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Clinical efficacy of 1 and 2% solutions of lidocaine

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Abstract

Both 1 and 2% lidocaine solutions were clinically evaluated for effectiveness in the induction of profound local anesthesia in adolescents. This effectiveness was measured by the ability to extract healthy premolars without discomfort. In a cross-arch design using paired premolars the double-blind administration of 1% lidocaine was found to be as effective as 2% lidocaine in induction of local anesthesia. Statistical analyses indicated that failures in mandibular teeth were associated with female patients. The results suggest that 1% lidocaine may be considered for selective use in the young child patient to reduce the possibility of local anesthesia toxicity. This approach may be important when lidocaine is used in conjunction with sedative agents in cases where multiple quadrants require therapy.

There have been documented reports of convulsive episodes and death following the administration of excessive quantities of local anesthetic agents to children for dental procedures (California Board of Dental Examiners 1978; Sanders et al. 1979; Malamed 1980). The magnitude of overdosage in these cases implies a lack of appreciation of dosage guidelines as well as a failure to adjust dosage for body weight in small children. There is a need in pediatric dentistry for a local anesthetic agent with greater margin of safety than the currently employed 2% solution.

Early attempts to evaluate lidocaine objectively as a dental anesthetic were performed by measuring tooth response to graded electrical stimulation. Studies by Bjorn (1946) and Brynolf (1947) demonstrated that painless tooth preparation may be accomplished in anesthetized teeth despite sensitivity to electric current. Bjorn and Huldt (1947) revealed that negative tooth response to electrical stimulation was achieved in 97.3% of cases anesthetized with 1% lidocaine and in 100% of cases anesthetized with 2% lidocaine when equipotent concentrations of epinephrine were employed. Historically, these findings appear to have paved the way for 2% lidocaine usage in dentistry. This small difference between the 1 and 2% concentrations, however, may not be significant clinically.

Since toxicity increases commensurately with increasing concentration, a safer anesthetic technique for use in small children may be possible by employing a similar volume of a less concentrated solution. Although the concentrations of lidocaine recommended for most infiltrations and peripheral blocks for purposes of medical procedures in children range from 0.5 to 1% (Eather 1975), 2% solutions continue to be used for dental procedures despite little reported research to substantiate this concentration. The purpose of this pilot study was to evaluate the effectiveness of 1 and 2% lidocaine in obtaining local anesthesia for the extraction of healthy premolars in an adolescent patient population.

Methods

Nineteen patients who met the following criteria were selected: healthy adolescents between the ages of 12 and 19 years who possessed at least 1 pair of contralateral premolars that were indicated for extraction as part of comprehensive orthodontic treatment. The mean age of subjects in this study was 14 years, 8 months. The procedures, possible discomforts or risks, as well as possible benefits were explained fully to the human subjects involved, and their informed consent was obtained prior to the investigation.

Standard 2% lidocaine with 1:100,000 epinephrine supplied in 1.8 cc carpules (Xylocaine™ — Astra Pharmaceutical Products Inc; Westboro, MA) was used as the control anesthetic solution. An equivalent 1% lidocaine solution with 1:100,000 epinephrine was obtained from multidose vials (Xylocaine) for use as the test anesthetic solution. Under sterile conditions, the contents of the 2% lidocaine carpules were expressed. The

emptied carpules were subsequently reloaded with the 1% solution by injection through the carpule's diaphragm. The volume of test and control carpules used for mandibular anesthesia was adjusted to 1.5 ml, while the volume of test and control carpules used for maxillary anesthesia was adjusted to 0.8 ml.

Thirty-two contralateral pairs of teeth were employed in this study. Each pair was in either the maxillary arch (18) or the mandibular arch (14). The right tooth was assigned randomly to receive either the 1 or 2% lidocaine anesthetic solution, while the left tooth was assigned the remaining solution. Double-blind conditions were obtained by having identically appearing carpules of both agents coded by an individual unassociated with the clinical procedure. All anesthetic and surgical procedures were accomplished by the same operator using standard techniques. Topical anesthesia was employed prior to inferior alveolar block injections only. Aspiration was performed prior to each injection to minimize the possibility of intravascular injection.

Mandibular Teeth: A 1.5-inch, 27-gauge needle was used to deposit approximately 1.0 ml of anesthetic solution for the inferior alveolar nerve block, 0.2 ml for the lingual nerve block, and 0.3 ml for the long buccal nerve.

Maxillary Teeth: A 1.0-inch, 30-gauge needle was used to deposit approximately 0.6 ml of anesthetic solution for apical infiltration and 0.2 ml to anesthetize palatal soft tissues.

