10.5005/jp-journals-10001-1261

REVIEW ARTICLE

A Brief History of Local Anesthesia

[1]John Nathan, [2]Lynda Asadourian, [3]Mark A Erlich

ABSTRACT

Mankind has, throughout its existence, been engaged in the quest to control the pain associated with disease and trauma. Evidence from over 4500 years ago demonstrates the Egyptians use of methods to compress peripheral nerves. Homer's Iliad relates the use of herbal remedies for pain control. Other early writings describe the use of electricity generated by the Torpedo ray for pain control as well as cold water and ice for pain reduction. These techniques, in their various incarnations, comprised the main armamentarium of local pain control until the early 1800's when the early framework for the hypodermic syringe emerged in America. Cocaine, noted for its stimulant effect as well as numbing properties, was first brought to Europe by Vespucci. The combination of a workable syringe and the purification of Cocaine by Niemann essentially gave birth to modern local anesthesia. Halsted would perform the first injections of cocaine via hypodermic syringe into a proximal nerve for distal pain control, introducing modern conduction local anesthesia. All that remained was the introduction of numerous blockers of nerve depolarization, combined with vasoconstrictors, to minimize systemic toxicity, and we arrive at the modern state of local anesthesia.

Keywords: Local anesthesia, Nerve depolarization, Pain control, Vasoconstriction.

How to cite this article: Nathan J, Asadourian L, Erlich MA. A Brief History of Local Anesthesia. Int J Head Neck Surg 2016; 7(1):29-32.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Pain control has not always been as efficacious as it currently is. Throughout our known history, people have attempted to manage pain using many different methods and techniques. One of the first examples of pain control by man was in Egypt over 4,500 years ago around the year 2500 BC. Paintings of apparatuses used to compress peripheral nerves to numb limbs were found on the walls inside the ancient Egyptian tomb of Saqqara.[1]

[1,2]17 DDS Candidate, [3]Assistant Professor

[1,2]Columbia College of Dental Medicine, New York, USA

[3]Department of Cell Biology and Pathology (Anatomy), Columbia University College of Physicians and Surgeons, New York, USA

Corresponding Author: John Nathan, 17 DDS Candidate Columbia University College of Dental Medicine, New York, NY USA, e-mail: jmn2156@cumc.columbia.edu

This primitive technique of anesthetizing entire limbs from a proximal site, probably unknowingly at the time, demonstrated the potential capabilities of conduction anesthesia. Compression anesthesia was not the only attempt made to relieve localized pain. Thirteen hundred years later, Homer wrote about the use of bitterroot in The Iliad. Patroclus, a warrior in the Trojan War, was said to have 'took the pain away and ended all (of Eurypylus') anguish' by rubbing the bitterroot on his wounded leg after being struck by an arrow.[2] Humans have been using herbal remedies for pain control for thousands of years.

Plato and Aristotle documented some of the first cases of using electricity as a method to decrease sensitivity in 350 BC. Aristotle described the numbing effect created by the Torpedo ray's electric shock capabilities. Scribonius Largus, the physician of the Roman emperor Claudius, applied the Torpedo ray's electrical capabilities further by regularly using it to numb the pain from various maladies including headaches and gout.[3] Around the year 1050, another early form of anesthesia was documented; Anglo-Saxon monks wrote about the use of cold water in the medical text called the Leechbook. In the Leechbook, it was recommended that the patient have their limb or area of surgery 'deadened' using cold water prior to performing simple surgeries and removal of cysts.[4] Ice and various 'coolants' are still used today as an inexpensive and rapid form of anesthesia.

