Review paper

The use of local anaesthetics in dermatology, aesthetic medicine and plastic surgery: review of the literature

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Abstract

The aim of the study is to present the latest information on local anaesthesia in plastic surgery, aesthetic medicine and dermatology based on the available literature. The aim of the work is to present a model of cooperation between an anaesthesiologist, dermatologist, and surgeon, so that the patients feel safe, and, above all, the procedure will be comfortable and painless for them. Regional blocks are an excellent tool to achieve this goal. Achieving this requires commitment and understanding by both the plastic surgeon and the anaesthesiologist.

Key words: regional blockades, local anaesthesia, plastic surgery, dermatology, aesthetic medicine.

Introduction

Nowadays aesthetic patients expect minimally invasive, painless and effective procedures to improve their look and self-confidence. Delivering these treatments with minimum pain and maximum comfort of a patient should be the goal of every practitioner as well as taking care of painless recovery time. Many modalities of local anaesthesia enable fulfilling this approach. It is estimated that around 12 million plastic surgery procedures and more than twice as many aesthetic medicine procedures are performed worldwide. Local anaesthetics act selectively, paralyzing the ends and fibres of the sensory nerves, thereby blocking the reception and transmission of pain stimuli. They work at the injection site to regionally restrict the conduction of centripetal impulses. Their action is reversible, and the duration of anaesthesia is variable and depends on the properties of the compound and its pharmacokinetic parameters (absorption, metabolism and elimination rates).

Medicines used for local anaesthesia are divided into esters and amides due to their chemical formula. The group of esters includes procaine and chloroprocaine, the group of amides includes lidocaine, prilocaine and bupivacaine, ropivacaine [1]. Due to the time of action, drugs can be divided into short, medium and long-acting ones. The main applications in plastic surgery are drugs with medium and long duration of action, such as ropivacaine or bupivacaine [2]. Due to the systemic toxicity of anaesthetics, the maximum doses, which are calculated individually for each patient and based on their body weight, should not be exceeded. Lidocaine can and is often combined with adrenaline, which makes it possible to increase the maximum dose (500 mg in a single injection with adrenaline). After injecting the maximum dose, the next dose can be repeated after 90 min at the earliest. It is recommended that this dose should be half the dose of the first dose [3]. Local anaesthetics are hydrophilic particles of a tertiary amine linked together with a lipophilic aromatic ring. They come in acid or base (non-ionized) form. However, only the ionized form shows an effect. As a rule, drugs used for injection solutions are slightly acidic and therefore ionized. They work by blocking rapid sodium channels in the neuronal cell membranes [4].

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The drug in its non-ionized form is quite soluble in fats, passes through the concentration gradient towards the inside of the cell, where at pH 7.1, it turns into ionized form. The drug passes through an open ion channel, preventing the influx of sodium ions inside the cell. Due to this mechanism, the nerve impulse causing the pain sensation cannot be generated and transmitted to the central nervous system (CNS).

The duration of action of the drug is affected by following factors:

– the degree of protein binding (the greater the longer the drug exhibits its effect),
– low pH (acidic environment) – causes more ionized drug, and therefore penetration through the cell membrane is lower, and therefore the potency of the drug is lower,
– fat solubility – the greater the fat solubility, the greater strength activities [4, 5].

Bupivacaine

The potency of bupivacaine is 4 times greater than that of lidocaine. It is mainly used for spinal and epidural anaesthesia and regional blockers. The maximum single intravenous dose is 175 mg without adrenaline and 225 mg with adrenaline. In animal experiments, high doses of bupivacaine above the recommended level may cause ventricular arrhythmias. Bupivacaine is broken down in the liver, therefore the dose should be reduced in the presence of hepatic failure [6, 7]. The FDA (Food and Drug Administration) in the United States has also approved liposomal bupivacaine in recent years as a new variant of the old drug. Unfortunately, in the current scientific publications, the advantage of this variant of the drug in ensuring effective postoperative analgesia or reducing the consumption of opioids after the procedure has not been demonstrated [8].

Ropivacaine

Ropivacaine can be used for infiltration anaesthesia, blockade of nerves, plexuses and for epidural anaesthesia. The commercial preparation contains a solution of 0.2%, 0.5% and 1%. In "*in vitro*" studies, the potency of ropivacaine is 25% lower than that of bupivacaine. The maximum single dose for intravenous injection is 300 mg. It is metabolized in the liver by cytochrome P450. The existence of 10 major metabolites has been demonstrated. It is less cardiotoxic than bupivacaine and is much less inotropic [9]. Currently, due to a high safety profile and versatility of use, it became the most popular drug used for regional blockades with a longer duration of action [10].

