

Arthur E. Guedel

Memorial Anesthesia Center

A Historical Tour of Nitrous Oxide Induction

By Merlin Larson, M.D.

Most anesthesia residents would deny that an anesthetic could be safely delivered without electronic monitoring equipment. However, to those trained in the early 1960s, an anesthetic without electronic monitors does not seem dangerous—the earpiece, esophageal stethoscope, and hands on the patient were adequate monitors.

Looking back in time, it is not difficult to find techniques that seem unsafe. The puzzling question is why some of these techniques were so difficult to abandon. A prime example of a practice that seems dangerous to us is the use of 100 percent nitrous oxide.

Arthur Guedel's first publications promoted the use of 100 percent nitrous oxide for labor analgesia. Prior to his landmark work on the depth of anesthesia, nitrous oxide anesthesia in obstetrics was his primary interest. In these papers Guedel advised the parturient to breathe pure 100 percent nitrous oxide for a few breaths at the beginning of each contraction. Figure 1 is copied from his article entitled "Remarks on the Technique of Nitrous Oxide in Obstetrics" from the *American Journal of Surgery*, October 1922. He had a rudimentary knowledge of the uptake and distribution of the gas in the body and thus advised that only a few breaths at the initiation of a contraction would provide satisfactory analgesia. He reasoned that the alveoli contained other gases and that pure nitrous oxide would be diluted in the lungs.

In one of his widely disseminated papers, Guedel stated that the fears of pure nitrous oxide inhalation were grossly overexaggerated. His seminal papers on the topic were published in 1915 (*Year Book of Analgesia and Anesthesia* (1915-1916)), just prior to the time when WWI would change his life forever. E.I. McKesson continued to use the pure nitrous oxide induction methods into the 1930s, but the practice lost popularity after C.B. Courville's landmark paper in 1936 on the deleterious cerebral effects of anesthesia with high concentrations of nitrous oxide.

The intriguing question is why this practice of using less than 20 percent oxygen during anesthesia lasted as long as it did. Edmund Andrews introduced the use of mixtures of nitrous oxide and oxygen in 1868 and promoted it as a safer alternative to either nitrous oxide alone or nitrous oxide mixed with air. Hewitt devised an anesthesia machine that delivered fixed mixtures of nitrous

Guedel Center (cont'd)

oxide and oxygen in 1876. Several enlightened anesthetists advised use of oxygen with nitrous oxide, but the practice of nitrous oxide alone or with air lasted well into the 20th century.

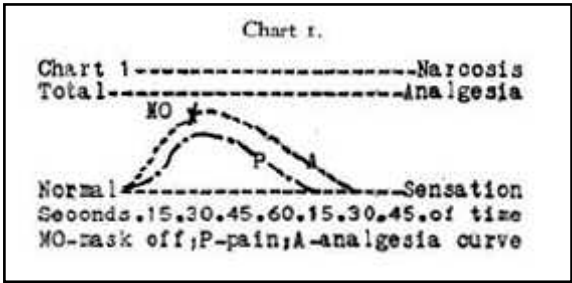


Figure 1: Guedel's labor analgesia with the nitrous oxide technique. On the x axis is time in 15-second increments. Pure nitrous oxide is inhaled from the beginning of the contraction until the black star initialed MO (mask off). Note that the analgesia curve stays above the pain curve for the duration of the contraction. In Guedel's papers, there are several variations on this chart, depending on the rapidity of the pain at onset, the duration of the contraction, and patient characteristics.

Gardner Quincey Colton, who first introduced nitrous oxide inhalation and demonstrated its effects to Horace Wells in 1844, was a forceful proponent for the use of the pure gas. In 1868, he described his method for dental extractions as follows:

Use a mouth piece which has an aperture of a full half inch to breathe through. Instruct the patient to take full, deep and slow inspirations of the gas, and hold the lips and the nose so as to allow **no particle of common air** to enter and dilute the gas. The symptoms as to when the patient is "ready," although unmistakable are hardly describable—usually stertorous breathing, and in delicately organized subjects, a slight twitching of the fingers or the head.

It became widely accepted that the addition of air or oxygen made the nitrous oxide anesthetic more difficult to manage. In 1895, for example, Buxton wrote that:

If nitrous oxide can be given without any cyanosis, jactitations (clonic or tonic spasms) or other signs of oxygen starvation, it may be employed with safety for practically all persons and ages...it is not denied that a mixture of air or oxygen and nitrous oxide is more

Guedel Center (cont'd)

difficult to manage and requires more skill to bring it to a successful termination, but the important aid it renders us in dealing with difficult and dangerous cases outweighs any disadvantages it may possess in this respect.

Ferdinand Hasbrouck delivered a high-profile nitrous oxide/air anesthetic to President Grover Cleveland on the yacht Oneida in 1893. On July 1 of that year, Cleveland had two-thirds of his maxilla removed for a cancerous lesion of the hard palate by the surgeon Joseph Bryant. The operation was performed in the stateroom of the yacht Oneida while it sailed from New York Harbor to Buzzard's Bay, where Cleveland had a private estate. Cleveland was a huge man, nearly 300 pounds with a large neck and a heavy mustache (Figure 2). The anesthetic was induced in the sitting position with air and nitrous oxide via mask, with no monitors other than a hand on the pulse. There were no laryngoscopes, no endotracheal tubes, no lab data, no EKG, no blood pressure measurements, no IV, and no operating table—and they were operating in the airway. Although the delivery of this anesthetic seems impossible and strictly dangerous to us, the details of Cleveland's anesthetic and operation have been well documented and can be readily reviewed at http://en.wikipedia.org/wiki/Grover_Cleveland. The neurosurgeon W.W. Keen wrote a short book on the operation that details the anesthetic and the surgery (*The Secret Operation on President Cleveland in 1893*, George Jacobs, 1917).