Many of the techniques previously discussed slowly evolved over time becoming more efficient and reproducible. This was true for the technique of compressing nerves for numbing limbs. In 1784, the English surgeon James Moore created and utilized adjustable clamps in order to compress the nerves just as the ancient Egyptians.[5] He believed that clamping the limb and thus nerve, blocked pain signals transmitted to the brain. Other surgeons not only used Moore's clamp and method, but also promoted its use for major operations, such as limb amputations during the late eighteenth century. Pressure anesthesia was not the only technique revisited hundreds of years later. In agreement with the Leechbook, Baron Larrey, Napoleon's army doctor, noted the ease and relative patient comfort when amputating limbs that were nearly frozen during Napoleon's invasion of Russia.[6] The use of cold temperature as an anesthetic continued to be used and applied in different manners. Well into the nineteenth century the British physician, Benjamin Ward

Richardson, used the technique of spraying ether onto the surgical site, in order to desensitize it. Ward invented an apparatus that he used to spray ether on teeth prior to extracting them.

A major breakthrough in modern local anesthesia was made in 1841 when Zophar Jayne, an American physician, created the framework for the modern hypodermic syringe. Before its invention, physicians had been searching for a method that could deliver adequate amounts of liquid to tissues. Dr Alexander Wood and Dr Francis Rynd, independently, created hypodermic needles and syringes before Jayne, with some controversy as to who created it first.[7] But Jayne's latest creation took the major step forward necessary to progress the field of local anesthesia. Jayne's hypodermic syringe still required an incision to be made before delivering the material, but nonetheless, it was a key first step in the direction of the syringe and needle system. Despite this major breakthrough, traction for its use did not develop immediately. This can partially be attributed to the limited anesthetizing solutions and imprecise delivery system. This is evident by the continued use of alternative methods to numb patients. In London around the year 1858, the dentist Joseph Snape was using electricity to attain anesthesia prior to tooth extractions. Snape reported remarkably good results with patients claiming the experience to be 'delightful'.[8]

Approximately 15 years after the hypodermic syringe was invented, Albert Niemann, a graduate student in pharmacology in Gottingen, Germany, was extracting cocaine from the leaves of the coca plant. At the time, Niemann did not realize its potential as an anesthetic in surgery; however, other researchers noted its effects on Peruvian Indians when they would chew the coca leaves.[9] The Peruvians could work extremely long hours without eating or tiring as long as they chewed the leaves.

Another 20 years later, Sigmund Freud, a graduate student in Vienna at the time, began experimenting with coca leaves on himself to observe its effects. To his surprise, he noted the profound numbing effect it had on his tongue. In 1884, he published the paper 'Uber Cocaine.' In the paper, Freud recommended its use for the treatment of morphine addiction and various other conditions including fatigue and headaches.[10] Freud himself did not utilize the coca extract for surgery; however, he recommended its use for eye surgery to Karl Koller, one of his colleagues. Koller published his first paper on the use of cocaine in eye surgery in 1884.

Surgeons did not quickly adopt the use of cocaine as an anesthetic. However, dentists began using it subcutaneously for tooth extractions. The anesthesia achieved was extremely effective, but the nonstandard dosing caused many unwanted systemic side effects, such as increased pulse, giddiness and exhilaration. Just 6 years later, dentists were already restricting their use of cocaine subcutaneously. Many dentists started solely using cocaine in a diluted solution as a topical anesthetic.[11] The many reported unwanted side effects initiated the research and development of safer alternative anesthetics.

In 1903, Heinrich Braun, a German surgeon, took one of the first steps toward creating a safer local anesthetic. Knowing that the products of the adrenal glands, such as epinephrine, caused vasoconstriction, Braun added the hormone to a solution of cocaine. He then injected the new solution into his arm and achieved long lasting anesthesia that was confined to his arm.[12] The vasoconstriction caused by the epinephrine kept the anesthetic from diffusing systemically. This formula is an anesthetic solution, i.e., currently used.

Around the same time, William Stewart Halsted and William John Hall formally introduced the concept of conduction anesthesia.[13] This concept of anesthetizing the nerve in a more proximal location to numb structures distal to the injection site, allowed for more efficient and comfortable anesthesia. This reduced the number of injections needed and provided for a more specific and targeted anesthesia method.

