., when cold water was used to chill the part before incision and drainage of an abscess.<sup>8</sup> This method has been rediscovered *de novo* many times, as with many things in medicine. In 1595 Costaeus mentioned the use of snow or ice to produce analgesia for surgery, and in 1646 Bartholin found Severino in Naples using ice or snow as an analgesic for lithotomy.<sup>2</sup> Baron Larrey also discovered during Napoleon's campaigns that frozen limbs could be amputated without pain.<sup>2</sup> Why then has this been so difficult a technique to remember? Anyone who has gone through medical school and surgical training, seen the usual number of severe burns, treated them, paid lip service, so to speak, to the pain with a narcotic or an ointment dressing, and then has been privileged to see the immediate complete relief afforded by cold water,<sup>12</sup> can probably appreciate the difficulties other generations have had, as he asks himself, "Now why didn't I think of that before?" It is the age-old problem of failing to realize that the pain is not synonymous with the disease, but can be separated from it, and treated vigorously and successfully in its own right.

Then, too, the human race is very tolerant of pain, usually when it occurs in someone else. Check this the next time you find yourself or someone else forgetting certain postoperative orders; it will more than likely be forgetting to do something for the pain.

#### *The Ancients*

It is often stated that the ancient Egyptians and Assyrians used compression of the neck vessels in order to produce syncope and insensibility before the operation of circumcision. The first mention of this custom dates from the year 1625. Davison feels this may be safely dismissed as without foundation.<sup>3</sup> However, Steiner in 1902 described a similar method for anesthesia among the natives of Java.<sup>13</sup> It is thus quite likely that methods of anesthesia by carotid compression and/or vagal stimulation have been discovered and used by many peoples at various periods of history.

Henbane, one of the plants from which we obtain hyoscyamine and scopolamine, was mentioned on cuneiform tablets from Mesopotamia (c. 2250 B.C.?) as an ingredient for a local application in the treatment of dental caries.<sup>3</sup> This has been purported to be the first recorded use of anesthesia in history. Davison, however, feels this far-fetched, since the belladonna alkaloids have almost no local anesthetic effect.<sup>3</sup> It seems nevertheless likely that this was the result of an unfortunate attempt to improve a known method of producing anesthesia through the ingestion of henbane. We must remember that most literature, even today, is not worthwhile literature (the subject of medicine will not entirely escape this generality), and there is no reason to believe that extant Mesopotamian literature should be any different. An illustration of this likelihood is found in the case of William Bullein's "*Bulwarke of Defense Against All Sickness*". Published in 1562, it contains probably the first reference to surgical anesthesia in the English language, yet it was a hastily written, uncritical compendium for popular usage, the chief purpose of which was to raise money for its imprisoned author.<sup>5</sup>

The ancient Egyptians sometimes buried poppy seeds with their dead, but to date we have no clear reference to their use of poppy seeds to allay pain until after Homeric times.<sup>14</sup> (It cannot be assumed, however, that effective use by man of many drugs as narcotics or analgesics was not made for even millenia before their use was recorded). Homer's *Odyssey* mentions a drug used in wine to cause relief of pain and bring "forgetfulness of every ill".<sup>2</sup> This, in turn, is said to have originated from Egypt, but there is no mention of this in extant Egyptian writings.<sup>14</sup>

After this there are many references made to various drugs used to relieve pain; these are found in the literature of many subsequent civilizations. In India in the fifth century B.C., Susruta, from whose work modern nasal plastic surgery got started,<sup>15</sup> mentioned 760 medicinal plants among which were henbane and hemp, used as soporifics.<sup>16</sup> In China the first mention of drugs given to produce sleep before surgery occurs c. 250 B.C.<sup>16</sup>

#### *The Drug Problem*

After these times, opium, henbane, hemp, and mandragora are mentioned repeatedly as having been used to produce sleep prior to and/or to lessen the pain

of surgery. Just how widely such drugs were used for anesthesia is not known. Davison feels they were not much used and, when used, they were administered so poorly that their effect could not have been great.<sup>3</sup> He mentions that Galen (c. 130-200 A.D.) recommended a paste containing opium for toothache; opium has no local analgesic effect. He mentions the *spongia somnifera*, a decoction of herbs, including mandrake, which was soaked up and dried in a sponge; this would then be wetted pre-operatively and the fumes were supposed to produce unconsciousness. Reference to this is contained in the Bamberg Antidotarium (c. 850 A.D.), also in codices from the Abbey of Monte Cassino, probably even earlier. But since the drugs were not volatile, Davison feels they were of little use.<sup>4</sup> These are probably instances of the way in which faulty modes of administration, developed in the hope of using and storing drugs which were originally quite effective, finally negated any use at all of these same drugs.