Figure 2: Would anyone today mask-induce this patient with nitrous oxide and air? The image is a caricature of President Grover Cleveland by Davenport, appearing in Rexford G. Tugwell's book *Grover Cleveland* (Macmillan, 1968). Image is from the "Collection of the New-York Historical Society," Negative Number 28541, and is reprinted here with permission.

The remarkable point about this anesthetic is that no one today could do it or would do it. Imagine inducing a morbidly obese 56-year-old male in a ship without an IV, laryngoscope, or any monitors. This was a top-secret operation

on the President of the United States, in a confined space, with no suction, and the operative site was in the airway. It sounds not only dangerous and foolhardy, but also impossible. Yet Ferdinand Hasbrouck, who delivered the anesthetic, had this to say prior to the procedure: "I have done it repeatedly and have never known any unfavorable results from its use under such circumstances."

Although Courville's article may have led to the abandonment of nitrous oxide by itself or with air, the use of nitrous oxide anesthesia was not neglected. Nitrous oxide found new life following the introduction of muscle relaxants into anesthesia practice. In the 1940s through the 1960s, the potent agents were ether, halothane, Fluroxene, and cyclopropane. Each agent had unique limitations. Practitioners tried to avoid "halothane hepatitis" by using the so-called nitrous oxide-narcotic method in patients who were "predicted" to develop this rare syndrome. Nitrous—narcotic anesthesia—consisted of nitrous oxide 70 percent, oxygen 30 percent, Demerol, curare, and hyperventilation. Although this combination should provide adequate oxygenation, it is highly likely that many of these patients were only marginally oxygenated. Pulse oximetry was introduced in the 1980s and this additional monitor largely led to the abandonment of the high-concentration nitrous oxide anesthetic.

There are anesthesiologists alive today who used the pure nitrous oxide induction and they recall no hesitation in using the technique, nor did they think that it was a dangerous practice at the time. It would have been difficult to find any change in cognitive function by simply observing individual cases in one's own practice. Grover Cleveland, for example, gave a rousing speech to Congress on August 7th and his efforts were largely responsible for the repeal of the Sherman Silver Act—effectively preventing the financial ruin of the country and avoiding a total collapse of the American economy. However, today we view these anesthetics with less than 21 percent oxygen as dangerous. Admittedly, they probably did lead to cognitive decline in some patients. Similarly, the lack of electronic monitoring equipment did occasionally result in an unpleasant "surprise" in the operating room (e.g., cardiac arrest).

But, the anesthesiologists, during those eras, were not particularly uneasy about their techniques and worked through their schedules without concern—just as we today go about our "safe" practices without awareness of any possible wrongdoing. What is dangerous or reckless today? Will our residents be slightly embarrassed by techniques that we have taught them? If the history of our specialty is prologue, then it seems certain that some aspect of contemporary anesthetic care will be looked upon as unsafe by the next generation.

Guedel Center (cont'd)

In the January-February 1998 issue of the CSA Bulletin, the Guedel Center section offered the article, "When the President Vanished," by John Moses, M.D., and Wilbur Cross, which tells of a risky and secretive anesthesia and operation given to then President Grover Cleveland. Please contact the CSA office (800-345-3691) if you wish to have a copy of the article.

Editor's note: This is a comment of some historical interest (at least to me, but perhaps more of hysterical interest) of Merlin Larson's Guedel article initially called "Safe Practice," but for which I suggested it be renamed "A historical tour of nitrous oxide induction." When I was a wee bit of an anesthesiologist doing open hearts as a resident at the Massachusetts General Hospital in 1966, I recall using a "hypoxic" induction mixture of nitrous oxide and oxygen, leading into halothane, for patients who were to undergo mitral valve surgery. Some of this data was published as a "Work in Progress" in *Anesthesiology* in 1963, Phillips Hallowell being the senior author (with three "giant" co-authors: Myron Laver, John Hedley-Whyte, and Gerald Austen), although the actual induction technique was not described in this brief article. Patients were medicated with morphine and scopolamine. Then here is the regimen as best as I can remember, and I do recall most if not all of the detail because of the trepidation of using a hypoxic mixture. Induction was preceded by preoxygenation for five minutes with 100 percent oxygen, after which we introduced a 7:1 mixture of nitrous oxide-oxygen for one minute, then a 4:1 nitrous oxide-oxygen mixture for another two minutes, and then moving onto a 4:2 nitrous-oxygen mixture with gradual introduction of halothane until succinylcholine was administered for intubation. I do recall Dr. Hallowell drawing arterial blood gases during the induction to assure me that this was a safe technique. Indeed, there never was an arterial oxygen tension anywhere near an unsafe level, and these were all very sick mitral valves, an almost universal circumstance in those early days of mitral valve surgery. And, no, there never was a case of recall by the patient, but of course, we had used scopolamine as a prophylaxis against any such event.



Arthur E. Guedel Memorial Anesthesia Center,
2395 Sacramento Street, San Francisco, CA 94115
(415) 923-3240; <http://www.cpmc.org/professionals/hslibrary/collections/guedel>