DOI 10.26724/2079-8334-2021-2-76-7-11
UDC 616-089.5+616.716.4:616-071

M.V. Anisimov, S.A. Shnayder, L.V. Anisimova, P.M. Skrypnykov[1], O.E. Reyzvikh
SI "The Institute of Stomatology and Maxillo-Facial Surgery National Academy of Medical Sciences of Ukraine", Odesa, [1]Poltava State Medical University, Poltava

STUDY OF THE PLACES OF DEPOSITION AND WAYS OF DISTRIBUTION OF THE ANESTHETIC SOLUTION OVER THE ANATOMICAL STRUCTURES ADJACENT TO THE LOWER JAW DURING MANDIBULAR ANESTHESIA

e-mail: vesnikstom@gmail.com

The problem of unstable quality of dental pulp anesthesia during mandibular anesthesia is very relevant in modern dentistry, since this method of local anesthesia is the most common for all types of dental treatment in the lower jaw, as well as for outpatient surgical interventions. Several dozen intraoral and extraoral variants of mandibular anesthesia are known. The main criterion for the effectiveness of mandibular anesthesia is considered to be anesthesia of the dental pulp. An interesting fact is that the axons that provide sensitivity to the pulp of the teeth, located in the center of the nerve, and therefore some of the latter are saturated with anesthetic solution. The anatomical part of the study – 21 sagittal cut of the human head, was carried out on the basis of the Department of human anatomy of the Odessa National medical University; X-ray part of the study – tomograms with a radiopaque substance of 6 sagittal cuts of the human head, was carried out on the basis of a private diagnostic center, which is equipped with a Somatom Definition AS tomograph from "Siemens" company. X-ray contrast substance "Verografin" was injected in a volume of 1.7 ml for each sagittal cut of the human head. The studies were carried out in the period 2013–2014 years.

Key words: local anesthesia, conduction anesthesia, tomography, anatomical structure of the trigeminal nerve.

М.В. Анісімов, С.А. Шнайдер, Л.В. Анісімова, П.М. Скрипніков, О.Е. Рейзвіх

ВИВЧЕННЯ МІСЦЬ ДЕПОНУВАННЯ ТА ШЛЯХІВ РОЗПОДІЛУ АНЕСТЕЗУЮЧОГО РОЗЧИНУ ПО АНАТОМІЧНИХ СТРУКТУРАХ ПРИЛЕГЛИХ ДО НИЖНЬОЇ ЩЕЛЕПИ ПРИ ПРОВЕДЕННІ МАНДИБУЛЯРНОЇ АНЕСТЕЗІЇ

Проблема нестабільної якості знеболювання пульпи зубів при виконанні мандибулярної анестезії є досить актуальною в сучасній стоматології, бо цей метод місцевого знеболювання є найпоширенішим для проведення всіх видів лікування зубів на нижній щелепі, а також проведення амбулаторних хірургічних втручань. Відомо кілька десятків внутрішньоротових та позаротових варіантів виконання мандибулярної анестезії. Основним критерієм ефективності мандибулярної анестезії прийнято вважати анестезію пульпи зубів. Цікавим є той факт, що аксони, які забезпечують чутливість пульпи зубів, розташовані до центру нерву, а тому одні з останніх насичуються анестезуючим розчином. Анатомічна частина дослідження – 21 сагітальний розпил голови людини; рентгенологічна частина дослідження – томограми з рентгенконтрасною речовиною 6 сагитальних розпилів голови людини і проводилась на базі кафедри нормальної анатомії Одеського Національного медичного університету, рентгенологічна – на базі приватного діагностичного центру, який обладнаний томографом Somatom Definition AS фірми «Siemens». Рентгенконтрасна речовина «Верографін» вводилася в об'ємі 1,7 мл на кожний сагітальний розпил голови людини. Дослідження проводилися в період 2013–2014 роки.

Ключові слова: місцева анестезія, провідникова анестезія, томографія, анатомічна будова трійчастого нерва.

The work is a fragment of the research project "Correction of pathogenetic mechanisms of metabolic disorders in oral tissues in patients depending on environmental and nutritional factors that affect carbohydrate and lipid metabolism", state registration No. 0118U0006966.