Local anaesthetics affect the entire nervous tissue, but their main site of action is peripheral nerves, which are mixed nerves. They contain sensory – centripetal and motor – centrifugal fibres [2, 5].

Mepivacaine

Mepivacaine also known as Scandonest is an amide type of local anaesthetics. The drug itself is poorly soluble in water, hence it has been formulated as a water soluble hydrochloride salt. It can be dosed at a concentration between 4–6 mg/kg and is effective for up 3 h of anaesthesia. Liver is the major organ which metabolises this drug. It should be used with caution in patients with a history of arrhythmia and heart block. Mepivacaine crosses the placenta, hence it should be used with caution in pregnant women, especially during early pregnancy as there are no available pre- and clinical data on toxicity from reproductive studies [11].

Tetracaine

Tetracaine is another example of the amide-type anaesthetic, which is typically used as a liquid. Tetracaine is altering the function of calcium release channels (ryanodine receptors) that control the release of calcium from intracellular stores. At low concentrations, tetracaine causes an initial inhibition of spontaneous calcium release events, while at high concentrations, tetracaine blocks release completely [12].

However, tetracaine is often used in combination with lidocaine cream for local anaesthesia.

Complementary substances – adjuvants

Adrenaline (Epinephrine)

Adrenaline is added to local anaesthetic drugs as an adjuvant. It constricts blood vessels, which reduces the amount of the drug that could enter the circulation. It should be remembered that adrenaline after local injection strongly constricts the vessels, so the dose must be selected appropriately to the procedure being performed.

Types of anaesthesia

Surface (superficial) anaesthesia

By performing this type of anaesthesia, the mucous membranes of the nose, mouth, trachea, throat, bronchi, oesophagus, genitals and skin are anaesthetized. The maximum effect is achieved after 5 min, the duration of action is about 20–30 min (lidocaine). There are different forms of local anaesthetics: gel, spray or ointment. Lidocaine 4% in the form of a gel is a good drug for surface anaesthesia. The disadvantage of this type of anaesthesia is its disappearance in the surface layers of tissues with a possibility of paraesthesia. It is not safer than other types of anaesthesia due to the difficulty of dosing the drug.

Infiltration anaesthesia

With this type of anaesthesia, the anaesthetic is injected intradermally, subcutaneously or intramuscularly.

The anaesthetic locally blocks the stimulation of the sensory nerve endings. The effect of anaesthesia is rapid, and the addition of adrenaline extends the duration of anaesthesia by 100%. The contraindication to this type of anaesthesia is tissue inflammation.

In terms of effectiveness, the following concentrations of agents are equivalent: procaine 1–2%, lidocaine 0.5–1%, mepivacaine 0.5–1%, prilocaine 0.5–1%, bupivacaine 0.25%, tetracaine 4%.

Due to the ability to spread in the tissues, 1% lidocaine should be mainly used for infiltration anaesthesia. A special form of infiltration anaesthesia is regional intravenous anaesthesia, during which the anaesthetic is injected into a vein previously tightened with a cuff. In the case of 1% lidocaine, anaesthesia takes place after about 2 min and lasts 15–30 min.

Local anaesthesia in specific procedures

Aesthetic dermatology

Pain often accompanies procedures of aesthetic dermatology decreasing patients' comfort and cause a feeling of insecurity. Local anaesthetics can be used to decrease this undesirable sensation and they may be divided into invasive anaesthetics and non-invasive anaesthetics drugs and procedures. The first group involves topical anaesthetic drugs and cryoanaesthesia. The second group is associated with using needles, so administration of the anaesthetic agent can be painful by itself and may frighten patients.

Topical anaesthetics are commonly used in dermatologic procedures. As ester anaesthetics, like tetracaine frequently caused contact dermatitis, nowadays the preferred topical anaesthetics are amides, such as lidocaine and prilocaine [13, 14]. The most commonly used topical lidocaine is EMLA (Eutectic Mixture of Local Anesthetics). It is an oil-in-water emulsion of 2.5% lidocaine and 2.5% prilocaine with polyoxyethylene fatty acid emulsifier enhancing absorption [15]. After 60 min EMLA reaches depth of 3 mm and after 120 min it reaches maximum dermal depth of 5 mm [16]. To increase the penetration and efficacy of EMLA, occlusion and longer duration of application can be used [17]. After application it causes initial vasoconstriction manifested as bleaching, subsequently erythema occurs as vasodilatation takes place [18]. It should be used only within limited surfaces, on healthy skin without any signs of injuries or inflammation, to avoid side effects [14]. Prilocaine can be associated with allergenicity and EMLA application can cause contact urticaria and allergic contact urticaria [19, 20].

