

Comparing Similarity And Difference between Two Local Anesthetics, Lidocaine And Procaine

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Abstract. Amide type lidocaine and lipid type procaine are important anesthetics. In fact, they not only solve the problem of overused opioids, but also stimulate the invention of local anesthetic operations, which both declines the time of surgery and limits the possible damage of general anesthetics to patients' bodies. But these two anesthetics also have their different target diseases, mechanisms, and side effects. For example, lidocaine is not only used for analgesic in dental and skin surgery operations, but also maintain the welfare of patients, who stay in the hospital waiting for recovery, by limiting the pain they could feel from their chronic illness. Actually, procaine has antiatherogenic effects, also multiple target sites which could provide some protection for the old while using. Besides, based on the fact that these chemicals come from different groups, amide type and lipid type, their mechanisms causing anesthetic effects could also be different, which would be introduced in the following context.

Keywords: Biochemistry, Pharmacology, Local anesthetics, Lidocaine, Procaine.

1. Introduction

There are two primary anesthetics: local and general. Anesthetics play a crucial role in medical procedures, ensuring patients experience minimal discomfort. Understanding their types and functions is essential for both medical professionals and patients. Local anesthetics are weak alkaline compounds specifically designed for pain relief and inflammation reduction. They have been vital for pain management, offering targeted relief without affecting the patient's overall consciousness. Their effectiveness and safety have made them a preferred choice in many medical scenarios. These anesthetics can be further categorized into esters and amides. Esters consist of an aromatic part and a basic chain linked by an ester bond. These include compounds like procaine, tetracaine, and chlorprocaine hydrochlorides.

Amides consist of an aromatic component and basic chain linked by amide bond and include lidocaine, bupivacaine, and ropivacaine hydrochlorides. Lidocaine are most frequently used among amides anesthetics. It is used for sedation in specific procedures, blocking nerves to ensure the patient remains numb. The lidocaine is widely used in many medical treatments such as local numbing agent, heart arrhythmia, epilepsy and others. The characteristic of lidocaine is intermediate duration and a rapid onset of action. Unlike other local anesthetics for example bupivacaine, which has a long duration. Lidocaine are commonly used in dentistry to do the nerve block or infiltration basically depends on the type of treatment [1]. Lidocaine are not merely used in dentistry, also can be used as surface anesthesia. According to preliminary research, topical lidocaine may be effective in treating neuropathic pain and pain at skin-graft donor sites [2, 3]. Meanwhile, lidocaine is also the most effective class-1b antiarrhythmic medication. It is used intravenously to treat ventricular arrhythmias in cases where amiodarone is unavailable or inappropriate. In addition, intravenous lidocaine was suggested as a second-line treatment for neonatal seizures in a review in 2013, if phenobarbital did not successfully cease seizures [4]. Lidocaine is utilized in many different treatments, thus its side effects are considerable and should be noticed before using it in a practical setting.

Most of the adverse drug reaction of lidocaine is due to the administration technique or pharmacological effects of anesthesia, allergic reaction is rare to occur [5]. When lidocaine is administrated correctly the adverse drug reaction is unlikely to see. If the administration technique is

improper, it can result in systemic exposure. Central nervous system and cardiovascular effects are the main side effects of systemic exposure to excessive amounts of lidocaine. Here is the following adverse drug reaction of lidocaine.

Excitation of the central nervous system can cause jitters, agitation, anxiety, apprehension, mouth tingling, headaches, dizziness, seizures and so on. As increasing exposure levels, drowsiness, lethargy, slurred speech, confusion, disorientation, respiratory depression, and apnoea are some examples of the symptoms of central nervous system depression. Apart from this bradycardia, arrhythmias, flushing, venous insufficiency, edema, and cardiac arrest-some of which may be brought on by hypoxemia as a result of respiratory depression [6]. There is some other adverse drug reaction on other aspect, for instance gastrointestinal, ears or eyes and so on.

Procaine as mentioned above is a local anesthetic drug of ester group. Procaine mainly applies in dental anesthetic [7], but procaine is now less frequently used because lidocaine and other better and hypoallergenic substitutes are available. Beyond from being as a dental anesthetic, procaine injection has been suggested to treat the extravasation issues brought by venipuncture, steroids, and antibiotics [8]. Procaine can also cause the excitation and depression effect on central nervous system. If it is overdosed, it can result in respiratory failure. Furthermore, allergic reaction should be considered during the procaine treatment. Hence, in the following writing, there are going to introduce the cases that lidocaine and procaine could be used, mechanisms of local anesthetic, and the side effect of lidocaine and procaine.

