

The Incidence of Complications Associated with Local Anesthesia in Dentistry

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Local anesthetics are frequently administered in dentistry and thus can be expected to be a major source of drug-related complications in the dental office. Additionally, the dentist will more often be confronted with the treatment of risk patients; thus, the incidence of side effects can be expected to rise. In this study, 2731 patients receiving dental anesthesia were evaluated by questionnaire for risk factors, type and dosage of local anesthetic applied, type and duration of treatment, and complications associated with the administration of the local anesthetic. Of all patients, 45.9% had at least one risk factor in their medical histories, with cardiovascular diseases and allergies being the most frequent. The overall incidence of complications was 4.5%. It was significantly higher in risk patients (5.7%) than in nonrisk patients (3.5%). The most frequently observed complications (dizziness, tachycardia, agitation, nausea, tremor) were transient in nature and did not require treatment. Severe complications (seizure, bronchospasm) occurred in only two cases (0.07%). Articaine was found to be administered in over 90% of all dental anesthetics in Germany despite the great variety of local anesthetics available. Articaine 1 : 100,000 caused more sympathomimetic side effects than did articaine 1 : 200,000. Additionally, doses of local anesthetics proved not to be strictly determined according to body weight, especially for patients weighing less than 50 kg. In summary, it can be stated that dental local anesthesia can be considered safe. Nevertheless, the incidence of complications due to dental anesthesia can be expected to be further reduced if (a) patients are routinely evaluated for risk factors with an adequate medical history prior to dental treatment, (b) doses of local anesthetics are strictly determined according to body weight, (c) anesthetics with low concentrations of epinephrine are used, and (d) the concept of a differentiated dental anesthesia is applied.

Key Words: Dental anesthesia; Local anesthetics; Epinephrine; Side effects; Complications; Articaine.

Local anesthetics are frequently administered in dentistry and thus can be expected to be a major source of drug-related complications in the dental office. Additionally, due to increasing life expectancies as well as progress in medical and dental therapeutic treatments, today's dentists will more often have to treat risk patients; therefore, the incidence of systemic compli-

cations can be expected to rise.¹ In 1966, Freitag² reported the incidence of complications related to dental anesthesia to be 7% (21 cases out of 299), and in 1969, Persson³ found the incidence of side effects associated with dental anesthesia to be 2.5% after having reviewed 2960 cases.

In 1976, articaine was introduced for dental local anesthesia, and it has become the most frequently used local anesthetic in the dental office (in Germany, it accounts for more than 90% of all applications).⁴ With the great variety of local anesthesia products available, it is now possible for the dentist to select a local anesthetic

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according to duration and type of dental treatment as well as the patient's specific risk factors and preexisting diseases. Thus, this differentiated local anesthesia could help to reduce or even prevent side effects associated with dental anesthesia.⁵ The purpose of this study was to assess the current use of local anesthetics in dental anesthesia in Germany and associated side effects.

Some questions posed in this study were:

1. What are the most frequent risk factors encountered in patients?
2. What are the incidences of side effects associated with dental anesthesia?
3. Which complications will most often be observed after dental anesthesia?
4. Is there an association between the local anesthetic administered and the complications observed?
5. Do specific risk factors cause an increase in the incidence of complications associated with dental anesthesia?
6. Which complications are to be expected in the presence of risk factors?

METHODS

Sixteen hundred German dentists in private practice were contacted by mail and asked to participate in this study. Their addresses were randomly drawn from a commercial mailing list. Each dentist who agreed to take part in the study received three questionnaires and information concerning the handling of the questionnaires. There were absolutely no limitations or specific instructions for inclusion of patients in the study with regard to biological data, type and duration of treatment, or type/branch of local anesthetic to be used. The dentist was asked to document the treatment of the first three patients receiving dental anesthesia after receipt of the questionnaires.

For each question, there was a detailed list of answers for the dentist to choose from. Participants also had the opportunity to freely add relevant information. The data used in this paper represent only the results from those questions dealing with complications associated with local anesthetics:

1. Biological data (eg, age, sex, weight, size)
2. Risk factors (eg, cardiovascular, pulmonary, hepatic, metabolic, allergic, CNS disease, pregnancy)
3. Daily medication
4. Type of dental treatment (conservative, surgical, prosthetic)
5. Duration of dental treatment (<20 min, 20-60 min, 60-90 min, >90 min)
6. Type and dose of applied local anesthetic

7. Medication taken by the patient without medical indication prior to dental treatment
8. Complications (eg, nausea, vomiting, erythema, urticaria, itching, mucosal edema, anaphylactic shock, confusion, desorientation, agitation, dizziness, trembling, headache, syncope, seizure, hypotension, hypertension, bradycardia, tachycardia, arrhythmia, cardiac arrest, pectoral angina, local bleeding, dyspnea, asthma attack, bronchospasm)

Other topics (eg, quality of local anesthesia) of the questionnaire are not covered in this paper.

This study was partially sponsored by ESPE Dentalmedizin (82229 Seefeld, Germany), who were responsible for printing, mailing, and collecting the questionnaires. The questionnaire was designed entirely by the authors of this paper. The statistical evaluation of the data by dBase and SPSS was performed at the University of Mainz, Germany. The data were analyzed by a two-tailed Student's *t*-test, a χ^2 test, linear regression, and analysis of variance. Pearson correlation was used to test for significance.

RESULTS

Of the 1600 dentists contacted, 1100 (68.8%) volunteered to participate in this study, with 911 dentists (56.9%) returning 2731 valid questionnaires.

