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## Systemic Reactions of Intraosseous (Vascular, Spongy) Anesthesia

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### Research Article

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#### ABSTRACT

Separation of the methods of local anesthesia on diffuse and vascular that we proposed (Petrikas et al.), is related to the safety of dental spongy anesthesia.

**PURPOSE:** To evaluate the systemic complications of dental spongy vascular injection based on publications and our records.

Spongy anesthesia containing epinephrine, in each subject causes systemic reactions of the sympathetic or parasympathetic type, usually the first. There are significant changes in heart rate and systolic blood pressure. They do develop in the first minute, falling to fourth. They are not typical to classical anesthesia.

Headache and tachycardia are specific symptoms of severe systemic reactions to spongy injection. Chest pain is another terrible symptom.

After classic (293) and spongy (431) anesthesia it was analyzed 17/56 systemic complications, properly. Quantitatively, the complication to vascular (spongy) injection was more common. It is essential that the vegetative (sympathetic and parasympathetic) reactions were observed only after a spongy injection. All reactions - complications were mild, transient and reversible. However, the transformation of reactions in severe complications are possible, as was the case in the 70s.

### INTRODUCTION

Vascular spongy intraosseous (intraosseous itself - IOA, intraligamentary - ILA, intraosseous-ISA) anesthesia, located in the supplemental section, take the larger place in dental practice <sup>[1]</sup>. Lalabonova et al. (2005) showed that in Bulgaria for 76% of dentists ILA has become a routine <sup>[2]</sup>. A survey of 800 from 2500 American endodontists found that about 95% of them use supplemental methods of anesthesia, mostly ILA - 50%, and also intraosseous two-stage injection <sup>[3]</sup>.

The popularity of spongy anesthesia contributed to the simplicity of its implementation, more than 2 times smaller dose and high efficiency in the absence of severe paresthesias of soft tissues <sup>[4-6]</sup>. Prevalence contributed to a new injection technique: pressure (multiplication) <sup>[1]</sup> and computer syringes (C-CLAD Systems) <sup>[7]</sup>, as well as a special needle <sup>[8]</sup>.

Separation methods of local anesthesia on diffuse and vascular that we proposed <sup>[1,9]</sup>, is related to the safety of dental spongy anesthesia.

Separation methods of local anesthesia and diffuse disease, proposed by us <sup>[1,9]</sup>, it is related to the safety of dental anesthesia spongy. Additional injections were in a section of classic diffuse with zero frequency of positive aspirations <sup>[10]</sup>. In addition to our research 61% of positive aspirations in the dental intraosseous anesthesia observed by other authors <sup>[11]</sup>.

**PURPOSE :** To evaluate the systemic complications of dental spongy vascular injection based on publications and our records.

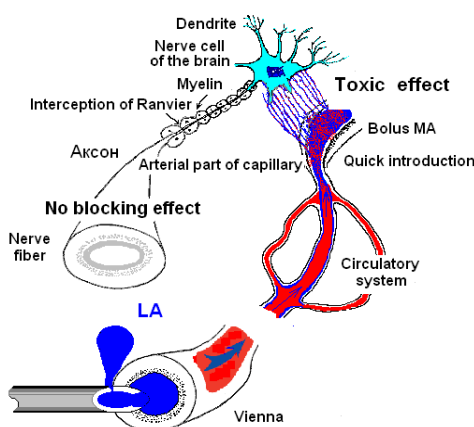
## MATERIALS AND METHODS

Data of the literature review include the summation of our work in recent years <sup>[1,12-15]</sup>, united by a common hypothesis, the clinic and uniform methods such as aspiration during injection, anesthetic 4% articaine with epinephrine at a dose of at least 2 half classical infiltration, monitoring heart rate and systolic and diastolic blood pressure (OmronMX3 plus.ERAtchnology), pain electrometer pulp (Pulptest-Pro).

## RESULTS AND DISCUSSION

The main factor that creates the relative harmlessness of the spongy anesthesia is a low dose of anesthetic, amounting 0.3 to 0.6 - 0.9 ml <sup>[9]</sup>. Given the small volume of injected substances the crucial role in the manifestation of adverse reactions, is vasoconstrictor not the anesthetic. It is needed from 5 to 9 cartridges 1.8 ml to create toxic effects of local anesthesia <sup>[10]</sup>.