The problem of unstable quality of dental pulp anesthesia during mandibular anesthesia is very relevant in modern dentistry, since this method of local anesthesia is the most common for all types of dental treatment in the lower jaw, as well as for outpatient surgical interventions. Several dozen intraoral and extraoral variants of mandibular anesthesia are known [4, 5]. Most often, mandibular anesthesia is performed according to the technique described by S.N. Vaysblat (known as "lower blockade") or by M.M. Weisbrem (torusal anesthesia, known as upper block, also includes G.A. Gow-Gates anesthesia). A number of authors, based on the results of X-ray studies with a contrast agent, indicate that there is no fundamental difference between the methods of anesthesia according to S.N. Vaysblat and M.M. Weisbrem, questioning the very term "torusal anesthesia" [3]. The main disadvantages of the above methods include the relative complexity of their implementation in relation to their effectiveness. The main criterion for the effectiveness of mandibular anesthesia is considered to be anesthesia of the dental pulp. So, in particular, the effectiveness of the "lower blockade" is 62.5 %, and 25-50 % in case of acute pulpitis [9, 10]. According to our assumption, such results, to a greater extent, may be due to the anatomical structure of the structures adjacent to the target site of anesthesia, and the structure of the inferior alveolar nerve itself (n. Alveolaris inferior), which is mixed in its structure [1, 2]. An interesting fact is that the axons that provide sensitivity to the pulp of the teeth, located in the center of the nerve, and therefore some of the latter are saturated with anesthetic solution [6, 7]. This is confirmed by everyday clinical observations, when anesthesia of the adjacent soft tissues occurs from the beginning (lower lip, gums, etc.) and the actual anesthesia of the teeth occurs last, or does not occur at all. In our opinion, the effectiveness of dental anesthesia directly depends on the factor of contact of the nerve with the anesthetic solution – the longer it is, the better the pulp anesthesia will be. This makes it relevant to study the places of deposition and the pathways of distribution of the anesthetic solution during mandibular anesthesia relative to the inferior alveolar and other target nerves.

The purpose of the work was to study the deposition places and distribution pathways of the anesthetic solution during mandibular anesthesia relative to the inferior alveolar and other target nerves.

Materials and methods. Anatomical part of the study – 21 sagittal cuts of the human head; X-ray part of the study – tomograms with a radiopaque substance of 6 sagittal cuts of the human head.

The anatomical part of the study was carried out on the basis of the Department of Human Anatomy of the Odesa National Medical University, X-ray part of the study – on the basis of a private diagnostic center, which was equipped with a Somatom Definition AS tomograph from "Siemens" company. X-ray contrast substance "Verografin" was injected in the volume of 1.7 ml for each sagittal cut of the human head.

The use of a significant number of sagittal cuts of the human head in the anatomical part of the research is caused by the complexity of the preparation of the anatomical structures adjacent to the mandible. In particular, this applies to the inter-pterygoid fascia and the corresponding anatomical space, which is little described in the special literature, but is easily destroyed during preparation, which makes it impossible to understand its effect on the spread of the X-ray contrast solution.

Within five minutes after the introduction of the X-ray contrast solution, the sagittal cuts of the human head were placed in a tomograph, after which the obtained data were compared and analyzed. On the obtained tomograms, in all cases, a similar distribution of the X-ray contrast solution was noted. According to the authors, the stability of the data obtained with tomography of sagittal cuts of the human head gives reason to consider the number of studied anatomical preparations sufficient.

Results of the study and their discussion. The anatomy of the mandible and adjacent structures is well known and has been studied quite thoroughly by practitioners. This is necessary to understand regional anesthesia, the appropriate surgical techniques, their risk factors and the mechanism of complications, the development of purulent-septic processes. Our long-term work in the study of local anesthesia in dentistry is primarily based on a detailed analysis of the anatomical structure of the target anesthesia point. If we take into consideration mandibular anesthesia according to its classical technique (Inferior Alveolar Nerve Block – IAB), it looks quite logical from an anatomical point of view, and should show a very high efficiency in condition of its correct execution. However, general clinical practice indicates a relatively large number of unsatisfactory results [8]. So, pulp anesthesia is only sufficient in about 60 % of cases when using a standard dose – 1.7 ml of a solution of 4 % articaine hydrochloride with epinephrine 1:100000 or 1:200000. Thus, we must state that the generally accepted, completely logical and holistic anatomical rationale for mandibular anesthesia does not critically correlate with the expected clinical efficacy. Our further research allowed us to be convinced that some of the nuances of the anatomical structure, which are considered anatomically insignificant in the context of topography and surgery, turned out to be fundamentally important for the clinical effectiveness of mandibular anesthesia.

During the anatomical study of the target point of mandibular anesthesia, we drew attention to a number of features, the presence of which, we believe, explains the relatively high percentage of failures even with the correct methods and the exclusion of other factors, mainly related to the individuality of each patient and the skills of the doctor. Among these features, there are two of the most significant. The first is the topography of the target nerves (inferior alveolar, lingual, and buccal). The second is the influence of anatomical spaces and fascia on the spread of anesthetic solution in the corresponding area.