Women accounted for the majority of dental patients (55.3%). The average values for female patients were: age 39.9 ± 16.8 yr; weight, 63.5 ± 10.7 kg; height, 166 ± 10.7 cm. The average values for male patients were: age, 42.8 ± 16.8 yr; weight, 79.4 ± 13.1 kg; height, 177 ± 9.1 cm. All three values reached statistical significance at $P < 0.0001$ when compared with each other.

Of the patients visiting the dental office, 45.9% had one (30.4%) or more (15.5%) risk factors in their medical history. Dentists most often encountered patients with cardiovascular diseases (22.1%), allergies (19.9%), metabolic diseases (10.4%), and pulmonary diseases (5.1%) (Figure 1). Also, 28.4% (773) of all patients were on a daily medication, with 7.9% taking more than two drugs daily. These patients were most frequently medicated with oral contraceptives (18.5%), β blocker/ACE inhibitors/Ca-channel blockers (18.4%), thyroid/antithyroid drugs (15.1%), cardiovascular drugs (13.1%), antihypertensive drugs (9.2%), NSAIDs (7.4%), antidiabetic drugs (7.1%), platelet aggregation inhibitors (6.2%), psychopharmaceuticals (5.3%), antiasthmatic drugs (4.4%), anticoagulating drugs (3.6%), diuretics (3.5%), drugs against hyperlipoproteinemia/hypercholesterolemia (3.2%), rheological drugs (2.1%), corticoids

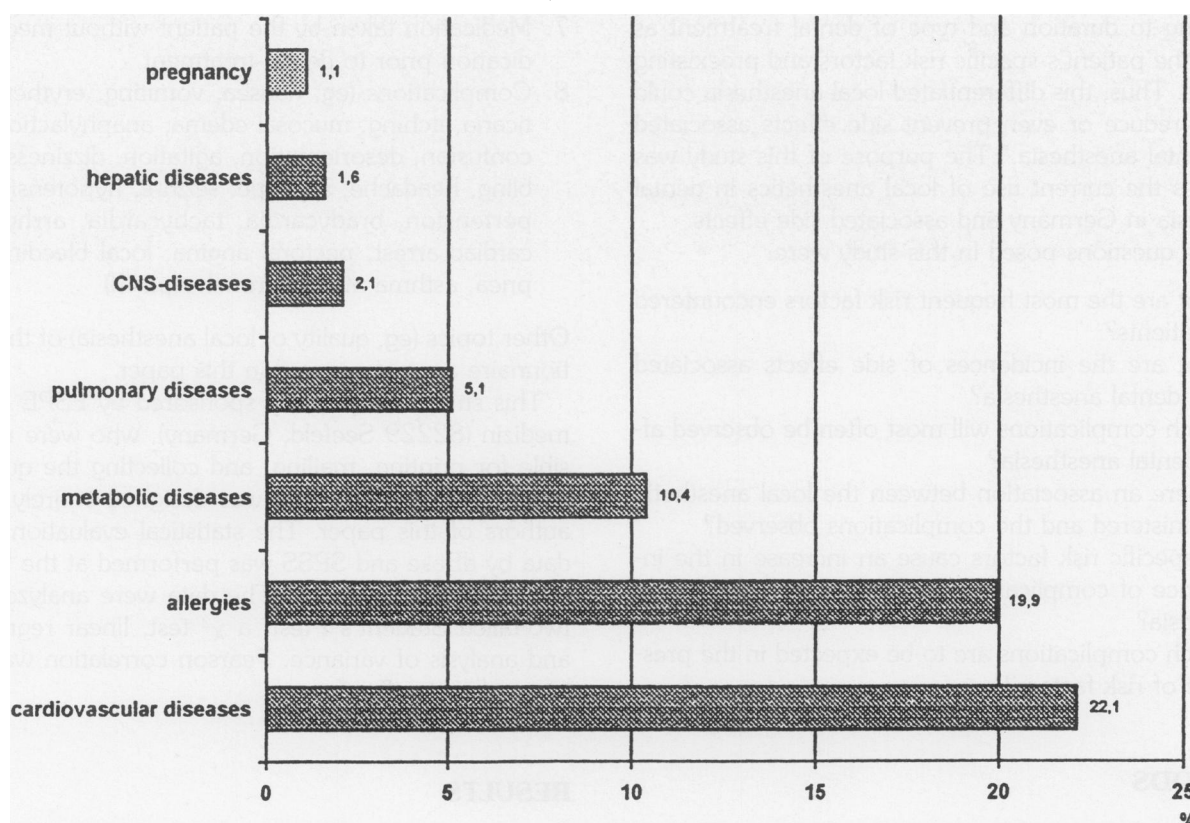


Figure 1. Incidence of risk factors in 2731 cases recorded (%). A patient may exhibit more than one risk factor.

for internal use (1.9%), therapeutics against gout (1.8%), drugs against epilepsy (1.4%), and antihypotensive drugs (1.4%). Additionally, 6.0% of all dental patients self-medicated themselves without medical indication with NSAIDs (61.5%), psychopharmaceuticals or sedatives (20.7%), and antibiotics (6.7%) prior to their dental visits. Patients undergoing surgical procedures premedicated themselves in 9.5% of all cases compared to 4.3% of patients undergoing conservative treatment and 3.6% undergoing prosthetic treatment.

Patients most often received surgical (36.2%) or conservative (33.8%) treatment. Prosthetic procedures accounted for 24.1%. Of all dental procedures, 46.5% took less than 20 min, and only 9.8% lasted longer than 90 min.

Articaine (4%) with epinephrine 1 : 200,000 (51.5%) and articaine (4%) with epinephrine 1 : 100,000 (38.7%) were the most frequently administered anesthetic solutions. Mepivacaine (3%) was used in only 3.0% and lidocaine (2%) with epinephrine 1 : 100,000 in 2.1% of all local anesthetics. The average doses patients received were highest for articaine 1 : 100,000 (2.9 ± 2.1 ml) and lowest for lidocaine 1 : 100,000 (2.3 ± 1.5 ml). Mepivacaine was administered with an average dose of 2.5 ± 1.7 ml and articaine 1 : 200,000 with an average dose of 2.4 ± 1.6 ml.

