THE LEGACY OF JOHN SNOW

An Appreciation of His Life and Scientific Contribution on the 100th Anniversary of His Death

NORMAN A. BERGMAN, M.D.

ANESTHESIOLOGY has evolved from the empirical application of a single observation to a discipline of medicine based solidly on scientific observation and experimentation. The genius and ability of John Snow have contributed in a large measure to this development.

When anesthesia was a new discovery, it was in danger of repudiation because of the haphazard and irrational techniques which were employed in its application. Snow became the principle defender of this infant art against those who, because of their lack of knowledge or misinterpretation of facts, incriminated anesthesia in situations in which it was blameless. He explained the physicochemical and physiological principles related to the anesthetic state and demonstrated the safe and beneficial application of these principles. His contribution to anesthesiology was best summarized by his biographer, Sir Benjamin Ward Richardson, when he wrote, "What had been a mere accidental discovery . . . was turned by the touch of the master into a veritable science."

THE MAN

John Snow was born on June 15, 1813, the oldest son of a Yorkshire farmer. His early years were spent on his father's farm and at a private school in York. At the age of fourteen he began his medical career as an apprentice to a surgeon in Newcastle and for the next eight years assisted rural practitioners in various localities. The prospect of an exciting and stimulating student life in London attracted Snow to the great city, where he spent the rest of his professional life. In October 1836 he was enrolled in the Hunterian School of Medicine. Two years later he passed examinations qualifying him in medicine and surgery and began his practice at the Westminster Hospital. It was at this time that Snow first became associated with the Westminster Medical Society, an organization which gave younger practitioners an opportunity to associate with their medical colleagues and to air their scientific thoughts. Snow regarded membership in this organization of paramount importance to his scientific and professional development. Despite his shy and retiring personality, his competence and the sound-

Received from the Department of Anesthesiology, Columbia University, College of Physicians and Surgeons, and the Anesthesiology Service, The Presbyterian Hospital, New York 32, New York, and accepted for publication April 30, 1958. Dr. Bergman's present address: Department of Anesthesia, Veterans Administration Hospital, Salt Lake City, Utah, and Division of Anesthesiology, University of Utah School of Medicine.

ness of his arguments were soon recognized by "Westminster Medical" and eventually the honors of the presidential chair were his.

As is often the case, the size and financial returns from Snow's practice were not commensurate with his abilities as a physician. He hung out his shingle without buying a practice or obtaining all-important introductions to influential people or prospective patients. He practiced good and rational medicine, refusing to succumb to the whims of patients and referring physicians. It is, therefore, not surprising that Snow had sufficient time for medical investigation and writing. He read several papers before the Westminster Medical Society. He became a visiting physician to the outpatient department of the Charing Cross Hospital ". . . and to many a representative of the great poor he extended a skill which would have been a blessing to the great rich." Again seeking the highest level of his profession Snow successfully completed examinations and was awarded M.B. and M.D. degrees in 1843.

The rapid pace of London life soon began to show on Dr. Snow, who had only a few years previously recovered from early pulmonary tuberculosis. In 1845 he was suddenly seized by acute and alarming symptoms of renal disease and became unable to carry on his professional activities. With careful medical treatment and after a short rest away from the hustle and bustle of city life Snow returned to London with renewed health and vigour in the fateful year 1846.

In that year news came from America that the pain of surgery could be prevented if the patient inhaled the vapor of ether during the operation. This physiological observation with its extremely practical and humane application immediately captured the interest and fired the imagination of Dr. Snow. He had been previously interested in this sphere through his earlier work on asphyxia and respiration. With no thought of personal profit or even of immediate application, he quickly began a series of investigations of the physical and physiological factors relative to the inhalation of ether. Earlier administrators of ether had given little thought to these matters and had used adaptations of previously existing apparatus or hastily designed equipment based on little more than their unfounded concepts of what an ether inhaler should be. For this reason many of the initial etherizations were unsatisfactory or wholly unsuccessful. During the course of his investigations Snow easily deduced the cause of these difficulties and constructed an ether inhaler based on the scientific principles which he had observed. By animal and self experimentation, he satisfied himself of the reliability of his inhaler and his technique for the administration of ether.

