CDA JOURNAL, VOL 35, Nº1

Calculating the Maximum Recommended Dose of Local Anesthetic

JOEL M. WEAVER, DDS, PHD

ABSTRACT Since patients have a wide variance in body size, it is appropriate to base the maximum recommended dose of a local anesthetic on a milligram of drug per kilogram of body weight. Other variables (severe overweight or underweight and cardiovascular compromise) also influence the appropriate maximum recommended dose. By calculating the specific dose limit from the maximum recommended dose for each patient, the chances of a local anesthetic overdose can be significantly reduced.

AUTHOR

Joel M. Weaver, DDS, PHD, is a professor of clinical dentistry, director of anesthesiology and pharmacology, Section of Oral and Maxillofacial Surgery, Pathology and Anesthesiology, and professor of clinical anesthesiology, Department of Anesthesiology, College of Medicine and Public Health, both at The Ohio State University.

The maximum safe local anesthetic dose should be individualized for each patient, based primarily upon their weight (mg drug/Kg body weight) and physical status. Although calculations based on the amount of body surface area may be more accurate, most of the current dosage guidelines are weight-based. For obese patients, the calculation should be based more closely on ideal body weight rather than actual weight. Excessive fat is so poorly perfused with blood that it does not readily participate as a drug reservoir to decrease blood levels of circulating local anesthetic molecules following their systemic absorption from a dental injection site. Severely underweight, starving, bulimic, or debilitated patients typically have low levels of circulating plasma proteins that normally bind a certain percentage of local anesthetic in the blood. These patients may be so cachectic that the fraction of anesthetic bound to blood plasma proteins, and thus held temporarily in an inactive state, may be unusually low. This decreased protein binding may result in unusually high blood levels of free, unbound drug that can cause overdose toxicity when the anesthetic diffuses from the injection site into the blood and rapidly into the brain and heart. Additionally, in these underweight patients, the reduced mass of skeletal muscle tissue that is normally well perfused with blood may markedly decrease the capacity of the muscle tissue to act as a temporary reservoir for the circulating local anesthetic molecules. Thus, without a significant skeletal muscle reservoir to help lower the blood level of the local anesthetic, higher levels of circulating local anesthetic molecules may perfuse vital organs and result in a toxic reaction. The maximum weight-based dose for these patients should

CDA JOURNAL, VOL 35, Nº1

TABLE 1

Maximum Limit for Lidocaine With Epinephrine for Healthy 3-year-old Child Weighing 33 pounds

- 2% Lidocaine/epi MRD range = 4.4 to 7 mg/Kg
- 33 lbs ÷ 2.2 lbs/Kg = 15 Kg body weight
- 15 Kg x's 7 mg/Kg = 105 mg maximum dose lido/epi (liberal limit)

  or
- 15 Kg x's 4.4 mg/Kg = 66 mg maximum dose lido/epi (conservative limit)
- 2% lido/epi = 36 mg lido/cart x's 3 cartridges = 108 mg (liberal max = Less than 3 cartridges)
- 2% lido/epi = 36 mg lido/cart x's 2 cartridges = 72 mg (conservative max = Less than 2 cartridges)

be lowered accordingly to prevent the hallmarks of toxicity such as loss of consciousness, seizures, respiratory arrest, and even cardiovascular collapse and cardiac arrest. Depending upon the site of the injection, the vascularity of the tissue and the presence or absence of a vasoconstrictor, these signs and symptoms of local anesthetic toxicity typically occur within a few minutes after completion of the dental injections that add up to too many milligrams of drug for the specific weight and health of the patient.