The general incidence of complications associated with dental local anesthesia was 4.5% for all 2731 cases. Frequent complications (calculated for all 2731 cases) were dizziness (1.3%), tachycardia (1.1%), agitation (1.1%), nausea (0.8%), and tremor (0.7%) (Figure 2). Syncopes occurred in 12 cases. Severe complications—one seizure and one bronchospasm—occurred in only 2 of the 2731 cases recorded (0.07%).

In the presence of risk factors in the medical history, the incidence of side effects rose to 5.7% ($P = 0.007$, compared to patients without risk factors). The incidences of dizziness, agitation ($P = 0.01$), tremor, local bleeding, and nausea were especially increased (Figure 3). In contrast, only 3.5% of the patients without any risk factors developed complications associated with the application of the local anesthetic. In patients suffering from cardiovascular diseases (600 of 2731 cases), higher incidences of tachycardia ($P = 0.003$), dizziness, agitation, and tremor were observed (Figure 4). However, severe complications such as arrhythmia, angina pectoris, and cardiac arrest did not occur at all. Additionally, in patients with cardiovascular diseases, the incidence of complications increased significantly with the duration of the treatment. Whereas during procedures lasting less than 20 min, only 2.9% of these patients developed complications, the incidence increased to 15.0% ($P =$

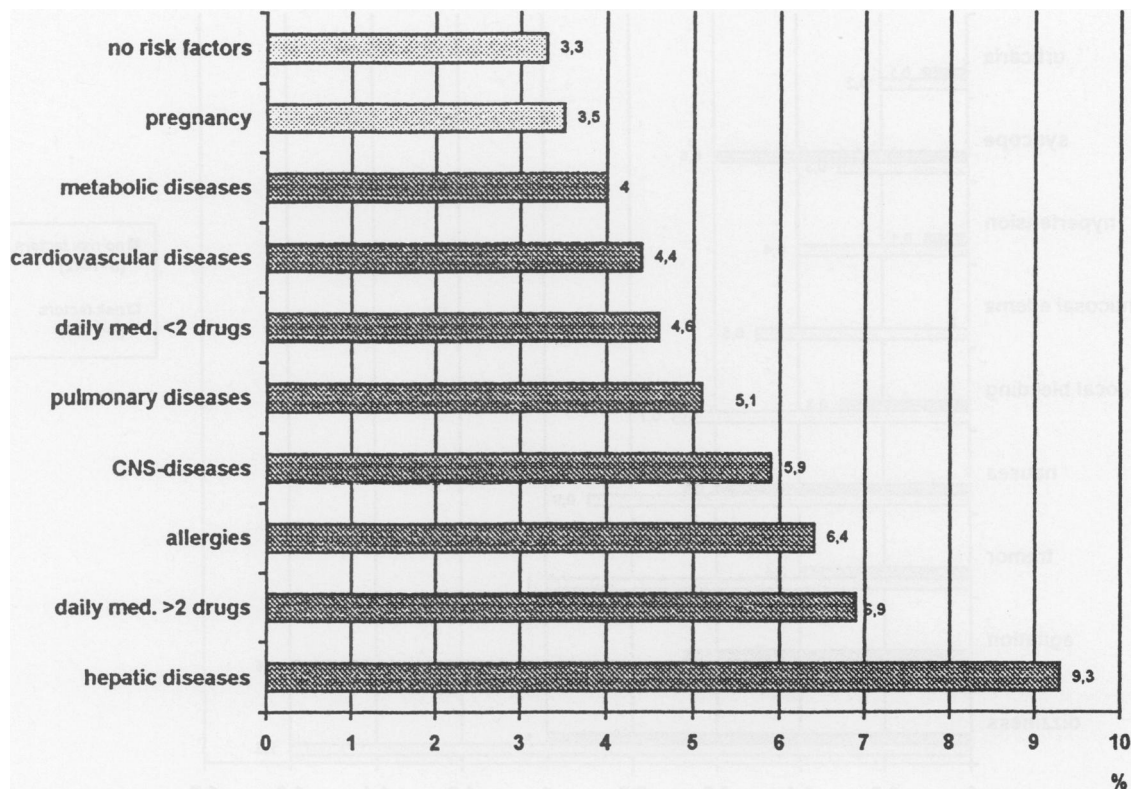


Figure 2. Incidence of complications in all patients depending on preexisting risk factors (single selection) (% of all patients).

0.0012) for procedures lasting longer than 90 min (Figure 5).

The incidence of complications rose to 9.1% ($P = 0.03$) for patients who had premedicated themselves prior to the dental procedure. Dizziness (3.0% vs 1.2%), tachycardia (3.0% vs 0.9%), hypertension (2.4% vs 0.2%), agitation (2.4% vs 1.1%), syncope (1.8% vs 0.4%), nausea (1.8% vs 0.7%), bleeding (1.2% vs 0.4%), and vomiting (1.2% vs 0.1%) were more frequently observed in these patients compared to non-self-medicated patients. Additionally, self-medicated patients received reinjection (28.6%) more often than did non-self-medicated patients (15.2%) ($P = 0.0001$) as well as higher total doses (first injection + reinjection) of local anesthetics (3.4 ml vs 2.9 ml; $P = 0.003$).

