

Leaves and Needles: The Introduction of Surgical Local Anesthesia

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THE CURARE REVOLUTION in anesthesia, initiated at the suggestion of Lewis H. Wright,¹ had several parallels with its predecessor, the local anesthesia revolution begun by Carl Koller with cocaine. Both were produced with an alkaloid, both applied pharmacologic information that had long been available, and in both a vast therapeutic advantage involved terrifying new dangers. The centenary of Koller's contribution offers an opportunity to sketch its dramatic, not to say melodramatic, context, accented with notes from the lullaby of the coca leaves and the early stabs with spinal needles.

Koller's epochal finding, in Vienna in 1884, was that the ocular instillation of cocaine completely abolished sensibility of the cornea and conjunctiva. This was announced and demonstrated at the Congress of Ophthalmology in Heidelberg, Germany, by Dr. Josef Brettau. Brettau did so on Koller's behalf because Koller himself, at the age of 27, was an impecunious intern and could not afford the cost of the rail journey from Vienna. It was ill fortune enough that Koller had to pass up his moment of his triumph, but there was worse to come.

Vienna in 1884 was gloomy, especially at night. There was no electric light. There was none anywhere in Europe. The first public power station had been built in New York in 1882, but a transatlantic follow-up was still 1 year away. Vienna was the capital of a turbulent multinational empire and a Mecca of medical education. Modern medicine was young, and drug action was poorly understood but surgery was already entering a new era in which Lister's system of antisepsis had made it safe to open the abdomen. Although asepsis and surgical gloves still lay in the future, Billroth had performed the world's first gastrectomy in Vienna in 1881. The Austrian Novara expedition² had brought back to

German-speaking Europe a big batch of the leaves of *Erythroxylum coca*, the sacred plant of the Incas; an active principle had been isolated from the leaf, but its properties were not clearly understood. Chewing the leaves of the coca plant was an ancient practice, reported to assuage the hungry, invigorate the weary, and brighten the depressed. "The leaf is a mild stimulant, and has legitimate medical uses. In fact it is the only known remedy for altitude sickness. In Bolivia's cities and towns, coca is sold on the open market. Five thousand years ago the dead here were buried with a bag of coca leaves to speed them on to the next world. Today the living chew coca to spare them some of the rigors of this world."³

In Peru the Indians dry the leaves⁴ and chew or suck a wad^{5,6} after priming it with plant ash. This is a remarkable instance of folkloric chemical wisdom, for the ash is alkaline and thereby releases the alkaloid in absorbable form. Choice coca leaves contain up to 0.6% by weight of cocaine⁷ as well as smaller quantities of other alkaloids. The levels of cocaine in the blood plasma of coca leaf chewers have recently been measured by Holmsted *et al.*⁸ The peak, about 150 ng/ml, is reached in 0.5 to 2 h and is followed by a slow decline. The level may be several times higher than after a nasal application of cocaine prior to nasotracheal intubation.⁹ The Indians say that, besides appeasing hunger and giving them endurance, chewing coca makes them feel warmer.¹⁰ One wad or chew of the leaves will last about 1 h, and is then discarded, and they typically repeat this four times a day.

The Indians of the High Andes are not alone in their liking for the coca leaf. Their predilection is shared by the larva of the lymantriid butterfly *Eloria noyesi*, which will eat nothing else.¹¹ It excretes most of the cocaine as unchanged base,¹² but cocaine is readily detected in its blood, where it reaches a concentration of about 0.7 µg/ml, or several times that seen in the blood of human leaf chewers.

It might be asked what advantage the *Erythroxylum* plant obtains in return for its investment of energy in the manufacture of cocaine. One answer is: it gets freedom from other insects, in particular freedom from Pharaoh's ant, *Monomorium pharaonis*.¹² This ant relishes

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FIG. 1. Carl Koller at home, 1884 (Photograph kindly supplied by Mrs. H. Koller Becker).

sugar and avidly exploits droplets of sugar water. But if the droplet contains a smidgeon of cocaine, even less than the coca leaf, the ant gives it a wide berth. Paraphrasing the Bible¹³: "Go to the ant thou sluggard; Consider her ways and be wise."