Pliny the Elder, a layman, (c. 70 A.D.) mentions the soporific action of opium — and disapproved of its use.<sup>4</sup> Evidently there were many who did not reawaken from the anesthetic. This is precisely the criticism of the preoperative use of opium made by Guy de Chauliac, 1363.<sup>4</sup> Even as late as the 17th century, Bailly, a barber surgeon of Troyes, was heavily fined for giving a patient a sleep-producing drug prior to surgery. Bailly's accusers were the representatives of contemporary orthodox medicine; they cited the dangerousness of Bailly's act and succeeded in making such practice henceforth illegal.<sup>17</sup> It is also to be remembered that with morphine and scopolamine only as anesthesia, it is possible to repair without pain and with sufficient abdominal relaxation even a large ventral hernia, as Waters demonstrated in 1938, using 128 mg. of morphine and 4.2 mg. of scopolamine in fractional doses.<sup>18</sup>

It seems then that on occasion, at least, opiates were used successfully for anesthesia — or often too successfully. We find it mentioned in the lay literature as well; thus in the *Decameron*, Boccaccio (1313-1375) mentions that before a certain operation the surgeon administered an opiate, because it was felt that otherwise the patient would refuse the surgery.<sup>2</sup> Thus we see that, though known, narcosis for surgery was not popular among physicians, the chief drawback being an inability to standardize dosages of relatively pure substances and give them in an effective, yet safe manner.

Considered for the moment purely on technical grounds, this was a problem that was beyond reach of the capacities of the times. The science of chemistry had to develop first. There was need of a satisfactory method of retaining and disseminating knowledge, without which the necessary faculty of criticism (i.e., towards that knowledge) could not develop. All of this necessitated first the introduction of papermaking to Europe (Italy, c. 1270) and the invention of the printing press (1454).<sup>4</sup> This in turn necessitated first a repository for and people interested in such knowledge; i.e., the university. This in turn necessitated a place where and a group of people among which such a university could come into existence; i.e., the city. Without these prior developments, subsequent to the fall of Rome, there could be no such thing as a science of pharmacology. Harvey (1578-1657) became famous for his

discovery of hemic circulation. Santorio, his little known contemporary, did equally brilliant work on metabolism, but the difference was that Harvey was fortunate enough to have worked on a problem that could be solved with the knowledge at hand in his day — Santorio was not.<sup>14</sup>

Then, too, the anesthetic concoctions of earlier times were often surrounded by superstitions and magical practices, such that in the eyes of many of the fathers of medicine, the very use of such drugs seemed unethical. For example, one of the proofs brought forward at her trial that Joan of Arc was a witch was the fact that she kept a mandrake (1431).<sup>4</sup> This she denied, saying she knew mandrakes were dangerous and evil things to keep. From the layman's point of view, there was so much charlatanry connected with, or at least practiced in, the name of medicine that doctors in general were little trusted. (Nor did it help matters when a physician like Paracelsus agreed in this respect with the laity).

One often hears the "Dark Ages" castigated because no progress or too little progress was made in those times, which thought seems not unlike that of a man beating his horse because it won't fly. Progress has occurred simply because there was a belief in progress; such a belief scarcely existed four centuries ago and it has not been more than one hundred and fifty years since the average man of our culture has realized that the limits of science are no longer ascertainable. Such a luxuriant belief was not possible in the face of century upon century of barbarian hordes (whose descendants most of us are) laying Western civilization waste. It was heroic enough for the civilized man of that age to believe that his civilization could survive. Persians, Egyptians, Assyrians, Chinese, Romans, multitudes of civilizations had arisen and decayed. It took great courage (it meant tremendous work and sacrifice, too) for men to believe that their civilization was meant to survive. Their belief in their stability seems today to be vindicated; because of it we can now afford our belief in progress.