With regard to the frequency of side effects associated with the local anesthetic applied, lidocaine and articaine 1:200,000 produced the fewest complications. Lidocaine 1:100,000 (applied in 56 cases) was not associated with any side effects. Articaine 1:200,000, applied in 1404 cases, showed minor complications in 3.1%; articaine 1:100,000, applied in 1057 cases, in 6.1%, and mepivacaine, applied in 83 cases, in 7.2%. For articaine 1:100,000, higher incidences of tachycardia (1.8% vs 0.5%; $P = 0.001$), agitation (1.4% vs 0.6%; $P = 0.001$), nausea (1.4% vs 0.4%), and tremor

(1.0% vs 0.4% $P = 0.001$) were observed than for articaine 1:200,000 (Figure 6). It could also be shown that articaine was equally administered to patients with and without risk factors and that lidocaine was given more often to patients without risk factors (Figure 7). Of the 83 patients receiving mepivacaine for dental anesthesia, 71 had risk factors in their medical histories ($P = 0.001$, compared to articaine).

Additionally, there existed only a weak correlation between the patient's body weight and the dose of local anesthetic administered and a similarity to a Gaussian distribution pattern with a maximum at 17 ml can be seen (Pearson correlation coefficient = 0.11; regression = 0.0807; $P = 0.0001$) (Figure 8). The same is true for patients weighing less than 50 kg (Pearson correlation coefficient = 0.26; regression = 1.2; $P = 0.0028$).

DISCUSSION

This study would suggest that today's dental practitioner should be aware that more than 45% of dental patients will have one or more concomitant diseases in their medical histories and that about 20% of all patients will suffer from cardiovascular diseases or allergies.

Severe side effects (one bronchospasm, one seizure)

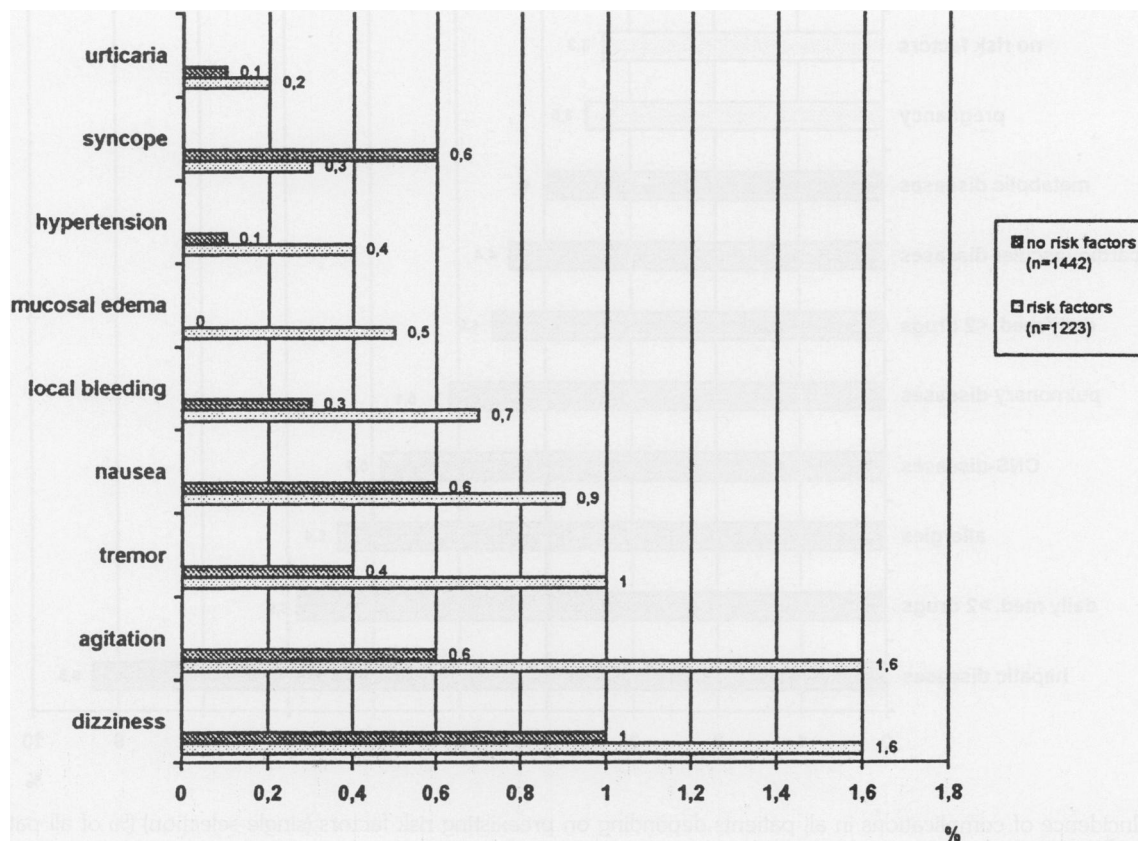


Figure 3. Incidence of specific complications depending on the presence of risk factors compared with the incidence in the absence of any risk factors (% of all patients).

occurred in 2 of 2731 cases reported (0.07%), which is comparable to the incidence of 0.05% of severe complications in general anesthesia.⁶ The overall incidence of mostly minor side effects associated with dental anesthesia was 4.5% and thus much lower than those of reports on incidences of complications associated with general (7.6%–23.2%) and regional anesthesia (0.2%–19.6%).^{7–10} Side effects were observed in 5.7% of risk patients receiving local dental anesthesia, compared to only 3.5% of nonrisk patients. Similarly, Schwilk et al⁹ report an increase in side effects associated with general anesthesia from 12.3% for nonrisk patients (ASA I, according to the classification of the American Society of Anesthesiologists) to 23.3% for ASA II patients, and even up to 33.8% and 34.9% for ASA III and ASA IV patients, respectively. Thus, with the lowest incidence of complications being associated with local dental anesthesia, it proves to be the safest anesthetic procedure compared to general or regional anesthesia.