The main system complication in traditional injection is also due to a vascular factor. This is usually accidental introduction of the solution into the lumen of the vessel, in the vein <sup>[11,12]</sup> (**Figure 1**).

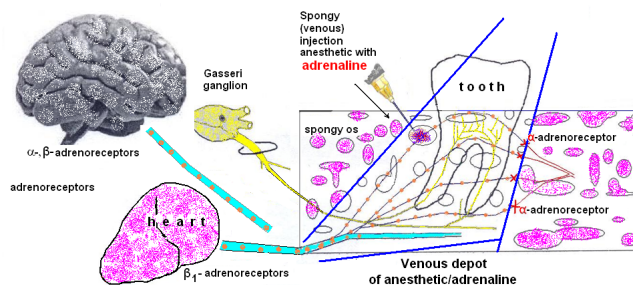


**Figure 1.** Accidental intravenous injection of local anesthetic (LA), which is due to the rapid introduction formed in the vessels the wave (bolus) of concentrated drugs, even undiluted by blood. Meeting with the excited tissues, such as brain cells, it has a blocking effect. Local anesthesia due to the lack of anesthetic in a place of injection does not occur <sup>[12]</sup>.

There is almost a lack of researches, devoted to systemic complications of dental spongy anesthesia. There are researches of reactions of HVS after spongy anesthesia at the best, of ILA and ISA are hardly ever.

Serious systemic complications to intraosseous anesthesia has been presented only by Boakes et al., dating back to 1972 <sup>[13]</sup>. It analyzed 12 reports of the Committee on Safety of Medicines (UK) about severe adverse reactions of local dental anesthetics with the painful hypertensive headaches, including death. It was estimated Xylestesin (ESPE), contains 2% of lidocaine and norepinephrine in high concentrations of 1:25.000.

In 2 cases out of 12, hypertensive crisis was developed after conducting intraosseous anesthesia which was very rare at that time in England. Both patients had intense headaches immediately after intraosseous injection for 4-5 minutes. One addition was a dimming of consciousness memory, speech and sensory disorientation for several days. Boakes had not a thought about hypertensive crisis because of a vascular nature of intraosseous anesthesia, in response to our observation <sup>[14]</sup>. In the Boakes,s work was found a link between the use of tricyclic antidepressants and local anesthesia with norepinephrine in high concentrations. It can be seen in 6 cases. Antidepressants were not applied for patients with intraosseous anesthesia. Although the main clinical syndrome for investigated states was a hypertensive crisis, in two cases, the headache joined the pain in heart and chest tightness. We believe that the headache is an important clinical sign of possible complications of spongy injections. (**Figure 2**).



**Figure 2.** Spongy injection passes through the venous vessels anesthetic,s epinephrine to adrenergic receptors in the heart, brain, causes, for example, a tachycardia. The activation of  $\alpha$ -adrenoreceptors in the injection zone creates inside the bones partially isolated depot of local anesthetic containing completely blocked the pulp-periapical complexes.

In 80s the vascular nature of spongy anesthesia was often investigated, but was not studied as a risk factor [15-17]. In the 21st century the diffuse mechanism of local anesthesia was the only one. Wood et al. showed that the blood level of lidocaine used in conjunction with epinephrine, is the same as in the case of infiltration, and intraosseous injections, ignoring the epinephrine as cause of side effects [18] (**Table 1**). He excludes a vascular mechanism, because, in his opinion, the anesthetic would pass by without stopping and without causing an anesthetic effect. Wood et al. the idea of "adrenaline depot of anesthesia" did not understand.