The manner in which Snow was encouraged to apply his newfound knowledge to the practice of medicine and thus become the first full time anesthesiologist, is described by Richardson:

One day, on coming out of one of the hospitals (I am giving this narrative as he gave it to me) he met a druggist whom he knew bustling along with a large ether

apparatus under his arm. "Good morning," said Dr. Snow. "Good morning to you, doctor," said the friend, "but don't detain me, I am giving ether here and there and everywhere, and am getting quite into an ether practice. Good morning, doctor!" "Rather peculiar!" said the doctor to himself; rather peculiar, certainly! For this man has not the remotest physiological idea. An "ether practice!" If he can get an ether practice, perchance some scraps of the same thing might fall to a scientific unfortunate.

Dr. Snow immediately arranged to administer ether to outpatients at St. Georges Hospital who were having dental extractions. Having favorably impressed the staff, he again demonstrated the superiority and reliability of his inhaler and his technique during subsequent major operations. In a short time, almost all of the ether practice in London was in the hands of Dr. John Snow.

When chloroform was introduced in 1847, he recognized the greater expediency in using this agent. Having satisfied himself of the practicability and safety of chloroform by animal experimentation, he began the exclusive employment of this drug for anesthesia, again using an inhaler and technique based on the results of experimental observations. As with ether, the indiscriminate use of chloroform, without regard for the basic physicochemical principles governing its safe administration, soon produced disastrous results. Anesthesia might well have fallen into disrepute at this time but for the efforts of a small group, of which Snow was a leader, who succeeded in pointing out to the profession that the fault was not with chloroform but in the mode of its administration.

As the result of further scientific investigations and a successful anesthetic practice, Snow was soon widely recognized as the outstanding authority and practitioner in anesthesia. He administered chloroform on two occasions to Queen Victoria during childbirth. By 1851 he had reached the zenith of his career and was a greatly respected and a much sought-after member of the London medical profession. In 1855 the Medical Society of London acknowledged his position and his achievements by conferring upon him the office of president.

In his quest for the perfect anesthetic, John Snow investigated the general effects of narcotic substances and inhalation therapy and tested many volatile agents for their narcotic properties. "His grand search was for a narcotic vapour which, having the physical properties of chloroform, should in its physiological effects, resemble ether in not producing paralysis of the heart," or ". . . an anesthetic that might be inhaled with absolute safety and which would destroy common sensation without destroying consciousness."

Anesthesia did not monopolize Dr. Snow's attention. His outstanding contribution to the field of epidemiology (2) had its inception during an epidemic of cholera around Newcastle in 1831–32 during his general practice days. His intensive investigation during the great cholera outbreak of 1854 culminated in Snow's theory on the mode of transmission of cholera, which was essentially correct in all its details. The

epidemic ceased, abruptly and dramatically, when the handle of the Broad Street pump, the source of the contamination, was removed at his suggestion.

John Snow's industry and perseverance were in evidence even in his early youth and he applied himself diligently to whatever undertaking was at hand. At the age of seventeen he became a vegetarian, abstaining from all foods of animal origin, including dairy products, until ill health forced him to revise his views eight years later. Simultaneously with the establishment of his vegetarian habits he espoused the temperance movement, became an active worker in this cause, and except for a very occasional sip of wine stood by his views on abstinence from strong drink for the rest of his life. He loved nature and enjoyed long walks through the countryside and in his youth was noted for his ability as a swimmer. His whole way of life was Spartan, and while he was establishing his medical practice ". . . he lived on anchorite's fare, clothed plainly, kept no company, and found every amusement in his science books, his experiments and simple exercise." Because of his very reserved manner and solitary existence he was considered somewhat peculiar by many with whom he came in contact.