Nevertheless, this patient profile and the incidence of side effects associated with dental anesthesia underline the necessity for taking an adequate medical history prior to the dental procedure, by far the simplest and most efficient method for the detection of risk factors.¹¹ How-

ever, taking a medical history is not part of the daily routine. According to a study performed by Jakobs,⁴ only 12.9% of 541 dentists surveyed always get a medical history prior to treatment, and 14.5% stated that they had never taken a patient's medical history. Thus, it is essential for dentists to take a medical history in order to reduce or even prevent side effects associated with dental anesthesia, because this enables the dentist to apply a differentiated anesthesia that meets the special requirements of the patient.^{5,12}

We also found self-medicated patients to have a significantly increased risk of developing side effects (9.1%). Additionally, self-medicated patients required reinjection more often (28.6%) and received higher maximum doses of local anesthetic (3.4 ml). Taking into account that 61.5% of the self-medicated patients will have taken NSAIDs or aspirin, these results are supported by the findings of Reinhart et al¹³, who showed that people taking analgesics, NSAIDs, and antibiotics failed significantly more often to receive a sufficient depth of anesthesia. Therefore, the increased incidence of complications for self-medicated patients might be partially due to the fact that they receive higher total doses of local anesthetic. Additionally, it can be assumed

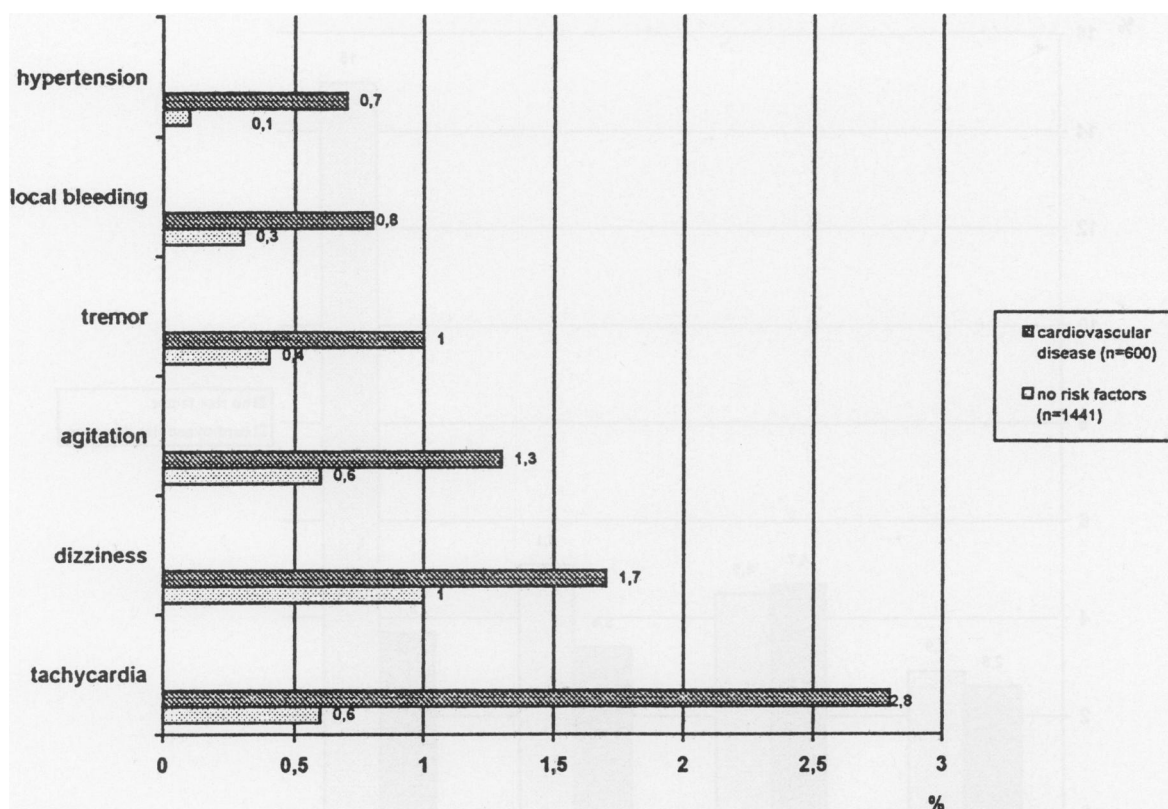


Figure 4. Incidence of specific complications depending on the presence of cardiovascular diseases compared with the incidence of complications in the absence of any risk factors (% of all patients).

that these patients are more afraid of dental interventions and may thus be more likely to show psychogenic reactions as well.

It has also been shown that the higher concentration of epinephrine in the local anesthetic solution of articaine 1 : 100,000 compared to 1 : 200,000 is the major source of sympathomimetic side effects. Hidding and Khoury¹⁴ also observed an increase in heart rate of more than 20 beats per minute in 4.1% of their patients, with a higher incidence of tachycardias for local anesthetic solutions containing 10 µg/ml (1 : 100,000) of epinephrine. Additionally, it has been definitely shown that the increase in plasma catecholamine levels observed after dental anesthesia with epinephrine is mainly due to the exogenously applied epinephrine.¹⁵ Thus, it should be investigated whether vasoconstrictor-associated complications could be further reduced if local anesthetics with lowest possible concentrations of epinephrine were routinely used.¹⁶ This is especially true since no statistically significant differences in onset and duration of anesthesia could be found between articaine 1 : 200,000 and lidocaine 1 : 80,000.¹⁷

The higher incidence of complications observed with the application of mepivacaine is most likely due to the fact that mepivacaine is preferred to risk pa-

tients who already exhibit an increased overall incidence of complications. Mepivacaine is still the local anesthetic of choice for patients with absolute contraindications to vasoconstrictors.⁵ Similarly, the low incidence of side effects associated with lidocaine can be explained by the fact that it is given mainly to patients without any risk factors and that it is given in much lower doses than articaine or mepivacaine. Additionally, it was only administered to 56 patients, compared to 2461 applications of articaine. Therefore, in order to draw valid conclusions about the incidence of side effects associated with lidocaine compared with those associated with articaine, a patient group of >1000 would be necessary.