For patients with significant cardiovascular disease or those who take medications like nonspecific beta-adrenergic-blocking drugs (propranolol) that can adversely interact with epinephrine, the maximum safe volume of anesthetic may be limited by the amount of epinephrine rather than the amount of the local anesthetic itself. No more than 40 micrograms (40 mcg) of epinephrine is recommended for these medically compromised patients, which equals 2.2 cartridges of 1:100,000 or 4.4 cartridges of 1:200,000 epinephrine.[1]

Each local anesthetic has its own maximum recommended dose, expressed in mg/Kg. If a combination of two local anesthetics is given, the patient who receives an amount that is calculated to be one-half the maximum recommended dose of one anesthetic should only receive an amount calculated to be one-half the maximum recommended dose of the other anesthetic, since the toxic effects of each drug are believed to be additive.[2] Unfortunately, not everyone uses the same mg/Kg maximum recommended dose for each drug. One package insert recommends 4.5 mg/Kg for lidocaine without epinephrine and 7 mg/Kg for lidocaine with epinephrine.[3] Malamed's text, however, lists another manufacturer's recommendations as 4.4 mg/Kg and 6.6 mg/Kg, respectively.[1] Malamed recommended 4.4 mg/Kg for lidocaine with or without epinephrine, despite the fact that the vasoconstriction provided by the epinephrine reduces the peak blood levels of the anesthetic absorbed from the injection site.[1] None of these recommendations are incorrect, but rather reflect a decision of how conservatively one wishes to calculate the maximum recommended dose of their choice of local anesthetic. This may depend on the dentist's experience, training, and practice venue. A solo office practitioner in a remote area may decide to be more conservative and use a lower maximum recommended dose than the hospital-based dentist in the operating room, or a dentist working with a dentist anesthesiologist where intravenous access is already established and appropriate monitors, equipment, and sophisticated emergency drugs are already in place.

No matter what maximum recommended dose guideline a dentist uses to calculate the dose limit for an individual patient, the process for the calculation of the limit is as follows: Convert the body weight in pounds into kilograms by dividing the number of pounds by 2.2 lb/Kg. Thus, a 33-pound child weighs 15 Kg. Multiplying 15 Kg by the maximum recommended dose, 7 mg/Kg in the first example below, gives the maximum limit of 105 mg of lidocaine with epinephrine. Since each cartridge of 2 percent lidocaine contains 36 mg, three cartridges would equal 108 mg, just slightly over the maximum limit for this 33-pound child. Using Malamed's maximum recommended dose of 4.4 mg/Kg would yield a limit of 66 mg, slightly less than two cartridges (72 mg). A child weighing twice as much (66 pounds) could have twice the number of cartridges (**TABLE 1**).

A 1.8 ml dental cartridge of any 2 percent anesthetic contains 36 mg, while a cartridge of any 3 percent anesthetic contains 54 mg and that of any 4 percent solution contains 72 mg. The maximum recommended dose for 4 percent articaine with epinephrine happens to be the same as for 2 percent lidocaine with epinephrine (7 mg/Kg), so the maximum number of cartridges is reached twice as fast with 4 percent articaine compared to a 2 percent lidocaine. For the 33-pound child, the limit for 4 percent articaine would be approximately 1 to 1.5 cartridges. When calculating the number of milligrams of articaine in a cartridge, the actual volume is much closer to 1.8 ml rather than the 1.7 ml the manufacturer was forced by the Federal Drug Administration to place on the labeling because the volume of

some cartridges weren't always exactly 1.8 ml. Thus, one should calculate that an articaine cartridge has a volume of 1.8 ml.

For 3 percent plain mepivacaine and 2 percent mepivacaine with vasoconstrictor, Malamed's book lists the manufacturer's maximum recommended dose as 6.6 mg/Kg.[1] For the 33-pound child, 99 mg of 3 percent mepivacaine is the calculated limit, and at 54 mg/cartridge, that limit is reached with slightly less than two cartridges (108 mg). For the same 33-pound child, 99 mg of 2 percent mepivacaine with vasoconstrictor is still the calculated limit, and at 36 mg/cartridge, that limit is reached with slightly less than three cartridges (108 mg). Malamed recommended a maximum recommended dose of 4.4 mg/Kg for mepivacaine, so his limit for this child calculates to be 66 mg, which equals a little more than one 54 mg cartridge of 3 percent mepivacaine or slightly less than the 72 mg contained in two cartridges of 2 percent mepivacaine with vasoconstrictor.[1]

Prilocaine's maximum recommended dose, according to Malamed, is 6 mg/Kg (with or without epinephrine), although Yagiela suggested 8 mg/Kg.[1,4] If 7 mg/Kg is a reasonable average maximum recommended dose for prilocaine, the 33-pound child's limit would be about 1.5 cartridges of 4 percent prilocaine (15 Kg x's 7 mg/Kg = 105 mg total dose). At 72 mg/cartridge, 1.5 cartridges of the 4 percent drug equal 108 mg.