Just a year after Braun started experimenting with adding vasoconstrictors to anesthetic solutions, Alfred Einhorn and Alfred von Bayer invented procaine, the first synthetic analog of cocaine. Procaine is commonly referred to by its trade name Novocaine.[14] This analog was much safer and caused fewer side effects than cocaine. It also did not have the addictive properties of cocaine. However, surgeons and dentists soon realized that it caused vasodilation and easily spread systemically. It was then combined with epinephrine to cause vasoconstriction, which allowed the medication to remain locally.

In 1906 Guido Fishcer, the director of the Dental University Institute of Greifswald, Germany, introduced what would become the modern syringe.[15] This model did not have all of the features that are seen today, however, Fischer's version laid the framework for iterations to come. A major breakthrough came toward the end of WWI in 1917, when Harvey S Cook introduced the cartridge system. Cook was a physician for the United States Army in France during the war. Cook envisioned creating a faster and more efficient system that could be used on the battlefield. He modeled his design after observing soldiers load their rifles with ammunition and watching the empty shells being dispensed after firing the gun. He cut glass tubing and filled them with anesthetic solution, so that the prepackaged cartridges of anesthetic were ready to be used on the battlefront or the next day. As a

stopper for the cartridges, Cook resourcefully used the erasers from the heads of pencils.[16] This system replaced the old procedure of drawing up the solution into the metal syringe every time anesthesia was needed. More iterations of the carpule system and syringe came in the form of a corkscrew that permitted aspiration in 1947. Later, a harpoon would replace the corkscrew giving us the syringe widely manufactured and used today. Cook patented his carpule system, after the war ended, in 1925 and went on to start Cook Laboratories in Chicago. Eventually, Cook Laboratories would partner with RB Waite, a dentist who created his own improved syringe system, to create the Cook-Waite Company. Cook-Waite would go on to be widely successful manufacturing pre-packaged anesthetic carpules of various solutions.[6]

The most recent major innovation came in 1949 when the Swedish pharmaceutical company Astra introduced Lidocaine to the market. Lidocaine, also known as Xylocaine, was the first non-ester local anesthetic available. Lidocaine proved to have even fewer side effects than procaine while instilling even deeper anesthesia. It is now one of the most widely used local anesthetics. There are three main types of local anesthetics that are clinically used today. Lidocaine 2% with epinephrine 1:100,000 is the most common amide anesthetic used when giving local infiltration anesthesia. It has a rapid onset and a moderate duration of action. Its low pKa and high lipid solubility are both factors that influence the quick onset of action.[17] The average duration of action on soft tissue ranges from 170 to 190 minutes.[18] Bupivacaine 5% with epinephrine 1:200,000 is used for longer procedures.[19] It has an intermediate onset and longer duration of action.[20] It is four times more potent than lidocaine.[17] It is known to be a more painful injection, so it is recommended to anesthetize the surgical area first with a different local anesthetic (topical benzocaine) to lessen to the initial injection.[19] The duration of action in soft tissue ranges from 340 to 440 minutes.[18] Mepivacaine is the most common local anesthetic, if the use of epinephrine is contraindicated. This anesthetic is used for short procedures and when vasoconstriction is less imperative. Its duration of action for soft tissue ranges from 90 to 165 minutes.[18]

Vasopressors are used in conjunction with local anesthetics to increase effectiveness, provide hemostasis, and increase duration.[20] Epinephrine activates the alpha-1 adrenergic receptors, which in turn, constricts the surrounding blood vessels. This prevents systemic toxicity by delaying anesthetic absorption.[19] It is recommended to not use local anesthesia with vasopressors on patients who have diabetes, hypertension, cardiovascular disease, or cerebrovascular disease.[20] The use of epinephrine and other vasopressors increases cardiac output, heart rate, and stroke volume, so it is recommended to use 3% mepivacaine in patients with cardiac contraindications.[19]

Another novel breakthrough in local anesthesia that has yet to catch on widely came in 2009, when an injectable form of phentolamine mesylate, a vasodilator that reverses local anesthesia, was introduced to the market. The local anesthesia-reversing agent has yet to become popular mainly due to patients choosing to allow the anesthesia to wear off on its own rather than paying for the extra cost of the reversing agent.