Snow was not what might be considered a brilliant man. His companion at the Hunterian Medical School, Joshua Parsons (1) observed that he was ". . . not particularly quick of apprehension or ready in invention" but that he "kept in the foreground by his indomitable perseverence and determination." He was the personification of order, having a time and place for everything and keeping minute records of his clinical and experimental observations. He let no personal considerations stand in the way of scientific pursuits. At the medical meetings which he attended frequently, he spoke often and his arguments were quickly formulated and of sound logic. He was widely read in science and the history of medicine but considered most fiction particularly unrewarding. In his relationships with his fellow man Snow exhibited the utmost honor and integrity. Although he joined no sect nor professed any religion he acknowledged the existence of a Divine Spirit by silent admiration and respect of His creations.

Although not quick to make friends, those who succeeded in breaking through the wall of reserve found in John Snow a warm and agreeable companion. His private conversation was amusing and filled with humorous anecdotes which he enjoyed relating in his peculiar droll fashion. He particularly enjoyed hearing passages from Dickens, Thackeray and other authors who saw and interpreted human nature as astutely as Snow himself observed it. He also took a particular interest in the appreciation and advancement of art. Although he never had any romantic interest, his great pleasure in being invited to be a member of a family circle and his fondness for children caused him to express regret at never having married.

In the prime of life and at the height of his medical career while working on his book "On Chloroform and Other Anesthetics," John

Snow suffered a cerebral hemorrhage and died eight days later on June 17, 1858, and was buried in Brompton Cemetery. Those who knew him best placed a simple marker over his grave.

The Scientist

In addition to many original observations and deductions John Snow made many important applications of known facts to the problems with which he was confronted. An example of the astuteness of his powers of observation and deduction is the estimation of pulmonary washout time by the chance observation that a certain individual required only three breaths to clear his exhaled air of smoke after a deep draught on a cigar.

Snow's first paper, read before the Westminster Medical Society in 1841, introduced a double piston air pump for use in resuscitation. It contained some thoughts on the cause of the first breath after birth which he attributed to lack of oxygen owing to the cessation of placental function. Subsequent papers concern a clever device for performing thoracentesis, a technique for removal of the placenta in cases of postpartum hemorrhage, and a discussion of the capillary circulation.

Less than two months after the introduction of anesthesia into England, John Snow published his first observations on ether. This and other subsequent papers and additional observations were summarized late in 1847 in Snow's first book "On the Inhalation of the Vapor of Ether in Surgical Operations." The greatest difficulty in the writing of this book was in the setting down of his ideas in a clear and understandable manner. In the introduction he stated: ". . . it is not easy to reduce a new branch of science to suitable language in the first attempts."

On the basis of many observations during the conduct of ether anesthesia Snow became the first to classify the signs of anesthesia into a clinically useful sequence. Although both Plomley (3) and Flourens (4) had suggested systems for the classification of depth of anesthesia several months prior to Snow, Plomley's was much too gross and Flourens' was based on his interpretation of animal experiments. The extreme importance of having such a workable clinical classification of depth of anesthesia was emphasized by Snow when he wrote that ". . . the point requiring most skill and care in the administration of the vapour of ether is, undoubtedly, to determine when it has been carried far enough."

To this end Snow divided the course of etherization into five degrees. He stated that these degrees were in some measure arbitrary, merged gradually into one another and were not always clearly distinguishable. The degree of etherization was not always obvious from observation of the patient; and frequently other factors such as duration of inhalation, strength of the vapour and the amount of ether consumed had to be considered in the assessment of depth of anesthesia.

The first degree of etherization was characterized by retention of

consciousness, orientation, and ability to perform voluntary movements. Although Snow stated that surgery is not practical without carrying etherization beyond this degree, he observed that once patients had been anesthetized in deeper degrees and subsequently lightened to the first degree ". . . they are not infrequently free of the pain of an operation which is still going on, at a time when the mental facilities have returned, together with the special senses of sight and hearing."

The second degree of etherization was recognized by the exercise of mental function and voluntary actions performed in a disordered manner and guided by instinct rather than reason. Patients could often be directed in this degree but they were obstinate and were no longer aware of their surroundings or cognizant of the purpose of the inhalation. In the course of a smooth etherization this degree was usually passed through smoothly but if for any reason a more dilute vapour of ether was used, difficulty with the excitement of this degree could often be anticipated. Although the patient would probably not remember an operation attempted at this stage, Snow pointed out that the associated delerium and inability to cooperate would make surgery more difficult than if etherization had not been attempted at all.