#### *Other Contributors before 1844*

Since the dawn of the belief in progress there have been investigators in the field of anesthesia. Paracelsus and Valerius Cordus, who worked together, described the synthesis of diethyl ether (the latter), as well as its use to alleviate pain and to produce sleep (the former), c. 1540<sup>2</sup>. Unfortunately, these spirits were far ahead of their times. Costaeus (1595) advocated ice and snow for surgical analgesia.<sup>1</sup> With the rise of anatomy surgical anesthesia by nerve compression was discovered; it was known to Paré (1510-1590), developed by Valverdi (c. 1600) and used at least once by John Hunter (d. 1793).<sup>5</sup> Although the method worked quite well, there is no further mention of its use. The number of those believing in progress was increasing, but still very limited. (Cf. the remark of Sir John Erichsen, famous London surgeon and author of a surgical text, who said in 1873, just six years after the discovery of antiseptics ". . . if we reflect on the great achievements of modern operative surgery, very little remains for the boldest to devise, or the most dexterous to perform").<sup>13</sup>

In 1798 Davy described how nitrous oxide relieved the pain of his cutting a wisdom tooth, performed other analgesic experiments with it and actually suggested its use for surgical operations.<sup>2</sup> Nothing came of it. One of the most famous surgeons of the day, Sir Astley Cooper, witnessed in 1800 a demonstration of the analgesic effects of nitrous oxide by William Allen.<sup>6</sup> Nothing came of it. John Warren, father of Dr. John Collins Warren (v. infra), used ether in 1805 to relieve the pain of pulmonary inflammation.<sup>2</sup> The latter had also tried hypnotism for surgery;<sup>2</sup> pain was becoming an important factor in the thinking of the few leading medical men. In 1818 Michael Faraday, while investigating ether and its soporific nature, described a man who slept for about thirty hours from inhaling it. James Guthrie, the New York chemist who first synthesized chloroform, once found his little daughter asleep beside an open bottle of it; she had been sniffing the pleasant smelling drug.<sup>2</sup> There were the ether frolics in America; there are even records of ether having been used for dental extractions as an outgrowth of these frolics as early as 1842.<sup>2</sup> Crawford Long, a Georgia country doctor, used ether anesthesia in 1842 on James Venable to excise a sebaceous cyst. This also was an outgrowth of ether frolics. Long was used to using large measures of alcohol per os on his patients before surgery. Since Venable was used to sniffing ether he used that instead. Long never published his work till after 1846 (and he had a series of cases in which he used ether anesthesia).<sup>13</sup> It was certainly known to chemists at that time that ether could produce deep sleep, so when Morton mentioned to Jackson that he intended to put someone to sleep before dental surgery (the idea he had borrowed from Wells), Jackson could immediately suggest ether.<sup>15</sup>

But for all those who stumbled over the discovery of anesthesia and dismissed it there were also a few who were seeking precisely that discovery, yet couldn't find it. The most renown was Hickman, who proved in 1824 by animal experimentation (at age 24) that anesthesia was possible with the use of carbon dioxide. He tried for six years to get a hearing for his scholarly work; he died at age thirty without success.<sup>2</sup> In 1832 Wardrop discovered a method perhaps more dangerous; he bled patients to the point of unconsciousness, then operated.<sup>6</sup> There were many who saw in hypnotism a method for anesthesia and used it successfully in instances — Esdaile, Elliotson, Braid, Cloquet and Recamier (all early 19th century).<sup>2,6</sup>

Yet it is incorrect to suppose that before the discovery of anesthesia there were only the 2 camps: Those who were searching for such a device and those who were not. Strangely, there were also those who discouraged the whole idea of anesthesia for one reason or another. There were those who felt such a thing, especially after the episode of Anton Mesmer,<sup>2</sup> to be associated, eo ipso, with quackery. Thus the renowned professor of clinical surgery at Paris, Velpeau, a few years before the discovery of anesthesia, wrote "To escape pain in surgical operations is a chimera which we are not permitted to look for in our days."(\*)<sup>17</sup> Magendie, the great physiologist, was consistent; even after the discovery of anesthesia he regarded it for some time even as he, and many others, had before — something immoral, debauching