Returning to Vienna 100 years ago, one can trace how Koller came upon his discovery. In Vienna, Sigmund Freud, the future founder of psychoanalysis, had recently read a paper by Aschenbrandt, an Austrian army officer who reported that he had put cocaine in the drinking water of his soldiers—without telling them—to see whether it would improve their endurance; he thought it did but it had no controls. Freud had also read of reports from the United States of America that praised cocaine as a cure for morphine addiction.^{14,15} Perhaps this was just what was needed for the treatment of Freud's great friend, the brilliant young physiologist Fleischl-von Marxow. Fleischl had infected his thumb during an autopsy; he had had to have it amputated, and then unbearably painful neuromata developed in the stump, which had made him an addict to morphine.¹⁶ Billroth had performed reamputation; Billroth had even tried electric stimulation under general anesthesia—an early example of transcutaneous nerve stimulation. All to no avail. Freud decided to try to wean Fleischl from morphine with cocaine. The early results were favorable

enough for Freud to write a glowing review¹⁷ in which he rather confusingly treated coca and cocaine as synonymous. The review was published in July 1884, and Freud then went off to see his fiancée in Hamburg and for the time being left the study of his cocaine to others.

Koller was a colleague and friend of Freud's and had helped him in some psychodynamic experiments with the drug, but Koller's real interest lay in a different direction. Koller (fig. 1) was then a junior resident at the Old General Hospital and aspired to an assistantship in the department of ophthalmology, the oldest and most prestigious of the surgical specialties. Arlt, professor of ophthalmology, used to emphasize to the students the grave dangers that the complications of general anesthesia presented during open eye operations, such that many eye operations were still being performed without any anesthetic at all; Arlt hoped quixotically for a method of locally anesthetizing the eye. Koller, who had acquired a research background in experimental embryology in the experimental pathology laboratory of Salomon Stricker, undertook a search, perhaps with Arlt's hope at the back of his mind. He tried to anesthetize the eye by instilling such available sedatives as morphine, bromide, and chloral, but of course without success. Here he was, in August 1844, studying the literature on cocaine in the absence of Sigmund Freud and still trying to make a discovery that would assure him the desired assistantship. Others had stated that tasting cocaine made the tongue go numb¹⁸ and had even suggested that cocaine could be used as a local anesthetic,¹⁹ although without mentioning surgery. Koller had put some cocaine on his tongue and duly noted the effect. And then the lightning struck! The numbness implied that cocaine should be anesthetic to the eye as well, perhaps sufficiently for a surgical operation. He rushed to the experimental pathology laboratory and quickly verified the idea on animals. Then he tried it on his own eye—and lastly, on patients. On September 11, 1884, history's first operation with local anesthesia, for glaucoma, was performed. Feverishly, Koller prepared a report for the Congress of Ophthalmology. The paper²⁰ was read on September 15, 1884, and created a sensation. Dr. Henry D. Noyes of New York City, who was present, immediately sent an eyewitness account across the Atlantic to the *New York Medical Record*, which published it on October 11.²¹

To be faithful to the sequence of events, one must note that Koller's communication to the Heidelberg congress in fact demonstrated cocaine hydrochloride anesthesia of the cornea and conjunctiva but did not mention that eye operations had been performed. It expressed the hope that cocaine could be used with success as an anesthetic in the removal of foreign bodies from the cornea as well as in more extensive operations.

Not until 1 month later, on October 17, 1884, at a meeting of the Vienna Medical Society, did Koller publicly report that actual eye operations had been performed; and this paper first appeared in print on October 25.²² Meanwhile, Noyes' astounding message in the *Medical Record* of October 11 had been read by several New York eye surgeons who began to apply cocaine in their own practice on the spot and hastened to describe the amazing results. The next week the *Medical Record* for October 18 contained no less than three letters by American ophthalmologists on the successful operative use of cocaine; a trio of clinical reports therefore got into print 7 days before Koller's. Not for the last time, the United States had scooped Europe in exploiting a European discovery. But the glory of course was Koller's. Freud inscribed a reprint of his next article "to his dear friend Coca Koller."

Despite its quasi-instantaneous acceptance and obvious importance, Koller's discovery did not earn him the appointment he coveted. His chances, already precarious because of growing anti-Semitic feeling in Vienna, were soon to be ruined by his own impetuosity.¹⁶ One evening in January 1885, while he was on duty in the emergency room, a workman with an injured finger was brought in. Koller noticed there was a tourniquet applied to the base of the finger. Zinner, Billroth's intern, asked Koller to admit the man to Billroth's service and Koller did so but himself urgently removed the tourniquet in order to save the finger. This act aroused Zinner's ire. Zinner called Koller an impudent Jew. Koller in return slapped Zinner's face. Zinner thereupon challenged Koller to a duel. The law specified that all duels were strictly prohibited, but both parties were officers in the Reserve and members of the patriotic German student society, whose unwritten code dictated that honor must be avenged. The duel was fought with swords the next day, and Koller wounded his opponent. The law impartially charged both parties with a crime.