2. Mechanism of local anesthetic

A stimulus initiates a nerve impulse. In order to sense pain, the nervous system must be enabling to transmit electrical impulses to neurons, this process is called depolarization. Depolarization functions on balancing the ionic gradient between intercellular region and extracellular region of cell by sodium-potassium pump, which uses the energy from the breakdown of adenosine triphosphate to function. During the resting potential, the extracellular region shows a less negative charge due to the low permeability of sodium ions to cell membrane the and the sodium-potassium pump will exclude 3 sodium ions for each of 2 potassium ions [9]. However, when stimulus stimulate the neurons, the sodium-potassium pump in the cell membrane will open. Thus, the sodium ions accumulated inside the cell, the potassium ions will move out, and the intercellular region presents positive. This will occur along the membrane and passes to adjacent neuron, therefore the transmission of nerve signals happened, also called action potential.

Local anesthetic will inhibit the sodium-potassium pump operation, which causes the sodium ions to be unable to flow into the cell membrane of nerve cell and stop the pain stimulus to pass through the neuron fibers [9]. Thus, it can make patient feel less pain. Lidocaine is one of the sodium channel blockers. Sodium channels have 3 states, phase 1, 0, and 2. According to above, the process of waiting an action potential to arrive is called phase 1. When the channel is activated and conducted sodium current, this process is phase 0. Phase 2 is after the sodium current has passed but before the channel has returned to phase 1. Lidocaine will block the channel by occupying the receptors (intercellular side) on sodium channel during phase 0 and phase 2 due to the high affinity of lidocaine to the receptors [10]. Procaine has a similar process to lidocaine. Procaine primarily affects peripheral neurons by preventing sodium ions inflow through sodium channels in the cell membrane in a same method with lidocaine. An action potential cannot form when the sodium influx is stopped, which prevents signal conduction (phase 0).

3. Targeted diseases

3.1. Lidocaine

For local anesthetics, the effect of analgesic, anti-inflammatory, and anti-hyperalgesic used in period before dental surgeries, skin operations, or other surgical operations would be the most

commonly used properties in clinical field. In dental and skin field, local anesthetic is frequently used in clinical treatments. For example, tooth extraction and skin grafting, those surgeries, which only have tiny or even no wounds and required part of the body for operations, would use local anesthetics instead of general anesthetics. Operations, like dental operations and skin biopsy, produce painful feelings during and after the surgery procedure. The pain would not only leave a negative experience to patients, but also cause unpredictable, uncontrollable, and impactive movement, like muscle irregular contraction, which would cause serious problem in surgery, especially for minimally invasive surgery. Because of its perfect anesthetic effect and relatively low addiction, it is a considerable substitute of opioids. Opioids, a kind of alkaloids medicine extracted from opium poppy, would cause body to tolerate addiction under repeated use [11, 12].

Table 1. Compare characteristics of lidocaine and procaine under normal condition and using epinephrine [1].

Anesthetics	Onset of action	Duration without epinephrine (min)	Duration with epinephrine (min)
Amide type: Lidocaine	2-3 min	30-120	60-400
Ester type: Procaine	5 min	15-30	30-90

As shown in the Table 1, the lidocaine has considerable characteristics of action time under both normal condition and using the epinephrine compared with procaine. Without other chemicals, lidocaine only needs 2 or 3 minutes to affect last for 30 to 120 minutes, but procaine needs 5 minutes to work and only last for 15 to 30 minutes. It is similar result under using of epinephrine. To summarize, lidocaine has longer working effect and less time taken for acting than procaine. But one thing needs to be clarified [1].

Besides, lidocaine is also a considerable choice of reducing pain for chronic illness patients and hospital stay after surgeries. Chronic illness, for example, could seriously affect the quality and satisfaction of patients' life due to frequently and uncontrollable painful feelings, which would cause anxiety, nervous and even irritability and insomnia. Wounds, inflammation, and other possible pain left after operations would also bring a hard time for patients to get through. For those chronic pain, the lidocaine also has great effect when it is been used properly with suitable amount and applicable frequency. Besides, parturition period would require both local anesthetics and general anesthetics to help. In order to produce a relatively more comfortable time when they stay in hospital for recovery. However, based on the fact that the lidocaine could be metabolized and excreted quickly through liver and kidney, the problem of lidocaine transportation from mothers to infants via breast milk, which should be consider. The drug toxicity effect would be introduced in the following contexts [13, 14].