Features of target nerves' topography**.** Understanding the specific features of the position of the target nerves, especially the inferior alveolar and lingual, as well as the inferior alveolar branches of the maxillary artery, is of great clinical importance. It should be emphasized that, contrary to the ideas about the anatomical structure of this area, widespread among dentists, neither the inferior alveolar nerve nor the corresponding artery goes «along the bone». They first encounter the lower jaw only when entering the mandibular canal, approaching the mandibular opening at an angle of about 45 degrees (fig. 1 a, b).

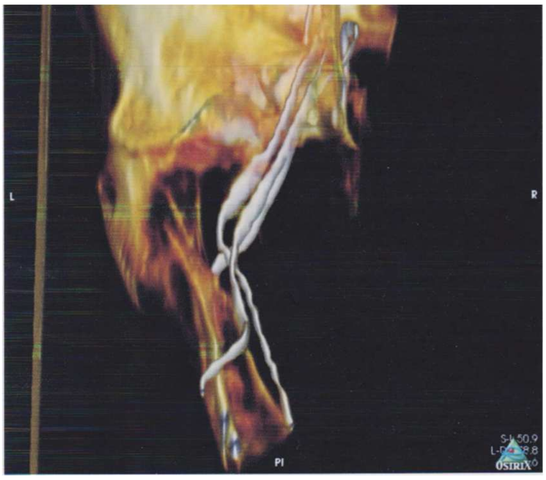

Fig 1 a. Visualization of the location of the target nerves along the bone structures in the area of the anesthetic depot during mandibular anesthesia.

Fig 1 b. Sagittal cut of the human head, the location of the inferior alveolar nerve and artery to the entrance to the mandibular canal.

The lingual nerve is similarly located and pressed against the bone at the level of the mandibular foramen, a little more medially, and further goes along the inner surface of the lower jaw (fig. 2 a). It follows that with the correct execution of mandibular anesthesia (contact of the needle with the bone 0.5 cm above the mandibular opening), the lower alveolar and lingual nerves will be at a distance of about 1 cm from the needle cut (fig. 2 b).

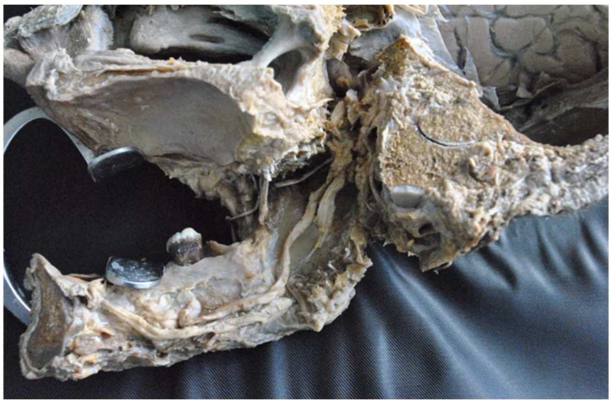

Fig 2 a. Dissected buccal, inferior alveolar and lingual nerves.

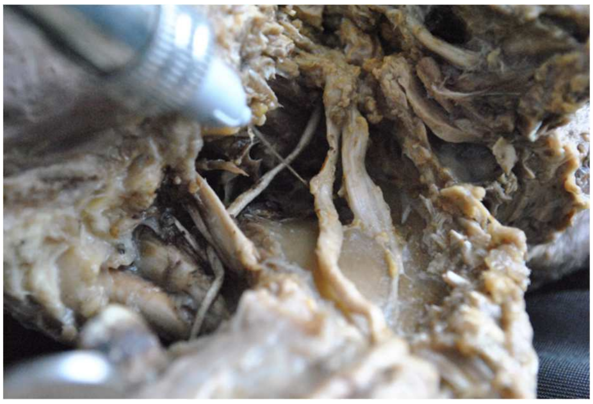

Fig 2 b. Position the needle at the target point of mandibular anesthesia.

Accordingly, the higher the point of contact of the needle with the bone, the further target nerves will be. It is believed that conduction anesthesia is based on the concept of «aimed hit», the closer the needle is to the nerve, the more effective the anesthesia. In turn, this leads to a number of typical complications for conductive anesthesia, such as injuries of blood vessels and nerves. When conducting mandibular anesthesia, injuries of blood vessels and nerves are a typical complication and is possible when the needle moves to its contact with the bone, and intravascular injection is possible with an accurate hit into the artery, which can occur only at the point of its entry – the funnel part of the mandibular canal. This can be caused by a violation of the technique or an atypical structure of this anatomical region.