**Table 1.** Study the pulse rate (beats/min bpm) during spongy primary and supplemental anesthesia.

Authors	Number n	Anesthetic, Vasoconstrictor	Primary/supplemental	% Subjects since raised pulse rate	Average increase in pulse rate
Bigby et al. [21]	37 patients	Articaine/epinephrine 1:100000 after 1 min after 3 min	Supplemental	83% 54%	32 bpm
Brown [27]	review	LA + vasoconstrictors	-	46-100%	
Guglielmo et al. [28]	40 patients	Mepivacaine 2% levonordefrine 1:200000.	Supplemental	80%	23-24 bpm
Chamberlain et al. [25]	20 volunteers	Lidocaine 2% /epinephrine 1:100000	primary	CVS HELL no significant changes	12 bpm
Susi et al. [22]	61 volunteers	Lidocaine 2% epinephrine 1:100000 fast injection 45 sec slow injection 4min 45 sec	primary		21-28 bpm 10-12 bpm
Coggins et al. [29]	40 volunteers	Lidocaine 2% epinephrine 1:100000	primary	78%	-
Dunbar et al. [30]	40 patients	Lidocaine 2% epinephrine 1:100000	Supplemental	80% heartbeat	
Replogle et al. [24]	42 volunteers	Lidocaine 2% epinephrine 1:100000 Mepivacaine 3%	primary	67%-	5 bpm p<0.05-
Reitz et al. [31]	38 volunteers	Lidocaine 2% epinephrine 1:100000	Supplemental	68% heartbeat	
Peñarrocha-Oltra et al., [19]	100 patients 200 injections	Lidocaine 2% epinephrine 1:100000 Mepivacaine 3%	Primary-		4,6 bpm p<0.05 1,6 bpm
Pereira et al. [26]	60 patients	Articaine 4% epinephrine 1:100000, 1:200 000	Supplemental		CVS HELL no significant changes
Yakupov [20]	76 patients	Articaine 4% epinephrine 1:100000 epinephrine 1:200000	primary	83%	13,4 bpm 9,6 bpm

The only one work devoted to a seemingly random system complications is in interest [19]. Compared to a traditional (infiltration and conduction) and intraosseous anesthesia (200 injection in 100 patients, lidocaine with epinephrine 1:100000 and mepivacaine one [19]. "No important incidents in this study were observed", except for the fainting of 7 patients with IOA... and only 3 patients received regular dental anesthesia. For the first time in Western literature was detected an excessive frequency aspirate during the intraosseous anesthesia in 61% (compared to 0% [10] and 90% [9]).

Increased heart rate is a new syndrome of spongy injection, which is celebrated by almost all doctors working with them. The main stimulator of these reactions is an epinephrine of anesthetic solution. The reaction occurs under the needle [4,20-22]. Increased heart rate is briefly. Heart rate returns to a baseline within 3-4 minutes in most patients. Four minutes is the half-life of epinephrine. A significant increase in pulse rate is accompanied with a subjective feeling palpitations, fear. Sometimes, it causes the patient's panic, anxiety, cardiac death fear appears [23]. Increasing heart rate after intraosseous introduction according to different authors, is presented in Table 1. This compelling specific symptom of spongy anesthesia distinguishes it from classical [20]. Such a condition we refer as the complication and/or the precursor to more serious complications. The severity of the reaction depends on the speed of injection. To exclude tachycardia Susi et al, prompted to enter the normal dose, for example, 1,4 ml slowly for 4 min and 45 sec [24]. Blood pressure in contrast to heart rate in spongy anesthesia was not noticeable and was not seriously investigated [25-27].

Injection creates an alarm condition, the stress, in which is both autonomic (vegetative) nervous systems: sympathetic and parasympathetic are uniformly involved (**Table 1**).

Increased heart rate in the first minute after injection, caused by a direct hit of epinephrine in a total venous blood flow. Then in the bone tissue venous-capillary depot of anesthetic is formed with the aid of epinephrine (Figure 2). It is an important part of the desired or, on the contrary, the side effects of the combined anesthetic [1,9]. Primary short reversible reaction can be a part of more serious mechanisms of vegetative crisis, for example, hypertensive stroke or a coronary heart attack [28].

Deferred monitoring cardiovascular performance is not immediately after the injection bypasses the onset of complications [9]. Our researches [20,29], proved that the performance of the CVS immediately after injection have a double benefit, both for online evaluation of health status of the patient and to control the injection and its effectiveness. For example, an increased heart rate of 5 beats/min says about the success of spongy injection.