No severe complications were observed in 600 patients with cardiovascular diseases, and it can be concluded that these patients can be safely treated under local anesthesia. This result is in accordance with the study of Cintron et al¹⁸, who did not observe any cardiovascular complications after dental anesthesia with lidocaine (2%) 1 : 100,000 in 40 patients with recent (6–20 days) myocardial infarction even if a high stress dental intervention such as tooth extraction was performed. Also, Davenport et al¹⁹ did not detect any significant cardiovascular changes after the application of lidocaine

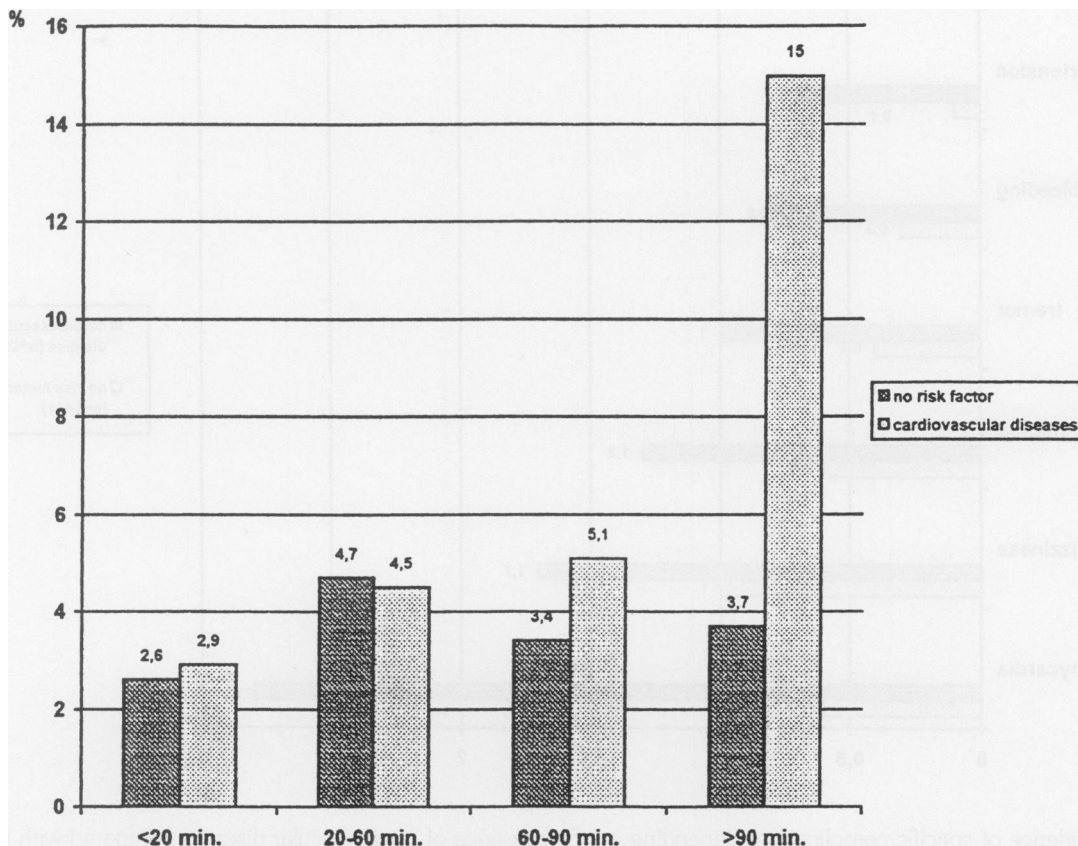


Figure 5. Incidence of complications depending on the duration of treatment. Comparison of patients without any risk factors to patients with cardiovascular diseases (% of all patients).

(2%) 1 : 100,000 in nine patients with stable cardiovascular disease. However, since 36.4% of all risk patients, including those with cardiovascular diseases, receive local anesthetics with epinephrine 1 : 100,000, it should be investigated whether the incidence of minor complications could not be further reduced if local anesthetics with no or low epinephrine concentrations, such as articaine 1 : 200,000, were routinely used for cardiovascularly compromised patients, as recommended in the literature.^{5,20} This recommendation is further supported by the findings of Kiyomitsu et al²¹, who found that lidocaine 1 : 80,000 led to more pronounced alterations of cardiovascular parameters (cardiac output, heart rate, stroke volume, afterload, mean arterial pressure) in elderly patients.

The treatment of any high-risk patients should also be limited to 30 min, since a significant increase in the incidence of complications, from 2.9 (for treatments <20 min) to 15.0% for treatments lasting 90 min or longer, was observed for patients with cardiovascular diseases. These results are supported by the findings of Walz et al²², who observed a slow but continuous drop in oxygen saturation measured by pulsoxymetry in ASA III patients undergoing dental surgery. In several cases, initial

symptoms of hypoxemia were recorded, especially if the treatment lasted longer than 30 min.