(\*) Be it said to his credit, Velpeau was one of the first to adopt and promulgate surgical anesthesia after its discovery.<sup>19</sup>

and degrading.<sup>19</sup> Such views, however, were to prove incapable of maintaining or justifying the current status of brute-force surgery much longer to a world rapidly awakening to the expanding ideals of humanitarianism.

*The Real Beginnings*

The discovery of anesthesia took place in 1844, in an age when human suffering began to mean something — at least could attract some attention. For the most part, however, it was still a very cruel age. Public executions were still a form of entertainment. Deserters from the British Army were branded with a “D”, and a private was flogged with 150 lashes for assaulting his sergeant (he died thereafter). In 1838 the president of the English Royal College of Physicians, accompanied by a friend, was on his way to a dinner engagement. His friend was suddenly stricken by a hemiplegia, whereupon he was removed from the train at a wayside station, the doctor proceeding on the train to the dinner engagement. In Boston a Negress slave, purportedly of sound body, was sold a few days before Christmas, 1845; but it turned out she had puerperal sepsis, the likely reason for the sale, and from which she died. All these incidents, drawn from the medical journals of the day, illustrate a bit of the callousness of the age into which anesthesia was born. But the fact that they were mentioned, and that they were protested against — and that by doctors — shows that the ground was prepared.<sup>13</sup>

For it was finally the age of man, the common man, the individual man, man the downtrodden, man the suffering. In these days, Wilberforce and the Abolitionists were fighting slavery, Kierkegaard was bringing philosophy back to the outlook of the individual man, Dickens was the champion of the common man and Karl Marx was composing his Communist Manifesto. The revolutions of 1848 were being planned all over Europe to bring to culmination the *liberté, égalité* and *fraternité* of the French Revolution, spread abroad so paradoxically by the tyrant Napoleon. 1844 — this was the year Florence Nightingale made her decision for man; to nurse and care for suffering man was to become a profession, her profession.

Horace Wells, a Hartford dentist and a sensitive, conscientious man, attended a demonstration for popular entertainment by one, G. C. Colton, on 10 December 1844, which was to exhibit the effects of laughing gas, or nitrous oxide. During the demonstration one of the participants, while in the stages of excitement from the gas, struck his shin violently. Wells noticed, however, that it evidently caused the man no pain. As the man left the stage Wells went up to him to question him about this and to examine the leg. What Wells had seen was so convincing that he persuaded Colton on the following day to administer the gas to him, while his assistant Riggs pulled one of his teeth. The operation was as Wells had planned it — painless; the synapse had fired at last. After this Wells prepared feverishly to give his discovery to the world. Unfortunately, it never occurred to him that men would regard him as a hoax until proved otherwise; he felt men would naturally welcome his discovery with open arms. Approximately one month later, after intensive but all too hasty research with the gas, Wells went to Boston, enlisted the aid of a



former dental partner, William Morton, then studying medicine at Harvard, through whose efforts Wells hoped to be able to demonstrate his discovery to influential members of the faculty. They went first to Professor Jackson, Morton's preceptor, who discouraged the whole idea. Somehow, nevertheless, Wells did gain permission to demonstrate the effects of his gas at the end of a lecture by John Collins Warren, easily the most respected surgeon in America at the time. The demonstration failed, Well's patient shrieked out in the stage of excitement as the tooth was extracted (though he later stated he could not remember the tooth being pulled) and Wells was laughed out of the classroom, out of Boston.<sup>15</sup>