An important pattern of observed spongy reactions to vascular introduction of anesthetic containing epinephrine, which we discovered while monitoring heart rate and blood pressure (OmronMX3 plus.E.R.A.tehnology), is to divide them into two types:

sympathetic and parasympathetic. An increase of pulse rate and systolic blood pressure are observed during the sympathetic type of reactions. This is a tendency to hypertensive risk of anesthesia. A decrease of heart rate and lowering blood pressure is observed during the parasympathetic reactions on the contrary (**Table 2**).

**Table 2.** The distribution of volunteers to increase or decrease the heart rate (PE) and systolic blood pressure (SBP) after spongy anesthesia (IOA,ILA, ISA) articaine 4% with epinephrine 1:100000 on materials of Yakupova, Medvedeva and Efimova [20,30,31]. In group ISA presents the scope of the study parameters and its average values.

Authors, year	Anesthesia	Change Indicators CVS	Indicators CVS	
			PE (beats/min)	SBP (mmHg)
Якупова ЛА 2006 [20]	Intraosseous anesthesia IOA	increase	8	7
		decrease	5	6
		number n	13	13
Медведев ДВ 2011 [32]	Intraligamentary anesthesia ILA	increase	8	7
		decrease	5	6
		number n	13	13
Ефимова ОЕ 2011 [33]	Intraseptal anesthesia ISA	increase	9 +(4-72) range, m=+27,8	5 +(5-8) range, m=+7,
		decrease	5 -(2-13) range, m=-6,5	9 -(3-4) range, m=-3,2
		number n	14	14

The potency of vegetative reactions was linked not only with medicine, but also with the emotional state of the volunteer. In this study, the subject knew about the technic of the intraosseous injection, but not its extent. He knew about the unusual experience of anesthesia, the rest was thought out and worried. As a result of lack of information negative emotion appeared. In terms of homeostasis the sympathetic and parasympathetic systems are balanced in each subject. The balance of the sympathetic and parasympathetic systems were violated under the influence of an injection pain, fear, expectations, internal adrenaline and especially external adrenaline (epinephrine), introduced with an injection, . The shift of the response to the stressor could be in the direction of sympathetic as well as parasympathetic systems, but it is more towards the first after vascular anesthesia. This pattern is probably universal, but sharply smeared (diluted) in the classical injection.

The response of heart rate in patients in the clinic, where "unusual" injection offset by one word "anesthesia" is interesting (Medvedev [30]; average data, n= 205; PE bpm: to ILA -75, immediately after the injection - 78 and after 15 min - 73). The changes are minor, they have an adrenergic orientation. The total average effect may give a misleading information, usually in the direction of increased frequency of emergency. Medvedev [30] classified the systemic complications to the sympathetic and parasympathetic. The reactions of the sympathetic (hypertensive) type were characterized by increased systolic blood pressure, the appearance of anxiety, tremor and tremor of the hands, increased the heart rate, headache, sometimes nausea and pallor. The parasympathetic response type was manifested by weakness, dizziness, pallor, syncope reaction, sometimes with the loss of consciousness, decrease in systolic blood pressure, decrease heart rate. They disguised under anesthetic toxicity. Medvedev [30] analyzed 36 complications in 205 ILA. To sympathomimetics (hypertensive) he carried 25 patients, to parasympathomimetics (hypotensive) - 11. Among the hypertensive patients 24 had increased SBP from 1 to 36 mm Hg, 20 had palpitations, and 12 - a headache. The cases of severe and prolonged headache were observed after intraligamentary anesthesia of articaine with epinephrine. Patient P.J., ASA 1, 23 years old in 2 min after ILA 1.2 ml of 4% articaine with epinephrine 1: 200 000 felt a sharp headache, nausea, denoting a pronounced widening of blood vessels in the whites of the eyes. Before injection, blood pressure was 138/91 mmHg, PE - 55bpm, immediately after the ILA - blood pressure - 128/91 mmHg and PE increased to 66 bpm. At the time of complaints - 2 min after injection, the blood pressure was 158/114 mmHg, PE 56 bpm. Intramuscular injection of Pipolphenum/dibazolium was made, but the headache did not diminish. After 40 minutes, blood pressure was 154/107 mmHg, PE - 58 bpm. Dental intervention was not carried out. An ambulance was called.

In the group of hypotensive in 7 one had a fainting reaction with a transient loss of consciousness [31].