Influence of anatomical spaces and fascia on the spread of anesthetic solution. As it is known, the main condition for successful conduction anesthesia is the creation of a sufficient concentration of anesthetic solution in the immediate vicinity of the nerve. This requires two main conditions–the introduction of a sufficient amount of anesthetic solution and its content at the target nerves, so that the anesthetic can penetrate in sufficient quantities through the fatty membranes of the nerve fibers to the desired axons. If these conditions are violated, then the nerve fiber is impregnated with the anesthetic not in full, but only superficially. In this case, we get “secondary” signs of anesthesia, such as numbness of the lower lip on the corresponding side, tongue, but pulp anesthesia does not occur. As we noted above, this is due to the fact that the groups of axons that innervate soft tissues are located outside the nerve, and those innervating the teeth are inside.

The target point of mandibular anesthesia, which is performed according to the generally accepted technique, is 0.5 cm above the mandibular opening and is located in the wing-mandibular space. Accordingly, an anesthetic depot is created in this space. Of direct interest to us was how and where the anesthetic solution spreads from its depot. Obviously, if with a fixed amount of solution, the larger the area of distribution of the anesthetic, the less will be its concentration on the target nerves. Six mandibular anesthesias (IAB) were performed on the sagittal cuts of the human head to examine the area of distribution of the anesthetic solution. In this case, the local anesthetic was replaced with a x-ray contrast solution "Verografin" in a standard volume of 1.7 ml. Three minutes after the injection, a computed tomography scan of the sagittal cut was performed. All tomograms showed a similar distribution of the solution (fig. 3)

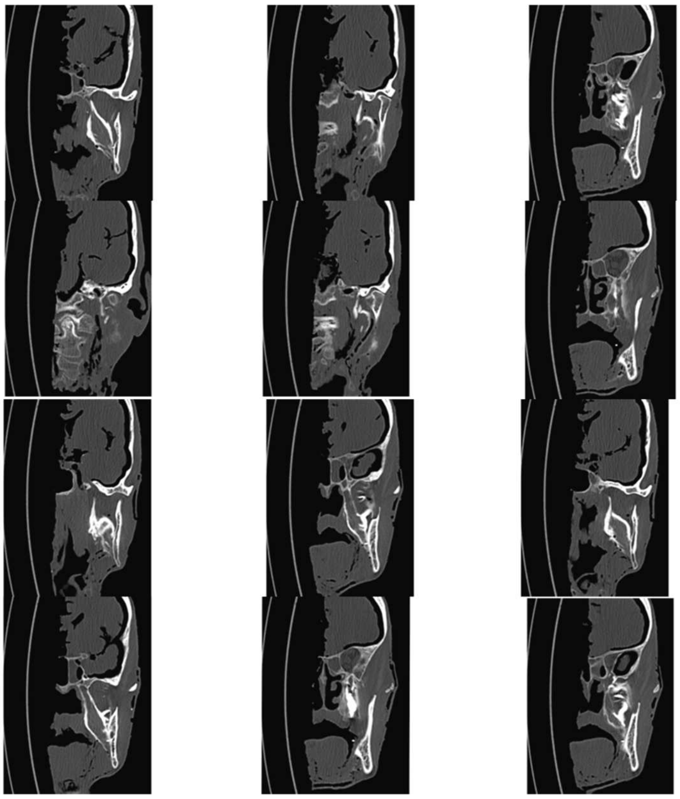

Fig. 3. Front view, slice order – from front to back.

The obtained tomograms show that the solution from the wing-mandibular space largely enters the adjacent anatomical spaces, the parapharyngeal and pterygomandibular. Moreover, it spreads over a large area, starting from the projection of the anterior edge of the coronoid process and to the posterior edge of the articular process. The contours of the medial and lateral pterygoid muscles are also clearly marked. At the same time, a fairly high distribution of the X-ray contrast substance with a loss of its concentration in the necessary areas of the target nerves can be noted. When dissecting these anatomical areas on cadavers, we were convinced that this distribution of the solution during mandibular anesthesia was directly affected by the pterygomandibular fascia. In this case, it prevents the target nerves from contact with the anesthetic solution.

If we count the area of the solution image on the tomogram sections, it becomes obvious that in the required area near the inferior alveolar nerve, it remains close to 1/4 of the total volume injected. At the same time, it does not concentrate in a specific area, but contacts the nerve over a considerable length and simultaneously with a loss of concentration. This creates the conditions for superficial contact of the nerve with a conventional anesthetic solution and, largely, explains the clinical consequences of anesthesia, namely the occurrence of anesthesia of adjacent tissues without the onset of anesthesia of the dental pulp.