Morton too might have dismissed Wells except that he met, while visiting one day in Stafford Springs, Connecticut, a young lady who claimed she had recently had a tooth extracted painlessly by a dentist in Hartford named Wells. This was in July, 1846. One day in September, 1846, a wealthy lady called on Morton. He proposed to make a denture for her, once several teeth could be extracted. Fearing to lose his patient, Morton again sought out Charles Jackson, but finding him not at home, he borrowed a bladder from his laboratory, hoping perhaps to try Well's trick with it. On the way out Jackson met him and as they talked, Jackson suggested, it seems, using ether. Morton got the ether and that very evening a man called at his office with a violent toothache.(\*). Morton tried the ether, and it worked. This time it was Morton, who, after some hurried studies with ether, assayed into the lecture-hall of Warren; and this time the demonstration was successful. On 16 October, 1846, Warren removed a tumor from the neck of Gilbert Abbott, Morton having first anesthetized the patient. Unlike Wells, however, Morton tried to keep his discovery a secret, at least until it was patented. By 7 November, the secret was forced from Morton by the staff of the Massachusetts General Hospital and the discovery went winging round the world.<sup>15,7</sup>

By 19 January, 1847, James Simpson was using it in his obstetric practice in Edinburgh (so was Long in Georgia), but the inhalation of ether was often so difficult that he began a search for other anesthetics. He tried various volatile agents and eventually, on the suggestion of the chemist Waldie, chloroform.<sup>13</sup> (Flourens in France had already tried it on dogs, but had abandoned it — if the world had only heard — as too toxic).<sup>2,10</sup>

4 November, 1847, was the date of the first anesthetic use of chloroform, and on 28 January, 1848, chloroform had caused the first recorded death from anesthesia. Hannah Greener died while the anesthetic was being given before the contemplated removal of an ingrown toenail could be performed. John Snow, a recent medical school graduate, then began to keep a record of all anesthetic deaths and set out to make a science and a profession of anesthesia,<sup>13</sup> but unfortunately he died in

(\*) This account follows Thorwald *op. cit.* The exact chain of circumstances will perhaps never be known. For an account which credits Morton with more originality, cf. Fulop-Miller, *op. cit.*

1858. (\*) After this the science of anesthesia made surprisingly few improvements before c. 1900.<sup>6</sup> This was in no small part due to the obscurantist insistence of such giants (and tyrants) of the surgical world as Syme and Simpson (even Lister, knowing very little about it, was induced to write on the safety of chloroform) that absolutely anyone could give anesthesia and that chloroform was absolutely safe.<sup>13</sup> In the events mentioned in this last paragraph lie perhaps the greatest lessons that the history of anesthesia has to teach.

The arguments on the safety of chloroform raged, especially in England and Europe, for over 50 years. Finally in 1911, Goodman Levy's classic experiments on the effects of epinephrine in light chloroform anesthesia settled the matter, but it was not until 1917 that chloroform was for the first time responsible for as few as 75 per cent of the deaths per annum from anesthesia in England — after which time its use quietly and rapidly declined.<sup>13</sup> The dangers of delayed chloroform poisoning were described in 1894 by Leonard Guthrie, almost 50 years after its initial use; it had taken 7 years to collect his first 10 cases.<sup>13</sup> In 1956, Siebecker and Orth from Wisconsin reported on 7 cases of prolonged chloroform anesthesia in thoracic operations; there were 4 instances of severe hepatic damage with 2 deaths.<sup>13</sup> Might not closer scrutiny of the historical record of chloroform have lent more precaution to such work?

It was not until 1863 that nitrous oxide was reintroduced, Colton again administering it for dental anesthesia. By 1881 he had administered anesthesia with this gas 121,709 times without a death.<sup>13</sup>

About 1850 successful work on local anesthesia got under way. (The impetus for the investigation of alkaloids began when Sertuerner in Prussia extracted morphine from opium in 1806).<sup>17</sup> Because of the reports of the numbing effects of coca leaves on the tongue, Gaedicke in 1855 isolated the first coca leaf alkaloid and in 1860 Nieman another, naming it cocaine.<sup>2</sup> Although Bennett in Scotland (1873) first demonstrated the anesthetic properties of cocaine, and von Anrep in Germany (1878) described its pharmacology, it remained for Carl Koller of Vienna to investigate and employ cocaine in surgery, first using it on the eye. In 1884, the first regional block, that of the mandibular nerve, was performed — by Halsted. In 1855 Corning in New York published his book *Local Anesthesia*, which contained the first description of peridural anesthesia. In 1931 Togliotti described his experiences with peridural anesthesia, believed it to be a new method which he had discovered. (There is probably another lesson or two here somewhere on the importance of history). In 1899 Bier in Germany first described spinal anesthesia.<sup>2</sup>