Currently, there is ongoing research on how to decrease the pain during the application of local anesthesia. Local anesthesia is an acidic solution that contributes to the burning sensation when receiving an injection. There are current studies analyzing if there are benefits to creating a more neutral solution in order to make the anesthetic injection a more pleasurable experience. Adding sodium bicarbonate to the lidocaine and epinephrine solution is one formula, i.e., under investigation. There are two theoretical advantages that this neutral local anesthetic solution provides: a less painful injection and a faster onset of desensitization.[21] Further research is needed on this topic.

The importance of local anesthesia cannot be overstated. Without local anesthesia, many of today's surgical and dental procedures could not be performed without more invasive methods of achieving patient comfort. With continued research and innovation, the field of local anesthesia will continue to advance the eternal quest for pain control.

REFERENCES

1. Fülöp-Miller, R; Paul, E; Paul, C. Triumph over pain [Internet]. Indianapolis, New York: Bobbs-Merrill Co. 1938. (cited 2015 Dec 21). 498 p. Available from: http://archive.org/details/triumphoverpain00fl
2. Homer I. The iliad-homer-ancient Greece-classical literature [Internet] (cited 2015 Dec 21). Available from: http://www.ancient-literature.com/greece_homer_iliad.html
3. Jocks IT. The compositiones medicamentorum of scribonius Largus [Internet] (MRes). University of Glasgow; 2013 (cited 2015 Dec 21). Available from: http://encore.lib.gla.ac.uk/iii/encore/record/C__Rb3009179
4. Davison MH. The evolution of anaesthesia. Br J Anaesth 1959 Mar 1;31(3):134-137.
5. Jastak, JT; Yagiela, JA. Regional anesthesia of the oral cavity. St Louis: Cu Mosby Co., 1981. p. 212.
6. Ring ME. The history of local anesthesia. J Calif Dent Assoc 2007 Apr;35(4):275-282.
7. Kravetz RE. Hypodermic syringe. Am J Gastroenterol 2005 Dec;100(12):2614-2615.
8. The home journal (cited 2015 Dec 21). Available from: http://chroniclingamerica.loc.gov/lccn/sn95068565/

9. 1872457304-The illustrated history of surgery by Haeger, Knut-AbeBooks [Internet] (cited 2015 Dec 21). Available from: http://www.abebooks.com/book-search/isbn/1872457304/
10. Randall T. Cocaine deaths reported for century or more. JAMA 1992 Feb 26;267(8):1045-1046.
11. Tainter ML. A century of progress in local anesthesia in dentistry S.l.: s.n., 1944.
12. Monica WS. The perilous development of safe local anestheisa. Dent Surv 1976 Jun;52(6):30-32.
13. Miller RD. Miller's Anesthesia:.... 1. Elsevier Health Sciences; 2010. p.3221.
14. The Journal of the American Dental Association 1962;p964.
15. Fischer G. Local anesthesia in dentistry: with special reference to infiltration and conduction anesthesia; a text-book for dentists, physicians and students. Henry Kimpton; 1933;p.228.
16. HANSAmed limited's dental anesthesia news: April 2013 [Internet] (cited 2015 Dec 20). Available from: http://dentalanesthesia-news.blogspot.com/2013_04_01_archive.html
17. Danielsson K, Evers H, Nordenram A. Long-acting local anesthetics in oral surgery: an experimental evaluation of bupivacaine and etidocaine for oral infiltration anesthesia. Anesth Prog 1985 Apr;32(2):65-68.
18. Haas DA. An update on local anesthetics in dentistry. J Can Dent Assoc 2002 Oct;68(9):546-551.
19. Becker DE, Reed KL. Local anesthetics: review of pharmacological considerations. Anesth Prog 2012;59(2):90-103.
20. Achar S, Kundu S. Principles of office anesthesia: part I. Infiltrative anesthesia. Am Fam Physician 2002 Jul 1;66(1):91-94.
21. Best CA, Best AA, Best TJ, Hamilton DA. Buffered lidocaine and bupivacaine mixture-the ideal local anesthetic solution? Plast Surg (Oakv) 2015;23(2):87-90.