The fact that true allergic reactions, with symptoms such as erythema, urticaria, mucosal edema, and bronchospasm, occurred in less than 1% of the patients is in accordance with the literature.^{23,24} Allergic reactions have to be well differentiated from psychogenic reactions, since psychogenic reactions can often mimic allergic reactions with respect to cardiovascular symptoms such as tachycardia and hypotension as well as concomitant nausea, dizziness, sweating, or hyperventilation. However, psychogenic reactions typically lack specific allergic symptoms as mentioned above.^{23,25}

In general, it must be stated that a differentiated local anesthesia that is well adjusted to the patient's specific requirements (type and duration of dental intervention, risk factors) is not applied in the daily dental routine.⁵ The majority of patients received articaine 1 : 200,000 or articaine 1 : 100,000 for dental anesthesia regardless of their risk profile.

Another very striking finding is that local anesthetics were not administered according to body weight in children weighing less than 50 kg; under these circumstances, an intoxication can easily occur. Cheatham et al²⁶

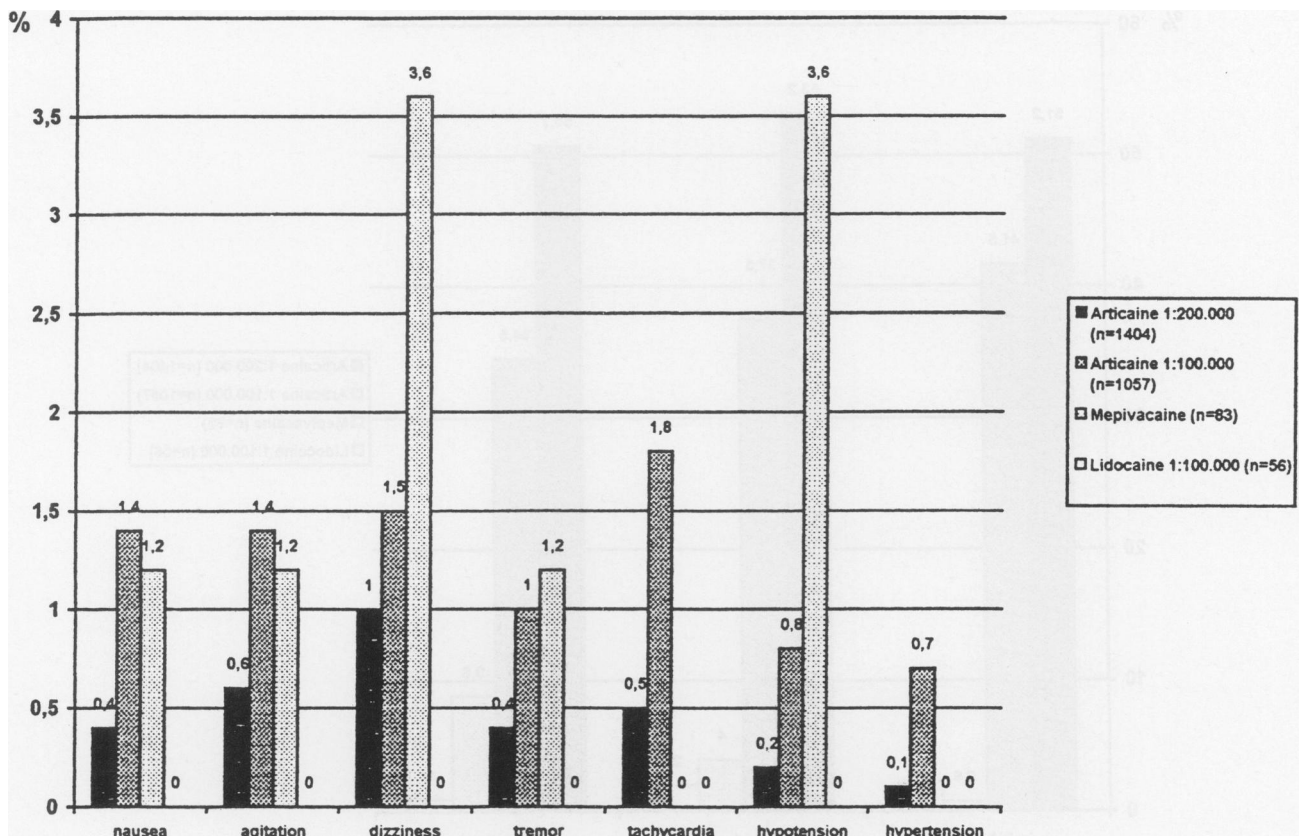


Figure 6. Incidences of specific complications depending on the local anesthetic injected (% of all patients).

came to a similar conclusion when examining local anesthesia application habits of dentists in Florida. They concluded that dose selection for children is not highly influenced by weight or age but, rather, by the desire to achieve a rapid and effective anesthesia. Additionally, Jakobs⁴ stated that only 55% of dentists accurately know the safe limits of local anesthetics and that 0.3% of the dentists asked did not know maximum amounts at all. However, in order to avoid the administration of toxic overdoses, especially to low-weight patients, doses of local anesthetics have to be strictly determined according to body weight, and maximum recommended dosages must be respected.

In accordance with Hidding and Khoury¹⁴, it can be concluded that local anesthetics can, in general, be regarded as safe drugs. The vast majority of observed side effects do not impose a severe danger to the patient's health, are transient in nature, and do not require treatment. Additionally, it can be assumed that evaluating every patient for risk factors and determining doses of local anesthetics strictly according to body weight will help to further reduce the incidence of dental-anesthesia-associated complications.

CLINICAL RELEVANCE

The overall incidence of complications associated with local dental anesthesia was 3.5% for nonrisk patients and 5.7% for patients with risk factors. Thus, dental anesthesia clearly proves to be one of the safest anesthetic procedures compared to general anesthesia, with an overall incidence of side effects of 7.6–23.3%, and to regional anesthesia, with an incidence of 0.2–19.6%. Severe complications occurred in only 0.07% (2 cases out of 2731 reported) of patients, which is comparable to the incidence of 0.05% of severe complications associated with general anesthesia. However, the vast majority of side effects were minor, were transient in nature, and did not require treatment. Nevertheless, in view of these results, it should be investigated whether this incidence of side effects associated with the application of local anesthetics in dentistry can be further reduced if the following aspects are taken into account.