Koller received an official pardon a few months later, but his prospects for advancement in German-speaking Europe were wrecked, destroyed by the first and last duel known to have been fought over a tourniquet. Soon he emigrated to the Netherlands, and, with Freud's and others' advice, in 1888 to the United States. His practice in New York City flourished, but the recognition that was his due came only tardily. In 1921 the American Ophthalmological Society awarded him its very first gold medal.²³ The International Anesthesia Research Society presented him with a commemorative scroll on his 70th birthday,²⁴ and the New York Academy of Medicine honored the 50th anniversary of the great discovery by creating the gold medal of the Academy²⁵ and making the first award to Carl Koller.

Koller's discovery surely merited a Nobel prize. Such

was the opinion of Professor Liljestrand, a member of the Nobel Award committee and author of the book, "Nobel and his Prizes." The prizes were first awarded in 1901. Liljestrand wrote that Koller was proposed several times²⁶ and was undoubtedly prizeworthy, but the statutes specified that an old discovery could be honored only if recognition of its importance was recent. Unluckily for Koller, his discovery had gained worldwide acceptance too quickly.

Parenthetically, history eventually vouchsafed a poetic revenge for the anti-Semitic tribulations suffered by Coca Koller. During World War II, Denmark was occupied by the Nazis, and Danes clandestinely helped their Jewish countrymen to flee to Sweden. Harold Flender relates that the Gestapo boarded the ships with police dogs to hunt down the fugitives,²⁷ but the wily Danes had distributed to the sailors pocket handkerchiefs containing a powder of cocaine mixed with dried blood, the sailors carefully blew their noses near the dogs, spilling the powder on the decks, the dogs sniffed the mixture and never discovered a single escapee. Koller did not live long enough to hear the story. He died in 1944.

I will next discuss some of the developments that followed from Koller's discovery (table 1), concentrating on one or two historic points that seem to merit clarification.

TABLE 1. Landmarks in the Lineage of Surgical Local Anesthesia

Year	Author	Contribution	Reference
1860	Niemann	Crystallizes and names cocaine	18
1868	Moreno Y Maiz	Forecasts cocaine local anesthesia	51
1880	Von Anrep	Hypodermic cocaine anesthesia on self	20
1884	Koller	Surgical local anesthesia by corneal application of cocaine	21
1884	Halsted	Cocainizes accessible peripheral nerves	30
1885	Corning	Sequesters cocaine by tourniquet	35
1885	Corning	Cocainizes spinal cord "via blood stream"	36
1891	Quincke	Accesses CSF by lumbar puncture	37
1898	Bier	Cocainizes spinal cord via lumbar CSF	39
1901	Sicard	Cocainizes by caudal epidural approach	52
1903	Braun	Adds epinephrine "chemical tourniquet" to cocaine	53
1908	Bier	IV regional block with procaine	40

Dr. Noyes's letter from Heidelberg²¹ triggered a wave of clinical experimentation in the United States. Everyone rushed to test the wonder drug on mucous surfaces. William Stuart Halsted, however, went beyond that and conceived the idea of nerve block. Halsted is remembered as a gifted surgeon-scientist who introduced the surgical rubber glove and the modern technique of radical mastectomy. The way he told the story of the gloves²⁸ says much about the character of the man. He designed the gloves to protect the hands of the operating room nurse but himself only began to use them much later.

"It is remarkable" wrote Halsted, "that, during the four or five years when as operator I wore them only occasionally, we could have been so blind as not to have perceived the necessity for wearing them invariably."

The self-criticism and candor were typical of Halsted, but his first great achievement and very nearly his undoing was the invention of neuroregional surgical anesthesia with cocaine.

The first dental nerve block was performed by Halsted and was reported together with blocks of several other nerves by his associate Hall,²⁹ 6 weeks after the Noyes letter appeared. Halsted held weekly teaching demonstrations of cocaine neuroregional anesthesia at the Roosevelt Hospital in New York City, attended by students from Columbia University. Halsted and Hall, in the best tradition of the times, experimented on themselves and innocently paid the terrible price of becoming habitual users, and as a result much of Halsted's innovative work with cocaine went unreported. In later years he transferred to Johns Hopkins, where he more or less vanquished the habit and wrote many letters to his friend Rudolph Matas of New Orleans, in some of which he alluded to the sessions at the Roosevelt Hospital.