The effectiveness of the local anesthetic solutions was evaluated using a 3-point scale:

1. **Failure** — Inadequate local anesthesia as determined by an elicited response upon periosteal penetration at any of the tooth's associated papillae with a number 23 explorer; painful response to subluxation or to forceps extraction
2. **Success after reassurance** — No response to periosteal explorer penetration, but an elicited response upon subluxation of the tooth which was judged by the operator to be nonpainful after patient questioning and reassurance
3. **Success** — No response to explorer penetration, tooth subluxation, or tooth extraction.

Five minutes after injection of local anesthetic, the efficacy of local anesthesia was assessed and the extraction of the tooth was initiated. Teeth that were judged to be inadequately anesthetized were reinjected with 2% lidocaine and were rated as local anesthetic failures.

Results

The results obtained for the maxillary and mandibular teeth are summarized in Table 1. No failures were seen with 1 or 2% solution in the maxillary teeth. By contrast, a total of 6 failures were observed in the mandibular teeth. A Chi-square analysis indicated a significant difference in anesthetic efficacy between the maxillary and mandibular teeth ($P < 0.0001$). Potential factors that may have contributed to these failures are shown in Table 2. Evaluation of anesthetic failures in mandibular teeth by a Chi-square analysis indicated significant relationships existed with sex, but not anesthetic concentration or dental arch.

TABLE 1. Incidence of Local Anesthetic Failures by Dental Arch and Per Cent Lidocaine Concentration

Dental Arch	*Lidocaine Concentration 1%*	*2%*	*Total (%)**	*Significance***
Maxillary	0/18	0/18	0/36 (0.0)	$P = 1.00$ (NS)
Mandibular	4/14	2/14	6/28 (21.4)	$P = 0.13$ (NS)
Total	4/32	2/32	6/64 (10.7)	$P = 0.14$ (NS)

* Significant difference between maxillary and mandibular teeth ($P = 0.0001$) as determined by Chi square analysis.
** Probability determined by Chi square analysis.

TABLE 2. Incidence of Local Anesthetic Failures in the Mandibular Arch

Factor		*Incidence of Failure*	*Per Cent Failure*	*Significance**
Concentration	1%	4/14	28.6	$P = 0.13$ (NS)
	2%	2/14	14.3	
Quadrant	Right	3/14	21.4	$P = 1.00$ (NS)
	Left	3/14	21.4	
Sex	Female	5/18	27.8	$P = 0.04$
	Male	1/10	10.0	

* Significance determined by a Chi square analysis.

Discussion

Systemic toxic reactions due to dental local anesthetic agents are considered uncommon complications. Toxic responses are usually the result of overdosage, rapid absorption into the blood from highly vascular spaces, or accidental intravascular injection leading to excessive plasma levels of these agents (Covino and Vassallo 1976). Not unexpectedly, young children are more likely to experience a toxic reaction than adults because of their smaller anatomic proportions (Aubuchon 1982). Additionally, the ability to recognize toxic reactions in small children often is limited. Initial signs of toxicity, such as circumoral numbness, tinnitis, or dizziness, are noticed readily by an adult or older child, but may go unnoticed in the young or sedated child. The first manifestations of toxicity in small children may not become apparent until the response has

progressed to tonic-clonic convulsions, cardiac arrhythmias, or arrest (Singler 1983).

Cowan (1964) demonstrated that the dosage of local anesthetic normally injected during dental procedures is greater than required, and has reported on the minimum dosage of various anesthetic agents necessary to produce satisfactory local anesthesia. Unfortunately, because of the large safety margin that exists in adults and the desire to achieve rapid effective anesthesia, the concept of minimum dosage has been ignored (Cowan 1956).

The potential for toxicity is increased when local anesthetics are used in conjunction with sedation medications. In 1982 Aubuchon reported the results of 2911 questionnaires to members of the American Society of Dentistry for Children. Eleven percent of surveyed dentists who used sedation techniques for children reported that they had observed a significant adverse reaction. Aubuchon's findings strongly suggest that local anesthetics helped precipitate these untoward responses. Analysis of case histories revealed that severe reactions, such as convulsive episodes, were more likely to occur following the use of increased dosages of local anesthetics during sedation procedures. Aubuchon noted a direct linear relationship between the number of carpules of local anesthetic administered and the frequency of severe adverse reactions. In a review of 14 cases of serious adverse reactions following pediatric dental sedations, Goodson and Moore (1983) found high drug dosage and drug interaction between sedation medications and local anesthetics to be common elements which contributed to the reported reactions. In all but 2 cases they reviewed, the dosage of local anesthetic administered was greater than that recommended when these agents were used alone without the influence of other drugs.