In the third degree ". . . there is no evidence of any mental function being exercised and consequently no voluntary motions occur." The breathing was usually deep and regular and the pupils may be stationary or exhibit voluntary motions but an active lid reflex was retained. If this degree was not well established, healthy and more particularly plethoric, individuals might respond to surgery or other external stimuli by breath holding or muscular contractions.

The fourth degree of etherization was manifested by lack of all movements except those of respiration, and these are incapable of being influenced by external impressions. Pulse and respiration remained good but "... an appearance is met with that would be truly alarming if we did not know that it was only due to an agent which is flying away every moment in the breath to leave the patient in a few minutes, without any permanent trace of its having been there." Snow believed that stertorous respiration was characteristic of this degree but that the pharynx and glottis retained their sensitivity and aspiration could not occur. He believed that maintenance of etherization in this degree for prolonged periods was not advisable and during lengthy procedures intermittent lightening of etherization was deemed important.

Difficult, feeble, or irregular breathing followed by the paralysis of respiratory movements were considered to be characteristics of the fifth degree. Snow wrote that his degree was not observed in the human.

Snow's ether inhaler was an immense improvement over all existing apparatus for the administration of ether. It was a direct and deliberate application of the known physical principles of thermal conductivity, vapor pressure, and gas flow; matters to which others had given little or no thought. He observed that many early inhalers were made from glass and a sponge. Both are poor conducters of heat, so

that during the course of an inhalation the temperature in the inhaler fell below the freezing point of water and very little ether vapor was inhaled. In addition many of the earlier inhalers offered obstruction to breathing because of the presence of the sponge, the ether itself, by valves of insufficient size or by tubing of too narrow calibre. For these reasons many of the first attempts at etherization were failures and in Snow's opinion when success was achieved it was often partly due to asphyxia.

Snow emphasized the importance of knowing the strength of the vapor during the administration of ether. By equilibrating ether with air he determined experimentally the quantity of ether vapor in a given volume of air at various temperatures. He applied these studies to the regulation of the concentration of vapor in his inhaler by varying the temperature of the ether. The inhaler was made of metal, the best conductor of heat, and incorporated a water bath, which could be regulated to any desired temperature, as a source of heat for the vaporization of ether. The quantity of water was sufficient for the vaporization of one or two ounces of ether without a significant fall in temperature. The helical design of the vaporizing chamber permitted almost complete saturation of the air with ether at the predetermined temperature of the water bath. All valves were delicately balanced and the tubes were larger than the trachea to permit unobstructed flow of the ether-air-mixture.

The ether used in the inhaler was a matter of considerable importance. The varying quantity of alcohol in the ether that Snow obtained was a source of difficulty because it altered the boiling point of ether and he believed that it made the vapor more irritating; therefore, extraction of this alcohol with water was advised. This "washed ether" contained 10 per cent water, but Snow recognized the importance of humidification of anesthetic atmospheres and believed this to be quite desirable.

By demonstrating that the effects of ether in oxygen are identical with those of ether in air, Snow disproved the early and popular theory that the action of ether was entirely by the exclusion of atmospheric oxygen. He differentiated sharply between the anesthetic state produced by ether and that of asphyxia when he wrote: "I found that when an animal was gradually asphyxiated . . . insensibility to injuries was induced, but that it was a painful process to induce insensibility in this way, and also dangerous to the life of the animal . . . the insensibility so induced being of short duration before it ended either in death or recovery to a state of sensibility; circumstances which practically cause it to differ widely from the state of etherization."

When chloroform was introduced in 1847, Snow commenced a series of laboratory investigations of this substance and, abandoning ether, employed chloroform exclusively in his clinical practice. His researches and clinical observations on chloroform are summarized in his unfinished volume "On Chloroform and Other Anesthetics" which was published posthumously in 1858. This work also contains the re-

sults of laboratory and clinical observations concerning other substances that were tested by Snow for their anesthetic value, as well as a restatement and further thoughts on ether.