Based on the results of the anatomical and X-ray studies performed on sagittal cuts of the human head, it can be concluded that when local conduction anesthesia was reproduced on the lower jaw using the standard technique, most of the retro-contrast material was not in contact with the target nerves, but to a large extent was observed on a fairly large anatomical array. We hypothesize that a similar distribution of the anesthetic solution during standard mandibular anesthesia may be the main cause of poor clinical results. It is obvious that the distribution of the anesthetic in adjacent tissues and spaces negatively affects the exposure of the solution to the target nerves, primarily the inferior alveolar, which leads to the fact that the central "dental" axons are not saturated with anesthetic solution in the required amount. This leads to the typical clinical picture of unsatisfactory mandibular anesthesia – minor signs of anesthesia are observed, but the tooth pulp remains sensitive.

Based on the carried out studies, we believe that the anatomical factor is the main factor in the failure of local conduction anesthesia in the lower jaw according to the standard technique. This creates the prerequisites for a deeper analysis of this problem, and makes it urgent to search for or develop more advanced techniques for conduction anesthesia in the lower jaw.

A number of authors [4, 6, 7, 8] has previously published studies on the problem of increasing the effectiveness of mandibular anesthesia. However, in our opinion, the reasons for a significant number of cases of ineffective anesthesia have a more complex anatomical basis [1, 2]. For a deep analysis and understanding of these reasons, it is necessary to compare clinical experience with various methods of anatomical research.

When studying the literature on the topic of mandibular anesthesia, we were unable to find publications in which the methods of descriptive computed tomographic anatomy in combination with the method of anatomical preparation were used for this purpose, which makes these studies unique.

Conclusion

Based on the carried out studies, we think that the anatomical factor is the main factor in the failure of local conduction anesthesia in the lower jaw according to the standard technique. Pulp anesthesia is sufficient only in about 60 % of cases when using a standard dose – 1.7 ml of a solution of articaine hydrochloride 4 % with epinephrine 1:100000 or 1:200000. Thus, we must state that the generally accepted, completely logical and holistic anatomical rationale for mandibular anesthesia does not critically correlate with the expected clinical efficacy.

Based on the results of the anatomical and X-ray studies performed on sagittal cuts of the human head, it can be concluded that when local conduction anesthesia was reproduced on the lower jaw using the standard technique, most of the retro-contrast material was not in contact with the target nerves, but to a large extent was observed on a fairly large anatomical array.

Our further research allowed us to be convinced that some of the nuances of the anatomical structure, which are considered anatomically insignificant in the context of topography and surgery, turned out to be fundamentally important for the clinical effectiveness of mandibular anesthesia.

References

1. Gayvoronskiy IV, Nichiporuk GI. Klinicheskaya anatomiya sosudov i nervov. Uchebnoye posobie, izdanie 7-e. ELBI-SPb, 2014:144 [In Russian]

2. Gayvoronskiy I, Nichiporuk G. Sosudy i nervy vnutrennikh organov ELBI-SPb.2016:56 [In Russian]

3. Kabanova SA, Pototskiy AK, Kabanova AA, Chernina TN, Minina AN. Osnovy chelyustno-litsevoy khirurgii Tom 1 Vitebsk; 2011:291 [In Russian]

4. Decloux D, Ouanounou A. Local Anaesthesia in Dentistry: A Review. International Dental Journal. 2021; 71(2):87-95.

5. Klingberg G, Ridell K, Brogårdh-Roth S, Vall M, Berlin H Local analgesia in paediatric dentistry: a systematic review of techniques and pharmacologic agents. Eur Arch Paediatr Dent. 2017;18(5):323–329. doi: 10.1007/s40368-017-0302-z.

6. Maha Ahmad The Anatomical Nature of Dental Paresthesia: A Quick Review Open Dent J. 2018;12:155–159.

7. Santhosh Kumar MP. Paresthesia following local anesthetic administration in dentistry. International Journal of Pharma and Bio Sciences. 2015;6(3):112–116.

8. Stanley Malamed. Handbook of Local Anesthesia 6th Edition 21st March 2012:432.

9. Thanawala V, Bedforth N. Handbook of Local Anesthesia BJA*:* British Journal of Anaesthesia*,* 2013;110(4):666–667 https://doi.org/10.1093/bja/aet047.

10. Toma M, Berghahn M, Loth S, Verrengia B, Visani L, et al. Articaine and paresthesia in dental anaesthesia: neurotoxicity or procedural trauma? OralHealth. 2015 https://www.oralhealthgroup.com/features/articaine-and-paresthesia-in-dental-anaesthesia-neurotoxicity-or-procedural-trauma.

Стаття надійшла 28.05.2020 р.