Matas himself was an eager exponent of regional neuroanesthesia—he invented the term—and wrote several historic studies on its early development,^{30,31} including the contributions by James Leonard Corning. Matas at first took Corning's brilliant originality at face value³⁰ but subsequently came to regard some of the innovations claimed by Corning as having begun in the head of Halsted.³² Corning, who probably attended Halsted's demonstrations at the Roosevelt, was a neurologist, and not a surgeon. It is not easy to assess his debt to others because his numerous reports tended to omit scholarly references except to himself. Nevertheless, they vividly convey Corning's profound interest in exploiting and advancing the therapeutic use of local anesthesia with cocaine. He saw in cocaine, as Rynd and Alexander Wood had previously in morphine, an agent for local application to the nerves in the treatment of neuralgic pain.

Corning's first paper on the subject made him famous. It appeared in the *New York Medical Journal* for September 19, 1885, and described how he used a tourniquet above the elbow to prevent absorption of cocaine injected distally and maintain the local anesthesia. Many years later Halsted³³ wrote that Corning borrowed this idea from him at the Roosevelt Hospital sessions. Incidentally, neither of them considered whether tourniquet asphyxia of itself might not be prolonging the anesthesia.

Two remarks by Corning on the rationale of the tourniquet are revealing:

A certain period elapses during which the anesthetic agent is diffused throughout the surrounding tissue. That the bloodstream in the capillaries renders efficient service in this process of distribution may be accepted as proved.³⁴

We are to look upon the circulation in a two-fold manner, as a distributor it is true, but afterward as a diluter and remover of the anesthetic substance.³⁴

Corning's celebrated next paper, only 6 weeks later, had the arresting title: "Spinal Anaesthesia and Local Medication of the Cord."³⁵ It stated that Corning injected the equivalent of 1.2 ml 2% cocaine hydrochloride into the space "situated between the spinous processes of two dorsal vertebrae" of a dog; this resulted in insensibility of the hind legs. A similar result was obtained in a man. Corning ended with the pregnant conclusion: "Whether the method will ever find an application as a substitute for etherization in genitourinary or other branches of surgery further experiments alone can show." That was a brilliant conjecture, but the rationale of his method rendered it still-born. Corning's own words betray why:

I reasoned that it was highly probable that, if the anesthetic was placed between the spinous processes of the vertebrae, it (the anesthetic) would be rapidly absorbed by the minute ramifications of the veins referred to, and, being transported by the blood to the substance of the cord, would give rise to anesthesia of the sensory and perhaps also of the motor tracts.³⁵

Corning seems to have had only a hazy idea of the anatomy of the meninges and was apparently unaware both of the cerebrospinal fluid and of the gap between the circulation of blood in the dura-arachnoid and that in the spinal cord. His needle between the spines ("spinal anaesthesia") of thoracic vertebrae was aimed directly at the spinal cord in an attempt to deliver the drug into it retrogradely via the veins. In a way this foreshadowed Bier's intravenous approach to regional anesthesia as much as Bier's lumbar puncture approach to spinal anesthesia. However, Corning inevitably missed seeing any spinal fluid because he kept a syringe attached to the needle, and his ill-conceived technique could not have any sequel until correct anatomy was applied by Heinrich Irenaeus Quincke in 1891 in devising the procedure of lumbar puncture.³⁶

Three years after Quincke's report, Corning published his book on Pain³⁷ and included in it a chapter on "The Irrigation of the Cauda Equina," but there was still no reference at all to the cerebrospinal fluid, nor, for that matter, to Quincke. Matas, writing in 1925, hinted that Corning's idea for spinal medication of the cord, too, may have come from Halsted.³²

As it happened, it was not until 1898 that August Bier (1861–1949), a colleague of Quincke's, applied Quincke's lumbar puncture technique to "cocainization of the spinal cord" for the deliberate purpose of obtaining regional surgical anesthesia.³⁸ Unfortunately Bier did not say how he arrived at the idea and made no written reference to Corning, just as 10 years later, when he devised intravenous regional anesthesia, Bier again did not record the train of thought by which he arrived at that concept.³⁹ Bier did write that he performed cocainization of the spinal cord on six patients before the desire to understand its complications led him to have the procedure performed on himself. In the end he did not undergo spinal anesthesia, but only lumbar puncture by his assistant, Hildebrandt, because when the time came for Hildebrandt to attach the syringe of cocaine to the needle Hildebrandt discovered that the two didn't fit. Bier recorded that after losing a lot of cerebrospinal fluid he got up and switched roles with Hildebrandt, and this time, Bier archly remarked, the syringe and needle did fit. In the aftermath, both of them had royal postpuncture headaches develop to such effect that Bier abruptly stopped using the method on patients.