#### *Quantitation*

The lack of quantitation held up anesthesia probably more than any other single factor. Gradually, however, it was realized, despite the protests of Syme, Simpson, Lawrie and others, that anesthesia had to become a science in its own right. The

(\*) Among other things, Snow was first to describe the stages of anesthesia, his scheme being later elaborated on by Guedel as a direct result of World War I, when it became necessary to teach a great number of people quickly how to give anesthesia.

first to investigate the proportions of nitrous oxide and oxygen to be used together in anesthesia was Andrews of Chicago in 1868.<sup>2</sup> He rightly surmised that the oxygen in nitrous oxide was not available for respiration and added measured quantities of free oxygen to prevent asphyxia. But until it was learned how to compress gases into cylinders and Hillischer, a Viennese dentist had devised the first portable machine to deliver measured amounts of a gas (1886), Andrews' work lay dormant. Indeed, it took the researches of such eminent students as Claude Bernard and Paul Bert to overcome the theory still present in the 70's that nitrous oxide anesthesia was a type of asphyxia.<sup>2,7</sup>

Codman at the Massachusetts General Hospital was the first to introduce anesthetic records (1894), and though Crile had been using a tonometer to measure blood pressure during operations, it was Harvey Cushing who brought back Riva Rocci's invention from Italy, the sphygmomanometer, and first used it in surgery in 1901.<sup>2</sup>

By the same token Pirogoff's use of rectal ether (1847), as well as the more recent oil-ether combinations of Gwathmey (1913-1930) and the rectal use of amylene hydrate (Avertin) were doomed to failure, simply because of the difficulty of calibrating the rectal uptake of anesthetic.<sup>2</sup>

In similar vein there are certain innovations, which according to the law of Galileo ("Science is measurement"), we can predict will become standard equipment eventually, such as carbon dioxide partial pressure gauges, blood pH monitors, etc.<sup>14</sup> Then, too, many of the discoveries made long ago, though not used, ought not be forgotten. Many of them will be returning. A method of Paul Bert's, a student of Bernard's, may be one of them. Realizing the far greater safety of nitrous oxide anesthesia, but also its inability to produce sufficiently deep anesthesia in some cases in less than asphyxiating concentrations, he devised an operating room (1878) in which the atmospheric pressure was increased by one-fifth of an atmosphere. At this pressure the patient could receive enough oxygen so as to avoid asphyxiation and enough nitrous oxide for deep anesthesia, a tremendously safe concept in anesthesia.<sup>2</sup> It is not inconceivable that a future surgeon on the moon will put on a sterile pressurized suit and step into an operating theater with such an atmosphere, where the patient falls asleep simply by entering the room.

#### *More Recent Developments*

Several other more recent developments in anesthesia remain to be mentioned.

Cyclopropane was discovered in 1882, but it was not investigated as an anesthetic till 1928 by Lucas and Henderson in Canada. In 1930, it was introduced into anesthetic practice by Waters at Wisconsin.<sup>2</sup>

Halothane was synthesized in England in 1957. It is hoped that the greater stability of the fluorinated hydrocarbons will avoid the toxic reactions known to occur with the chlorinated ones, such as chloroform and trichlorethylene. With its use the explosiveness of ether is also avoided. However, Davison points out that

the development of a new anesthetic, productive of multiple effects, goes against the modern evolution of anesthesia, which is to use separate drugs for each individual effect desired, and for this reason predicts no great future for such agents.<sup>6</sup> For the present, however, fluorinated hydrocarbons are capturing the imagination of many workers in the field and new ones continue to be synthesized and investigated.