The degrees of chloroform anesthesia in general resembled those of ether. Snow again pointed out the excellence of analgesia in light degrees of narcosis after previous establishment of anesthesia at a deeper level. He explained this on the basis of peripheral action of chloroform. He reasoned that the delay in the return of the anesthetic from the tissue fluids to the blood caused a higher concentration to be present in peripheral nerves at a time when the brain, with its relative lack of lymphatics and tissue fluid, had been cleared of most of its narcotic. Snow's chloroform inhaler was designed on the same principles as his ether inhaler, modified because of the greater potency of chloroform and the smaller amount of agent required. Again the percentage of vapor was regulated by the temperature of a water bath. He emphasized repeatedly that a known and controllable anesthetic concentration was the prime requisite for the safe administration of chloroform.

A great deal of attention was given by Snow to certain quantitative aspects of ether and chloroform anesthesia. By placing animals in large jars containing known concentrations of anesthetic vapors he determined the concentration of vapor necessary to produce each degree of narcosis. He also determined the air/blood ratio for these substances and thereby also the blood concentration at any level. Using current estimates of blood volume or total body fluid he was able to calculate the weight of anesthetic agent necessary to achieve any given degree.

Snow also observed and reported for the first time, the progressive intercostal paralysis characteristic of deeper levels of anesthesia. He observed and explained the continued deepening of narcosis for a short interval after cessation of administration of chloroform. When he employed a solution of potassium hydroxide to absorb carbon dioxide during rebreathing in the course of an experiment, he became the first person to use the absorption technique during anesthesia. He described the decrease in oxygen consumption and carbon dioxide production during the anesthetic state and pointed out the significance of the anatomical dead space in calculations concerning ventilation. In the belief that the most exact way to administer chloroform was to make a sufficient quantity of vapor by introducing a measured amount into a large balloon, Snow anticipated Clover's apparatus and used this method for a short time. The 4 per cent chloroform that resulted produced excellent clinical anesthesia but he abandoned this technique because of the large size of the apparatus required and other technical difficulties

In January 1848, the death of Hannah Greener, the first fatality recorded from chloroform, attracted wide attention in both medical and lay circles. The conclusions at the inquest were based on medical

testimony and post-mortem findings. This death was attributed to some constitutional peculiarity of the patient which caused her to react to chloroform in this manner and which was not detectable prior to administration of the agent. Other deaths from chlorofrom were reported at intervals and Snow collected 50 cases, subjected them to careful analysis and inquiry and published his conclusions.

Francis Sibson, in 1848, first pointed out that death during chloroform anesthesia was due to paralysis of the heart but he was not aware of the mechanism of this phenomenon (5). By subjecting animals to varying concentrations of chloroform vapor Snow demonstrated that with dilute mixtures respiratory failure could occur before cardiac failure with an excellent possibility of recovery when anesthesia was discontinued. However, with more potent concentrations of chloroform primary cardiac failure occurred and frequently respirations continued for a short interval after cessation of circulation. Snow concluded that the cause of death in each of the 50 cases in his series was the failure to regulate the percentage of vapor resulting in the administration of a too concentrated chloroform vapor too quickly. If the proper strength of vapor were used death would have been gradual, respiration would have ceased before circulation and many of the patients would have recovered, spontaneously or with artificial respiration, when administration of the chloroform had been stopped on the appearance of alarming symptoms. However in each case death was sudden and unresponsive to therapy. In many cases Snow was able to report that the amount of chloroform placed on the handkerchief or in the inhaler was greatly in excess of the quantity which he had previously calculated to be necessary for the production of narcosis. In many cases the patient was already pulseless when there was still evidence of respiratory and other muscular activity. Other alleged causes of death such as extremes of age, idiosyncrasy, impurity of the agent, faulty apparatus, asphyxia, and respiratory obstruction were examined by Snow and eliminated as factors in this group of cases. He concluded that the most important measure in the prevention of death due to chloroform was to be certain that the vapor was always sufficiently dilute so that primary cardiac syncope did not occur. Symptoms were observed as they arose and since it was very difficult to treat an overdose effectively careful administration of chloroform was of paramount importance. In the treatment of an overdose, prompt application of artificial respiration was the only therapeutic measure recommended by Snow which would reverse the overdose when this was possible. All other measures were useless and usurpers of valuable time.