3.2. Procaine

As an old-fashioned medicine, procaine is not that commonly used in nowadays compared with previous periods. Procaine first became popular and widely used by doctors is due to its considerably less addiction and longer time of duration for anesthesia comparing with opioids. Under limited clinical situation over that time period, procaine helped people give up cocaine. Besides the local anesthetic effects, anti-inflammatory, antioxidant, and antiatherogenic effects are also considerable advantages of procaine based on its chemical mechanism, which would be described in next part. Secondly, procaine also has multiple targets, and the effect of cerebral age-related pathology, and DNA methylation. In Table 1, the time difference of two chemicals are compared. Except the low addiction, short duration for anesthetic time could be a kind of advantage under special condition limitation. For example, to patients who only need short time operation and tiny wound to operate the whole procedure, including small dental operation, procaine, which has less time of effect, might be a better choice comparing with lidocaine without considering any other medicines [15].

4. Side effect of lidocaine and procaine

4.1. Lidocaine

As a typical amide type anesthetic, lidocaine is metabolized by liver and discharged through kidneys with a fast speed. Therefore, patients with kidney issues should be careful about the using of lidocaine during surgery. Allergic reactions are also common problems of using local anesthetics, including lidocaine. Metabolized production PABA would cause serious anaphylaxis due to immunity defense. But good news is that lidocaine has relatively low possibility of causing allergic reactions, because it metabolized through P450, a group of enzymes which help breaking down medicines and chemicals. Consequently, lactating would be affected based on this mechanism, which means that the drug could be excreted in breast milk from mothers to infants.

Besides, oral administration might also cause side effects, such as nausea and vomiting, based on clinical observation, case studies, and data analysis. Therefore, it is more commonly used intravenous injection to introduce the medical into the patients' bodies. However, the toxicity of the drug should also be considered when using injection methods. The toxicity of lidocaine, also the complication, direct neurotoxicity, highly depends on the rate of absorption and total amount. Consequently, the clinical doctors should consider the sum of volume with same patient in different operations. Besides, in order to increase the time of anesthesia, vasoconstrictors, including epinephrine, are commonly used, which would increase the toxic dose. The position of injection would be another possible factor of negative drug effect. Accidentally injection in arteries, which might cause local anesthesia inside those arteries, might lead to toxicity even if the dose lower than the standard volume of toxicity.

From gender and ages to analyse, lidocaine has different presentation under different indicators. Different genders show approximately equal distribution of possible negative effects. However, extremes of ages and pregnant females would affect the possibility ratio of side effects. In fact, the possibility of occurring serious systemic toxicity and peripheral nerve blocks would increase to 1:10,000 and 1:2000, which is a high percentage in clinical field [1].

4.2. Procaine

As a kind of anesthetics, neural injury and toxicity are common appearance of complication of failure. In fact, the blockages of central neural still account for larger than 70% of local anesthetic operations. Actually, the highest possibility of systemic toxicity, about 7.5 per 10,000, and the lowest incidence of severe neural injury, about 1.9 per 10,000, occur of peripheral nerve blockages.

Allergic reactions would be one of the possible negative effects as well. Based on the metabolism mechanism, the procaine could also be transport to infants through breast milk from their mothers, which need to pay attention. Also, doctors using procaine penicillin on kidney injured patients might also need to think carefully due to their limited excretion functions and brittle organs. Furthermore, bad position of injection, such as arteries, might also cause some problems, including irreversible neurovascular injury and setting of inadvertent intravascular administration. Hoigne syndrome symptoms also could occur with combativeness, anxiety, confusion, and seizures.

To be honest, the possible negative interaction with other drugs should always be considered. That means the careful observation after first injection is really important for both emergency AD and future treatment [15].

5. Conclusion

To summarize, both lidocaine and procaine are used in the local anesthetics area, but they have different target diseases, mechanisms, and side effects. Comparing with lidocaine, which is relatively safer and more had less possibility leading to anaphylaxis effects, procaine is not that commonly used in recent years in clinical area. However, scientist still finding possible methods to effectively and efficiently using these two chemicals. Actually, lidocaine has already experienced an improvement. Due to the reason that take in lidocaine by oral pathway has high possibility causing negative effects,

such as dizziness, nausea, and vomiting, lidocaine injection has been invented, which significantly increasing the feeling of patients who used. Another typical example is the procaine penicillin, combining with penicillin, this drug has more effects, such as sterilize. But still, based on the reasons that both two medicines have possibility to cause anaphylaxis effects, pre-tests before using is essential for patients. More possible methods, target diseases and combination of drugs are still waiting for further researching. Scientists are highly expected to find more chemicals fighting against the illness.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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