Our studies [20,32,33] of the incidence of systemic complications during the spongy anesthesia compared with the classic infiltration and mandibular block anesthesia we summarized in the following (**Table 3**).

**Table 3.** The frequency of systemic complications during infiltration, mandibular, intraosseous, intraligamentary and intraseptal anesthesia according to the Tver authors (2006-2011) [20,33].

Technique	Number of Anesthesia n(%)	Complication (%)	Hypotensive Parasympathic n.(%)	Hypertensive Sympathic n.(%)
Infiltration	167 (100%)	8 (4,8%)	8 (4.8%)	0 (0%)
Mandibular	126 (100%)	9 (7,1%)	9 (7.1%)	0 (0%)
The amount	293 (100%)	17 (5.8%)	17 (5.8%)	0 (0%)
Intraosseous	72 (100%)	8 (11,1%)	7 (9.7%)	1 (1.4%)
Intraligamentary	205 (100%)	36 (17,5%)	11 (5.4%)	25 (12.2%)
Intraseptal	154 (100%)	12 (7,8%)	10 (6.5)	2 (1.3%)
The amount	431 (100%)	56 (13.0%)	28 (6.5%)	28 (6.5%)

The final Table 3 shows a higher incidence of complications after bone injection (13%) in comparison with the classical (5,8%);  $t=2.11$ ;  $p<0.05$ . The second feature was the absence of vegetative reactions among the classical complications. Conversely, the typical of the autonomic system complications appeared in groups of spongy anesthesia. There are two causal factors of such complications: the vascular distribution of the anesthetic and the formation of adrenaline depot of anesthetic. Despite the relative ease of systemic reactions they can be the initial link of serious current pathological complex.

Example: after a brief sympathetic reaction immediately after ILA with 0.7 ml articaine with epinephrine 1:100000 a patient who had had a previous myocardial infarction, angina pectoris developed. SBP mm Hg: up to 124, immediately after -146, PE bpm; up to 65, after -72. In 2-3 minute pains in the chest appeared; the patient has taken nitroglycerin. The pain diminished and went away in 7 minutes.

The example with the development of hypertensive crisis has been presented previously.

In this way, spongy anesthesia due to the long-term experience of use, promise minimal systemic effect, despite of vascular in nature. Referring to the article of fifty years ago (Boakes et al 1972) it can be seen that a slight modification of the vasoconstrictor, can tragically affect the security of local dental anesthesia especially in the vascular distribution of drugs.

Spongy anesthesia causes significant changes in a heart rate and blood pressure. They are not typical for classical anesthesia. All reactions-complications were mild, transient and reversible. It is not excluded the possibility of transformation reactions in a more difficult situation. An important factor in these systemic reactions is epinephrine, as an integral part of the anesthetic solution.

Monitoring indicators CVS is necessary, since the moment of injection. The fourth minute is the second critical point of monitoring. Monitoring may be limited with the measurement of at least the pulse frequency.

The complaints and a behavior of the subject are extremely important to assess his health status before and after injection. They are primary in a relation of monitoring.

A headache is almost a specific symptom of a systemic reaction of spongy injection. A chest pain is the second threatening symptom.

An important pattern of observed reactions to vascular introduction of adrenergic anesthetic, we discovered, is to divide them into two types: sympathetic and parasympathetic.

The reactions of the sympathetic (hypertensive) type were characterized with the emergence of anxiety, tremor and tremor of hands, increased systolic blood pressure, increased heart rate, headache, sometimes nausea and pallor. Other conditions, manifested by weakness, dizziness, pallor, syncope reaction sometimes the loss of consciousness, decrease in systolic blood pressure, decrease heart rate could be a variant of vegetative stress or/and direct toxic effects of anesthesia.

## **CONCLUSION**

- After 293/431 classic and spongy anesthesia analyzed 17/56 systemic complications, respectively. Quantitatively, the complication on vascular (spongy) introduction were met more frequently. It is essential that the autonomic (sympathetic and parasympathetic) reaction took place only after spongy injections.

A positive aspiration is not a criterion of danger of injection. On the contrary, it becomes a measure of the success of spongy anesthesia. For the first time in western literature a high frequency of positive aspirate during intraosseous anesthesia (61%) is presented instead of accepted in American literature of the zero frequency.

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