In 1902 Fischer and von Mering in Germany synthesized the first barbiturate, which insured the continuance of intravenous anesthesia.<sup>2</sup> Christopher Wren had been the first to try this method, using opium in 1656.<sup>9</sup> The next step was not until 1872 when Oré in France began using chloral hydrate by this route.<sup>2</sup> Then came Hedonal in 1899, which because of its low solubility, required large amounts of fluid intravenously. Sykes estimates 11 deaths from pulmonary edema in 1600 cases of its use, and it also quietly passed from mention in the literature after 1913.<sup>13</sup> After 1903 intravenous anesthesia really belonged to the ever increasing host of barbiturate compounds. In 1934, the "ultra short-acting" barbiturates got their start with the discovery of thiopental by Lundy.<sup>2</sup> Since then their popularity has been ever increasing and the search for new ones continues.

The use of nitrous oxide and the thiobarbiturates having been established, the newest contributions to the simplification of anesthesia (in line with the one-drug-for-one-purpose concept) is the introduction of the muscular relaxants. Curare had been known in Europe since Sir Walter Raleigh mentioned it in a book in 1596.<sup>13</sup> In 1811, over 130 years before it was used in anesthesia, its muscle relaxing properties were described by Benjamin Brodie, who also showed how artificial respiration, if continued long enough, would rescue an animal from the poison.<sup>6</sup> (Interestingly enough, Brodie also had experimented on guinea pigs with ether, but after killing some, he gave up his investigations). In the 1930's, West reinvestigated and described the actions of curare and concluded, "I think the therapeutic use of curare will remain very limited". In 1942, Griffith in Montreal first used it in surgery and a whole new field of pharmacology and physiology was born.<sup>13</sup>

Of course, the use of the muscular relaxants had to await the development of positive pressure breathing. It was in 1543 that Vesalius first described tracheotomy and positive pressure breathing with one's own mouth in order to resuscitate an animal whose thoracic cage had first been laid open for study.<sup>2</sup> (Paracelsus had introduced a tube into the mouth and attached a bellows to it for resuscitation some years before).<sup>20</sup> The first successful resuscitation by mouth-to-mouth breathing recorded in the literature was performed by William Tossach in 1744.<sup>20</sup> But the method was too unesthetic ever to gain any wide popularity (though the method may be as old as history, cf. 2 Kings 4:34, and Genesis 2:7.) Therefore, various types of tubes were developed in the 18th and 19th centuries to aid in resuscitation. MacEwen was the first to use an endotracheal tube in surgery (1878); unfortunately, his 4th case died from chloroform anesthesia so he abandoned the method.<sup>13</sup> The man who then popularized the use of an endotracheal tube was O'Dwyer in New York (1882), who began saving victims of diphtheria from asphyxia by this means.<sup>13</sup> After this, Annandale (1889) and Kuehn (1905) popularized them for surgery.

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Incidentally, it was Elam and Safar of the U.S. Army who finally demonstrated (1956) the superiority of mouth-to-mouth breathing over all indirect methods of artificial respiration.<sup>20</sup>

In 1915, Jackson described a method for CO<sub>2</sub> absorption using soda lime, which would enable the rebreathing of anesthetics in a closed system, thereby greatly reducing the cost of anesthesia. This was popularized and improved by Waters in 1924; in 1926 the circle system was devised by Sword.<sup>2</sup>

In conclusion it can be stated that anesthesia has come of age. The year 1938 marked the high water mark in England of deaths associated with anesthesia. Till that time the number had increased almost annually, paralleling the increase in number of surgical procedures. Since then, the number of surgical procedures performed annually has risen faster than ever, but the number of deaths associated with anesthesia has shown a steady overall decline.<sup>13</sup>

In 1936, a chair in anesthetics was created at the University of Oxford, the first in the British Commonwealth and the first important endowment to promote training and research in anesthesia.<sup>13</sup> This was made possible, however, by the foresight and insistence of Lord Nuffield, a layman, over against the reticence of the Regius Professor of Medicine at Oxford at the time, Farqhar Buzzard, who, among other things, was the author 7 years prior to that date of an address entitled "Arrogance and Ignorance in Medicine". Let us hope that, among surgical brethren at least, the days of Syme and Simpson — insofar as anesthesia is concerned — are forever done with.

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