Cryoanaesthesia uses cooling effect to reduce pain. One might distinguish contact cooling and non-contact cooling. In the first case, the medium contacts the skin directly, as ice or ice packs [21]. In the second option the cold is transferred by a gaseous medium, like cold sprays, cold air [21]. The cooling effect may be obtained at any time of the procedure (pre-, during or post-treatment). These methods are the easiest ones with a high level of patient acceptance and perfect safety profile.

Injected anaesthesia include infiltrative local anaesthesia, specific nerve blocks and tumescent anaesthesia [21]. In the first case, an anaesthetic is injected into a tissue with a risk of significant tissue distortion. Lidocaine, buffered lidocaine or lidocaine with epinephrine can be used. The patient can experience lidocaine toxicity when lidocaine with epinephrine is applied because of the anaesthesia volume required [22].

In the case of nerve blockers, the volume of the applied anaesthetic is smaller, the patient's tolerance is greater but the administration itself is much more complicated. Nerve blocks are based on injections of the local anaesthetic in the nearby nerve and are dedicated for lesions located within particular skin dermatomes. In the case of aesthetic procedures, their most common applications concern the face and neck. There are a number of nerve blocks to anesthetize this area e.g., the supratrochlear, supraorbital, zygomaticofrontal, zygomaticofacial, infraorbital, auriculotemporal, mental, great auricular and transverse cervical nerves blocks [23].

The tumescent anaesthesia (TA) is a specific subtype of injected anaesthesia. In TA a large volume of the diluted anaesthetic solution is administered into subcutaneous fat compartments of the targeted region. The solution often consists of lidocaine, epinephrine, natrium bicarbonate and normal saline.

Recently, a number of studies suggested using a vibration device for an injection associated pain relief and it has been shown that it can induce stimulation-induced analgesia. This concept originated from the Gate Control Theory of Pain reported in 1965 by Mekzack and Wall. A recently published clinical study performed on female patients undergoing hyaluronic acid or botulinum facial injections used a vibration anaesthesia device at 183 Hz. Out of 32 patients, 28 reported pain relief during vibration based on NRS (Numeric Rating Scale) [24].

Laser procedures

Pain is often a side effect of dermatological laser procedures and sometimes leads to laser parameter reduction affecting treatment efficacy making pain management a very important issue.

In the case of laser hair removal, topical anaesthetic drugs and skin cooling are used. Studies showed that EMLA cream is superior to cooling of the skin [14]. Lasers are often used to treat vascular lesions. Cold and EMLA cream act as vasoconstrictors so they should be used very carefully as they can significantly interfere with the procedure. In the case of benign lesions, laser removal infiltrative local anaesthesia with lidocaine or lidocaine/epinephrine and EMLA cream are the most often used options.

Laser resurfacing is a common procedure which among others results in improvement of wrinkles and

scars due to stimulation of collagen production in the skin. Nowadays, the most often used lasers are ablative fractional lasers. There is an important controversy about using topical anaesthetics before resurfacing with these lasers. Distilled water is a major component of most anaesthetic creams and using them before treatment with fractional CO_2 laser or fractional erbium-doped yttrium aluminium garnet laser may disrupt the photothermal reaction. Punyaratabandhu *et al*. [25] conducted a study to compare ablative width and coagulative depth of fractional lasers with and without topical anaesthetic cream. They found no significant differences in those parameters between analysed groups, although they noted a tendency to narrower ablative width and deeper coagulative depth in areas pre-treated with topical anaesthetic compared to the controls. However, the main limitation of the study was a small sample size and these conclusions should be verified. Nevertheless, special care must be taken in case of using topical anaesthetic creams in occlusion longer than 1 h before treatment with fractional ablative lasers [25]. Cryoanaesthesia reduces pain and additionally provides a thermal protection enabling the use of higher therapeutic parameters without causing the epidermis damage [21]. It reduces the post-treatment side effects like erythema, purpura or crusting [21, 26]. However, it should be used carefully not to reduce the effectiveness of the laser therapy. Nowadays less aggressive laser resurfacing procedures are preferred by patients and practitioners. Mainly because of the risk of severe side effects and patients' expectations for earlier return to normal activity. In such cases non-invasive anaesthetic methods are the best and sufficient choice. Invasive methods, as injected anaesthesia can be used in deep resurfacing, when non-invasive methods are insufficient for pain reduction. Pay and Kenealy conducted a retrospective study of 135 patients with 816 nerve blocks treated with lasers. The study showed that in 96% of cases a complete nerve block was achieved and complications occurred only in 1.1% [27]. The complications were transient neurapraxia, vasovagal syncope and swelling. The first application of TA in facial aesthetic procedures involved dermabrasion, it was successfully used in a laser resurfacing as well [28–30]. However, in the case of dermabrasion, there were problems with accurate determination of the dermis depth based on the end point of visible capillary bleeding, additionally more delicate wrinkles disappeared due to massive distention phenomenon [29]. In the case of laser resurfacing the combination of nerve blocks and TA may be used. The advantages of this method involve avoiding general anaesthesia, achieving thorough cutaneous anaesthesia, immediate post-anaesthesia recovery and anaesthetic effect lasting for many hours postoperatively. The disadvantage includes time extension of the procedure and multiple injections what may be difficult to accept for some patients [30].