However, subarachnoid regional anesthesia was enthusiastically taken up by Théodore Tuffier (1857–1929)⁴⁰ in Paris and received great impetus from his demonstrations to the Thirteenth International Medical Congress in the summer of 1899, which was attended among others by Rudolph Matas. Rudolph Matas, Professor of Surgery at Tulane University, was by then a leading American exponent of local anesthesia. He published a valuable review of local and regional block methods in *The Philadelphia Medical Journal* of November 3, 1900, including his experience with spinal cord cocainization, in nine cases, the first American series.³⁰ It is particularly interesting that the same issue of that Journal carried a long report on surgical intraspinal cocainization in a series of 20 patients.⁴¹ The author of the last mentioned article was Sydney Ormond Goldan (1869–1944), a full-time anesthetist (fig. 2). One month later, Goldan published a second study on an additional 11 cases.⁴² Goldan had received his M.D. degree from Columbia University College of Physicians and Surgeons in 1896. He was brimful of enthusiasm for anesthesia, an excellent communicator and a prolific writer, a gadgeteer and the owner of several patents of anesthesia

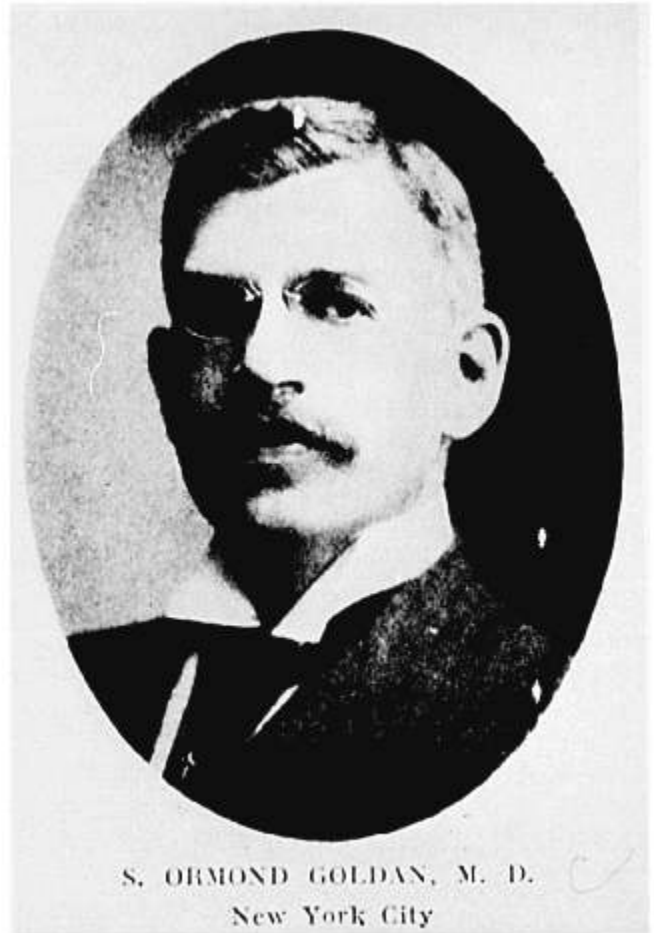


FIG. 2. Sydney Ormond Goldan (1869–1944), the first anesthetist to practice regional anesthesia (Photograph from the Archives of the New York Academy of Medicine).

equipment. In the year 1900 he published no less than seven papers, an unheard of productivity by an anesthetist and perhaps by anyone else in those more leisurely times.

His first article on intraspinal cocainization vividly evoked the dramatic novelty of the method:

It was a somewhat unique experience to see the uterus and appendages removed by celiotomy—the patient being perfectly conscious, completely relaxed, and anesthetic—this impressed me so forcibly that as an anesthetist the subject had for me more than ordinary interest.⁴¹

This article was also notable for including the very first published illustration of an anesthesia chart. In Goldan's words: "The value of any new method depends largely upon completeness of the observations recorded." The chart, like the rest of Goldan's writings, became completely forgotten. Thirty years later a very similar chart⁴³ was presented by Roscoe C. Webb in the *American Journal of Surgery*, where it was put forward as a timely new idea.