1. An adequate medical history should be routinely obtained for every dental patient.
2. Doses of local anesthetics should be always strictly

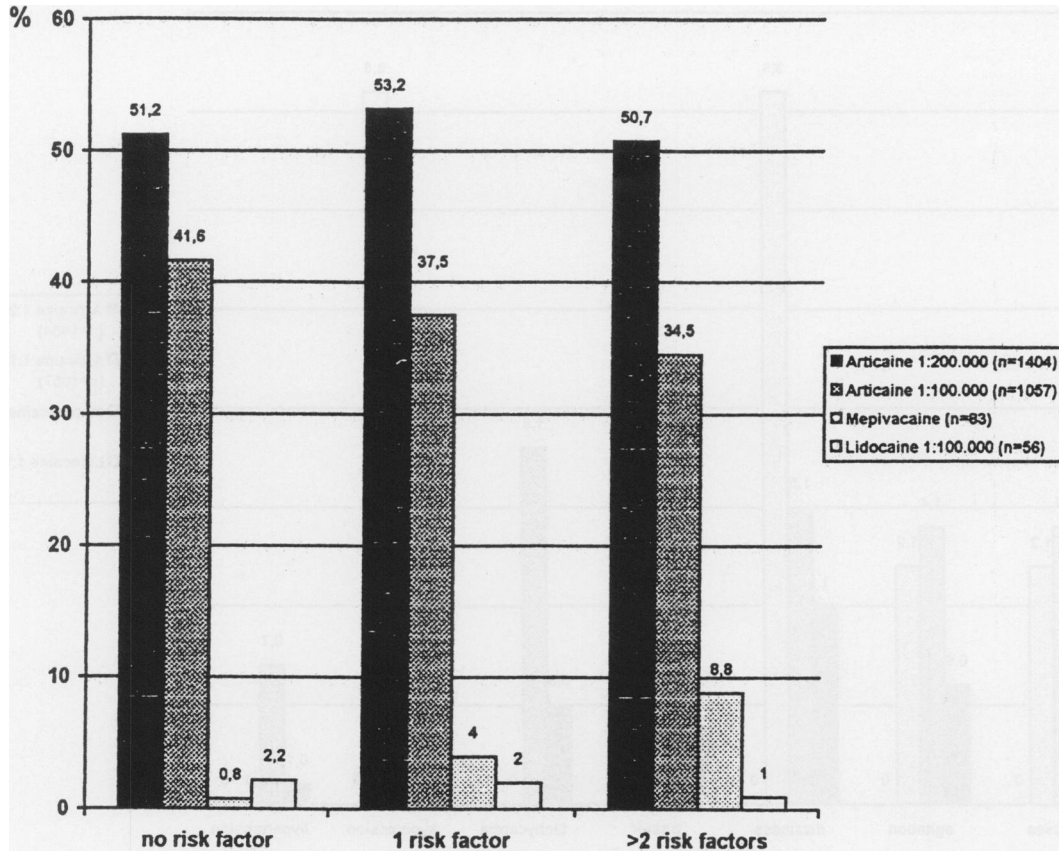


Figure 7. Incidence of local anesthetic applied depending on the presence of risk factors (% of all patients).

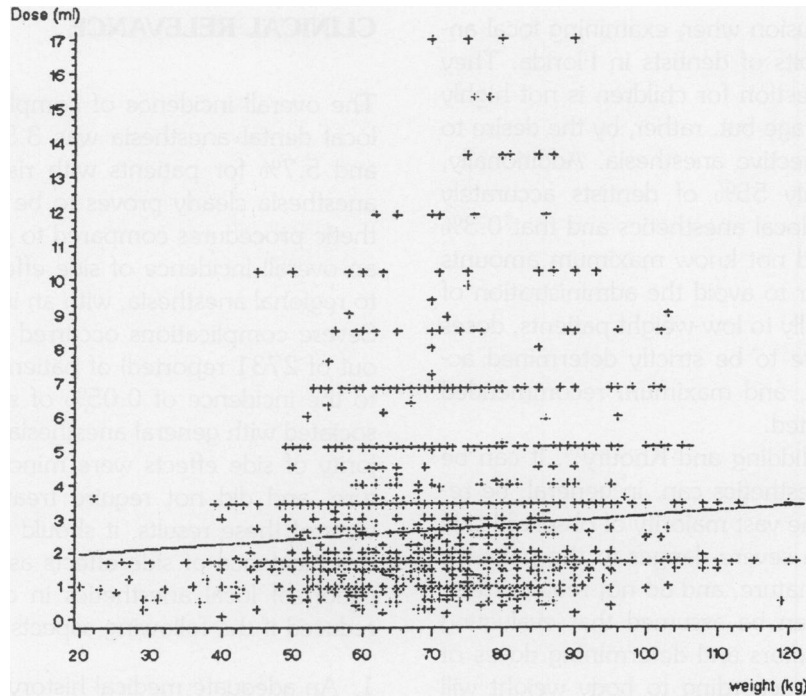


Figure 8. Distribution pattern of injected dose of local anesthetic depending on body weight. Linear regression $r = 0.081$, $P = 0.0001$; Pearson correlation coefficient = 0.11, $P = 0.0001$.

determined according to body weight, and maximum recommended dosages should be respected.

3. Anesthetics with low concentrations of epinephrine should be preferred, since this helps to reduce the incidence of sympathomimetic side effects.
4. The concept of a differentiated anesthesia that meets the special requirements of the patient (type and duration of the procedure, risk factors) should be always employed.

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