Malamed's text recommended a maximum recommended dose for bupivacaine with 1:200,000 epinephrine of 1.3 mg/Kg (but not more than 90 mg total dose) while one manufacturer recommended a limit of 225 mg for bupivacaine with epinephrine for nerve blocks in medical anesthesia, which equals a maximum recommended dose of 3 mg/Kg for a 70 Kg adult.[1,5] Although bupivacaine is not recommended by the FDA for dentistry for children under age 12, a 33-pound child could potentially tolerate a range of 19.5 mg to 45 mg of bupivacaine. Since 0.5 percent bupivacaine contains 9 mg/cartridge, which would translate into a range of two to five cartridges. Because it is a long-lasting anesthetic, toxicity with bupivacaine is also long-lasting, and overdosed patients are resistant to resuscitation efforts. Overdoses of bupivacaine often terminate in lethal central nervous system and cardiac failure. It seems wise for the typical dentist to use the conservative bupivacaine maximum recommended dose of 1.3 mg/Kg. for adults.

CONVERT THE body weight in pounds into kilograms by dividing the number of pounds by 2.2 lb/Kg.

Finally, there is minimal research data to provide an answer to the question of "How long after giving a maximum recommended dose of a local anesthetic can a dentist give more?" Some local anesthetics have active metabolites that contribute to local anesthetic toxicity, in addition to that of the parent compound. Lidocaine, for instance, produces the de-ethylated metabolites glycinexylidide and monoethylglycinexylidide, which are active compounds that can add to the toxicity of additional doses of lidocaine.[6] Because there is insufficient scientific data regarding the "time for safe re-dosing" in dentistry after a maximum dose has already been given, the conservative approach is to not exceed the maximum recommended dose in a single day.

It makes good sense to calculate the maximum dose of anesthetic for every patient, particularly for children, small adults, medically compromised patients, and anyone having extensive procedures, to prevent the tragic consequences of local anesthetic overdose toxicity. If done routinely for every patient, even for one who might need only a half cartridge, we would master the process, and then doing it for the most critical patients would be quick and easy.

Alternatively, a dentist could decide which maximum recommended dose he/she wishes to use for a particular anesthetic, then make a chart of various body weights with a corresponding maximum number of cartridges recommended, and post it in every operatory. That way, there is no excuse for not knowing how much is too much for each individual patient.

REFERENCES

1. Malamed SF, Handbook of Local Anesthesia, fifth edition, C.V. Mosby, Inc., St. Louis, Mo., 2004.

2. Jong RH, Bonin JD, Mixtures of local anesthetics are no more toxic than the parent drugs. *Anesthesiology* 54(3):177-81, March 1981.

3. Dentsply Pharmaceutical, Xylocaine (lidocaine HCL Injection USP), injections for local anesthesia in dentistry, package insert, revised February 2004.

4. Yagiela JA, Dowd FJ, Neidle EA, Pharmacology and therapeutics for dentistry, fifth edition, St Louis, Mo., 2004.

5. AstraZeneca LP, Bupivacaine hydrochloride, package insert, revised March 2002.

6. Strong JM, Parker M, Atkinson AJ, Identification of glycinexylidide in patients treated with intravenous lidocaine, *Clin Pharmacol Ther* 14:67-72, 1973.

TO REQUEST A PRINTED COPY OF THIS ARTICLE, PLEASE CONTACT Joel M. Weaver, DDS, PhD, The Ohio Sate University, College of Dentistry, Section of Oral and Maxillofacial Surgery, Pathology and Anesthesiology, 305 West 12th Ave., Columbus, Ohio 43218.