Animal studies tend to support clinical experiences of increased toxicity when narcotic drugs are used in combination with local anesthetic agents. The interaction of narcotic analgesics and/or antiemetics was first reported by Smudski (1964). In this study, mice premedicated with meperidine, phenothiazine, or both, demonstrated a significantly reduced convulsive threshold to lidocaine. In a subsequent study, Gangarosa et al. (1978) reported an increased incidence of lidocaine-induced convulsions in mice premedicated with meperidine. These animal studies in conjunction with clinical reports strongly suggest a need for reducing the maximum dosage of local anesthetic when treating the child patient premedicated with sedative agents.

While the toxicity of local anesthetics in pediatric dental patients is well established, few specific strategies to minimize potential dangers have been formulated. The increased number of practitioners who employ sedative agents in conjunction with local anesthetics has resulted in an increased incidence of adverse reactions (Goodson and Moore 1983). Although guidelines exist that delineate toxic doses of local anesthetic (American Dental Association 1982), practical applications of current anesthetic concentrations often dictate greater than recommended dosages. Several approaches to reduce the toxic potential of local anesthetics may be effective. Significant reductions of local anesthetic volumes would reduce toxicity but may result in decreased diffusion and less effective local anesthesia (Cowan 1956). Furthermore, Cowan reported that guidelines for reduced volume of anesthetic were proven to be ineffective. Alternatively, a reduced anesthetic concentration would result in lower toxicity if an equal volume would achieve profound local anesthesia. Such reduced concentrations of local anesthetics are often utilized to obtain local anesthesia in the pediatric patient for nondental procedures. This study confirms the validity of this second approach in the dental environment.

Maxillary infiltration anesthesia was accomplished equally well with both 1 and 2% anesthetic solutions. This finding indicates that 1% lidocaine may be reliably used in the adolescent patient to obtain profound anesthesia while reducing the risk of systemic toxicity. With both 1 and 2% lidocaine, more difficulty was encountered in achieving profound local anesthesia in the mandibular teeth. This difference may be associated with an increased difficulty in local anesthetic placement for mandibular block anesthesia when compared to the infiltration technique utilized in the maxillary teeth. An insignificant reduction in anesthetic efficacy was seen with the use of 1% in the mandibular teeth. This diminished effectiveness may have been associated with the reduced effectiveness of lower concentrations of lidocaine on nerve trunks of larger diameters (Eather 1975). The difficulty encountered in this patient population may be more than might be expected in a preschool group which possessed reduced nerve diameters and more favorable tissue diffusion properties. A significantly greater number of anesthetic failures was seen in females in this adolescent patient population.

The results of this study agree with the widely held concept that concentrations of lidocaine which are less than 2% are clinically effective in a wide variety of circumstances (Eather 1975). These findings question early research that established 2% lidocaine as a standard in the dental profession (Bjorn and Huldt 1947). This discrepancy may be related to differences in methodology. Earlier studies utilized sensitivity to electrical stimulation as a measure of anesthetic efficacy. It is

possible that conductance to remote structures may have clouded the determination of effective dental anesthesia (Bjorn 1946; Brynolf 1947). The ability to luxate a tooth may be a more direct measurement of local anesthetic efficacy.

The value of this and similar studies is limited by the subjective nature of anesthetic efficacy evaluation. This is especially the case in a pediatric population and in situations where anxiety may complicate a subject's response. The evaluation scale utilized in this investigation was developed in a preliminary study that identified critical areas of anesthetic failure. This scale focused on the success of the local anesthetic based on inability to elicit discomfort either upon periosteal penetration with an explorer or during the luxation of the tooth. The intermediate rating (2) was necessary to differentiate questionable results that could have been associated with either patient anxiety or inadequate anesthesia. Evaluation scales that attempted to further separate anesthetic efficacy were less objective and more difficult to apply appropriate statistical analyses.

This study demonstrates that 1% lidocaine is an effective local anesthetic when used for maxillary infiltration anesthesia. While mandibular block anesthesia may be less effective with a 1% solution in adolescent patients, it may be quite effective in a younger patient population. Current studies are being undertaken to confirm these findings and to extend clinical investigation into a younger patient population with pulpally involved, carious primary teeth requiring different types of dental procedures. The clinical significance of this study is that it provides a rationale for a method which may reduce total anesthetic dosage in small children receiving extensive dental care. Such an approach could significantly reduce the potential for toxic anesthetic reactions in dental procedures performed on the young child patient.

Conclusions

1. One and 2% lidocaine were not significantly different in achieving profound maxillary and mandibular local anesthesia.
2. Profound local anesthesia was much more difficult to obtain in mandibular teeth for both anesthetic concentrations.
3. A significant trend toward decreased efficacy of local anesthesia in mandibular teeth of females was observed.
4. An anesthestic solution of 1% lidocaine should be considered in the young dental patient when toxicity from local anesthesia administration is a concern.

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