As Snow pointed out, if certain individuals were liable to die during chloroform anesthesia because of some undetectable idiosyncrasy peculiar to their constitution, any person could be justifiably terrified at the prospect of being anesthetized because of the possibility of being in this unfortunate group. By his logical exposition of the cause of

death during chloroform anesthesia Snow undoubtedly did much to restore confidence in anesthesia and to bolster the waning enthusiasm of surgeons and their patients to avail themselves of this now indispensable blessing. Snow readily acknowledged the greater safety of ether when compared with chloroform. When asked why he did not therefore use ether he replied: "I use chloroform for the same reason that you use phosphorus matches instead of the tinder box. An occasional risk never stands in the way of ready applicability."

Snow's outstanding contribution to medicine, aside from his work in anesthesia, was his theory on the epidemiology of cholera. During the period before the foundation of modern bacteriology Snow postulated that the etiologic agent of cholera was a microorganism, an obligate parasite propagated only in the human intestinal tract and disseminated by ingestion of human excreta. It is difficult to determine how much of this theory was original and to what extent Snow incorporated previous work in his thinking. It is inferred that he was the first to state this idea *in toto* since his contemporaries referred to it as "Dr. Snow's theory."

The Practitioner

Richardson estimated that during the time Snow was engaged in the practice of anesthesia, a little over ten years, he gave approximately 450 anesthetics each year. Thus his personal experience was drawn from approximately 5,000 cases, the great majority of which were chloroform anesthetics. During this period his average annual income was 1,000 pounds, a good amount for those times but far short of many of the estimates of his contemporaries.

John Snow acknowledged no contraindication to the inhalation of anesthetic vapors. In the belief that no matter what other complicating disease was present the fear, pain, and struggling of surgery without narcosis was far more deleterious to the patient than the anesthetic state, he never declined to accept any candidate for anesthesia. In his entire career Snow had 3 deaths during inhalations: one during the administration of chloroform, which was in his opinion not related to the anesthetic, and two during clinical trials of amylene, probably caused by faulty vaporization of the agent.

Many factors were observed to modify and influence the effect of anesthetic agents. Extremes of age altered the response to inhalation of narcotic vapors, the very young and the very old being particularly susceptible. Snow also stated that the effects of anesthetics last longer in elderly people because of their slower respiration and circulation. Physical strength and vigor were noted to increase the amount of agent required while debility and the shock-like state following acute illness or severe injury markedly decreased anesthetic requirements. "Hard drinkers" were recognized as particularly difficult subjects. If asphyxia occurred during induction a great deal more struggling could be anticipated.

In Snow's early anesthetics the vapor was administered through a mouthpiece which the patient held between his lips. There was a great tendency for the patient to breath around the mouthpiece or through his nostrils, however, and this apparatus was soon abandoned in favor of a face mask. Snow adapted the mask invented by Francis Sibson (6) which was fabricated from thin sheet lead and covered with leather so that it could be molded to conform to each patient's face. Directional valves in the mask permitted inhalation from the inhaler and exhalation to the atmosphere. The ether inhaler was adjusted to deliver vapor in a concentration of 35.0 per cent (in earlier cases 45 per cent was used) and the chloroform inhaler delivered a concentration of 5.0 per cent under clinical conditions. These concentrations were much too irritating for induction of anesthesia so initial dilution with air and gradual attainment of the final tensions were necessary. Snow achieved this by designing the exhalation valve to pivot sideways permitting inhalation to occur through the exhalation port as well as from the inhaler. Induction began with the exhalation port open, thus greatly diluting the vapor from the inhaler. The port was gradually closed until full-strength vapor was respired. If all went smoothly this often required only 15–30 seconds but if coughing or breath holding occurred appropriate dilutions of the vapor were necessary. Narcosis was maintained by intermittent inhalation of vapor when deemed necessary by observation of the patient.