The effectiveness of lidocaine/tetracaine cream was recently evaluated in a double-blind study of 20 subjects undergoing non-ablative laser treatment. VAS scores were significantly lower in the treatment sites compared to placebo. Investigators also noted adequate anaesthesia in 95% of treatment sites compared to 20% of placebo sites. Lidocaine/tetracaine cream is a stable compounded mixture of 7% lidocaine and 7% tetracaine. It has been shown to be safe and effective in producing local dermal anaesthesia for dermatological procedures. The median duration of analgesia in a clinical study of 40 subjects was 11 h [31].

Fillers

Dermal fillers injections are one of the most common aesthetic procedures used to treat unwanted wrinkles as they are non-invasive and associated with minimal down time. Hyaluronic acid dermal fillers are used most frequently for soft tissue augmentation. Fillers are applied in various anatomical regions and depending on the treated area patients commonly report mild to severe pain during injections. Before the injections, cooling of the skin or topical anaesthetics may be used. However, in the case of lip augmentation it should be noted that EMLA cream acts as a vasoconstrictor and may cause transient blurring of vermillion border. To reduce patient discomfort most fillers contain lidocaine and several studies show their efficiency in pain reduction and good safety profile without affecting their longevity [32–37].

Microneedling

Microneedling is a non-invasive, effective and well-tolerated procedure utilizing repetitive puncturing of the skin with special curated, sterile microneedles. Its applications include skin rejuvenation, acne scarring, rhytides, surgical scars, dyschromia, melasma, enlarged pores and transdermal drug delivery. The latest devices with high frequencies and latest treatment protocols with multidirectional passes, proper depth of microneedling with pinpoint bleeding as a guide to treatment end point, shorten the duration of procedures and make them far less painful. Using of topical anaesthetic is not only unnecessary but also controversial. Lidocaine itself is a vasodilator what can result in increased bleeding during the procedure and commonly used EMLA cream causes vasoconstriction what interfere the pinpoint bleeding, the end point of the procedure. Moreover researchers showed that lidocaine inhibits processes relevant to dermal repair in aged human dermal fibroblasts [38].

Microfocused ultrasound

Microfocused ultrasound is recently one of the most popular non-invasive rejuvenation therapies over the

skin of the entire body. The devices deliver thermal coagulation in the dermis and sub-dermal tissues, lead to collagen denaturation and finally to neocollagenesis. Although the treatment is well tolerated by most of the patients, sometimes pain management during the procedure is challenging [39]. The pain may lead to reduction of treatment areas, elongation of the time of the procedure, energy reduction and limitation of the procedure effectiveness [40]. Recommendations include a single oral dose of ibuprofen, topical analgesics and cooling devices for pain relief but in some cases those methods are insufficient. Polacco *et al.* [23] performed face and neck nerve block after the pre-treatment protocol including lorazepam, ibuprofen and topical anaesthetic (20% benzocaine, 4% lidocaine and 4% tetracaine) 15 min prior to the therapy. The authors concluded that these nerve blockers are well tolerated by the patients and lead to significant pain reduction during the procedure.

Summary

There are effective methods of local anaesthesia to manage pain associated with aesthetic dermatology procedures. They should be always chosen carefully not to reduce efficiency of the selected procedure. The preferences of the patients and experience of the practitioner should be taken into account as well. Moreover, every practitioner should have sufficient knowledge about side effects of the topical anaesthetics as they can be severe and life-threatening. Severe postoperative pain is one of the most important issues in plastic surgeries, at the same time there is a growing number of surgeries performed as a day-case operation and these are the reasons why local anaesthetics have been found of greater use.

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Conflict of interest

The authors declare no conflict of interest.

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