Goldan, in 1900, was doubtless the first anesthetist to adopt spinal anesthesia as part of his armamentarium and quite certainly the first anesthetist to write about it: until 1920 all the published articles on local or spinal anesthesia came from the pen of surgeons. His career as an anesthetist, however, spanned only 7 years. After that he apparently took up other work and wrote no more, and his name utterly disappeared from the journals. His last two papers^{44,45} reveal the reason for his early extinction as a specialist anesthetist: he had probably offended his surgical colleagues. On the question of responsibility for the consequences of anesthesia to the patient, he declared unambiguously:

There can be but one correct way of viewing this subject, and that is the administrator, whether experienced or not, is responsible for the narcosis.⁴⁴

and on the question of fees:

The surgeon should divest himself of the idea that he is doing the anesthetist a favor by having him administer the anesthetic, as he (the anesthetist) is far more important to the patient and to the success of the operation . . .

It has been questioned whether I would have the courage of my convictions. This paper answers that question.⁴⁴

What Goldan was up against is glimpsed in a contemporary article by W. R. Stone, an early exponent of cocainization of the spinal cord during labor. Stone presumably spoke for a lot of other surgeons: "The presence of an anesthetist and his expense can be dispensed with if cocaine be employed."⁴⁶

Goldan's lengthy last paper⁴⁵ was the lead article in the *New York Medical Journal* and ended as follows:

Complete equality ethically, professionally, materially, between the anesthetist and the surgeon, is the only solution for the correction of the abuses whose only right for existence is usage.

Fate decreed that when Goldan staked his claim to equality he had to stand alone, for there was no organization whatsoever of anesthetists to back him up. The Long Island Society of Anesthetists was formed 2 years later with nine charter members, but Goldan was not among them.† By then he may have turned to gynecology, which he was listed as practicing in 1920 and continued to be practicing until his death in 1944. We will never know whether Goldan's experience helped to stimulate the formation of The Long Island Society. The early records of the Society were lost in a fire. However that be, Goldan's years as the pioneer regional anesthetist and forerunner of the generation of activist

leaders of anesthesiology surely deserve to be remembered. Doubtless it was partly his expertise in spinal anesthesia that encouraged him to claim equality with the surgeons, for regional anesthesia had until then been their exclusive province. Goldan was also far ahead of later anesthetists—and surgeons—in insisting that the interests of the patient demanded the full responsibility of the anesthetist. It was only in the 1920s that such a development began to win the support of far-sighted leaders of surgery.⁴⁷ In 1920, Dr. William Mayo persuaded Gaston Labat, a disciple of the French anatomist and surgeon Victor Pauchet, to become lecturer in regional anesthesia at the Mayo Clinic, with the new mission of training surgeons in the methods of regional anesthesia. Gaston Labat soon transferred to New York University to head his own Department, the new Department of Regional Anesthesia. Thereafter, regional methods regularly began to challenge the skill of general anesthetists. Labat's classic book⁴⁸ brought an area of surgical expertise into the armamentarium of anesthesiologists, a development that inevitably sharpened the appreciation of surgeons for anesthesiologists so equipped.

Ironically enough, Goldan, while seemingly reaching for the moon, was in fact asking for no more than a return to the pristine relationship that had been declared at the very dawn of surgical anesthesia. On that memorable October 16, 1846, in Boston, Dr. Morton was to administer the ether but was late for his appointment. Dr. Warren, the surgeon, waited for 10 or 15 min and then decided to go ahead without Dr. Morton.⁴⁹ Strong aides prepared to hold the patient down. Just as Dr. Warren took up his scalpel, Dr. Morton appeared. Warren paused, turned to Dr. Morton and said: "Sir! your patient is ready." Your patient. That was the relationship that Goldan two generations later wanted to reestablish. Unfortunately, he apparently lacked the maturity necessary to achieve his aim.

Historically, at all events, it is incontrovertible that schooling in block procedures laid the foundation for a new level of excellence in anesthetic care in the operating room and in the pain clinic. These developments stemmed of course from Koller's discovery and from the impulse it gave to the ageless quest for human dominion over physical suffering. A passage borrowed from Chauncey Leake,⁵⁰ Koller's champion and friend, seems as timely as ever:

and so the search goes on . . .

Let us learn patiently the gentle way,

Firm to prevent such anguish as we may.

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