Criteria for beginning surgery included assessment of the degree of narcosis, consideration of the amount of agent vaporized and the duration of inhalation, but Snow regarded the disappearance of an active lid reflex as the most important indication that surgical anesthesia had been achieved. The onset of stertorous respiration, marking the beginning of the fourth degree of narcosis was a signal to stop the inhalation. He believed that this indicated an unnecessary depth, but he acknowledged that in situations requiring muscular relaxation, such as in the reduction of long standing dislocations, the fourth degree was often necessary. Pulse and respiration were observed carefully and continuously throughout the inhalation.

Snow described both passive regurgitation and active vomiting during and after anesthesia and regarded them as unpleasant nuisances rather than potentially dangerous incidents. He recommended that patients fast for two to four hours prior to anesthesia. He recognized that patients in a state of fear, anticipating surgery, often had a greatly prolonged gastric emptying time. In operations where avoidance of vomiting was of importance to the outcome of the operation as in cataract extraction, a much longer fast was recommended. All postoperative vomiting was not due to anesthesia. Opiates or associated disease were often to blame. He also advised that a large towel be included in the anesthetists' armamentarium to wipe away the copious quantities of saliva produced during inhalation.

Cyanosis sometimes occurred during coughing and breath holding but it was not observed at other times during anesthesia. Snow emphasized that those who taught otherwise were not giving their patients a sufficient amount of air. Many other specific anesthetic problems were considered by Snow. In amputations and other procedures where large vessels were involved he emphasized the importance of keeping patients motionless until they were secured. During surgery around the airway, such as excision of tumors of the jaw or cleft lip operations, the importance of retaining the laryngeal and cough reflex was pointed out. Frequent drainage of blood from the mouth by tilting the head forward was advocated. Anesthesia was induced with the inhaler and maintained by careful administration of the agent from a sponge. Keeping the patient asleep frequently was quite difficult. He became the first person to administer endotracheal anesthesia when he gave chloroform through a laryngotomy to a young boy for exploration of the air passages for a foreign body. On this occasion he observed that when the vapor was given rapidly a feeling of suffocation occurred. He deduced therefore that when this occurred during routine inhalation it was due, in part, to the presence of concentrated anesthetic vapor in the lower air passages. Snow acquired a considerable experience in the administration of anesthetics for labor and delivery and in various medical conditions such as asthma, convulsions and tetanus. He discussed these at length. His ability as a clinician was not restricted to the practice of anesthesia; and his opinions on other medical matters were much sought and respected, circumstances which caused Richardson to refer to him as "one of the soundest and most acute of our modern physicians."

Summary

On the hundredth anniversary of the death of John Snow, the first anesthesiologist and the founder of the science of anesthesiology, his life and his work stand as a source of inspiration and wonderment to those who practice this discipline today. We are only beginning to rediscover and appreciate some of the principles which to him were obvious and fundamental.

REFERENCES

1. Biographical material and quotations were obtained from Sir Benjamin Ward Richardson's Monograph: John Snow, M.D. A Representative of Medical Science and Art of the Victorian Era, Aesclepiad (London) **4**: 274, 1887.
2. Other material and quotations were obtained from the following publications by John Snow: (a) On the Inhalation of the Vapour of Ether in Surgical Operations. John Churchill, London, 1847. (b) On Chloroform and Other Anesthetics. John Churchill, London, 1858. (c) Snow on Cholera. Reprinted by Commonwealth Fund, New York, 1936. (d) Numerous original papers and articles published in *Lancet* and *London Medical Gazette* from 1847–1851. All were summarized in the book "On Chloroform and Other Anesthetics."
3. Plomley, F.: Lancet (Jan. 30) 1847.
4. Flourens, P.: C. P. Acad. Sci., Paris **24**: 161, 253 and 340, 1847.
5. Sibson, F.: Med. Gazette **42**: 109, 1848.
6. Sibson, F.: Med. Gazette **42**: 363, 1848.