J Forensic Sci, Sept. 2002, Vol. 47, No. 5
Paper ID JFS2001190_475
Available online at: www.astm.org

CASE REPORT

Jack R. Kalin,[1] *Ph.D., D-FTCB and Robert M. Brissie,*[2] *M.D.*

A Case of Homicide by Lethal Injection with Lidocaine*

ABSTRACT: This report describes a homicide by overdosage with lidocaine. The decedent, a 32-year-old male hospitalized for a lengthy period with acute intermittent porphyria and chronic pancreatitis, suffered apparent asystole and seizure. Failed resuscitation preceded death. A forensic autopsy was conducted based upon suspicions of alleged patient mistreatment by one of the attending nurses. Toxicological analyses revealed the presence of lidocaine in blood, liver, kidney, brain, and heart at 22.2 mg/L and 43.6, 28.3, 23.1, and 13.1 mg/kg, respectively. Also present were diazepam, phenytoin, and promethazine. Both diazepam and phenytoin had been administered during resuscitation, but lidocaine had not. The cause of death was determined to be ventricular arrhythmia precipitated by lidocaine overdosage. The administered dose was calculated to have been approximately 1500 mg. The manner of death was determined to be homicide. The nurse was arrested and subsequently tried for murder by administering a lethal quantity of lidocaine.

KEYWORDS: forensic science, forensic toxicology, lidocaine, homicide, drug intoxication, lethal injection

Lidocaine is a commonly administered drug used both as a local anesthetic and as an antiarrhythmic (1). Its antiarrhythmic mechanism of action is through inhibition of ventricular fast sodium channels, thus effecting more uniform conduction and reducing ectopic contractions (1,2). This action is the basis for its use in relieving and preventing ventricular fibrillation during the treatment of acute myocardial infarction.

As an antiarrhythmic, lidocaine is administered intravenously or parenterally. Oral bioavailability is poor due to a large first-pass effect. Lidocaine rapidly distributes into well-perfused tissues (lung, liver, heart, and kidney), then redistributes into skeletal muscle and adipose tissue (3,4). Elimination from blood proceeds with a half-life of 0.7 to 1.8 h (5), due primarily to hepatic metabolism. Dealkylation of lidocaine produces monoethylglycylxylidine (MEGX), glycylxylidine (GX), and 2,6-xylidine (2,6-X) (5,6). Diminished cardiac output or hepatic function reduces distribution and prolongs elimination, which mandates a reduction in the quantity or rate of administration (7).

During treatment of acute myocardial infarction, lidocaine is administered intravenously as a 1 mg/kg (50 to 100 mg) bolus injection over 1 min, followed by infusion of 20 to 50 μg/kg/min (1 to 4 mg/min) to maintain a serum concentration of 1 to 5 mg/L (8). The onset of action is within 60 to 90 s, and the duration would be 10 to 20 min without the maintenance infusion. The bolus injection is typically available as a preloaded syringe containing 5 mL of a 1 to 2% solution of the hydrochloride salt. The infusion is typically available as an ampoule containing 30 to 50 mL of a 1 to 2% solution of the hydrochloride salt intended for dilution into a flowing intravenous drip (9).

Lidocaine toxicity may appear at serum concentrations greater than 8 mg/L (5). Symptoms include dizziness, confusion, agitation, seizures, conduction defects, bradycardia, and hypotension. A number of reports describing non-fatal (10) and fatal (6,11–13) lidocaine poisonings have been published, including one case of a series of homicidal injections (6,14). This report describes the toxicological findings arising from a homicidal overdosage with lidocaine.

Case History

The decedent was a 32-year-old male hospitalized for several months in 1990–1991 with progressive weakness, the result of acute intermittent porphyria (AIP), chronic pancreatitis, and gonorrhea. The decedent was quadriplegic at the time. Whereas AIP causes severe nerve damage, which can induce seizures and arrhythmias, the decedent had not displayed these symptoms until this incident. The decedent suffered apparent asystole and seizure and died despite 2.5 h of attempted resuscitation. A medical autopsy was conducted because the decedent had been under treatment for quite some time. The pathologist concluded that death was due to natural causes resulting from cardiovascular collapse.

The actions of one particular nurse were thought suspicious during this incident. The suspect nurse, who was not the attending nurse, had exited the decedent's room immediately prior to the initial seizure/asystole event. This nurse claimed to have been cleaning the decedent's tracheostomy tube, then attempted to detain the regular nurse, who was returning from her break, from entering the decedent's room. Furthermore, two other patients suffered non-fa-

[1] Alabama Department of Forensic Sciences, Birmingham, AL.
[2] Jefferson County Coroner/Medical Examiner's Office, Birmingham, AL.
* This manuscript was presented at the 47th Annual Meeting of the American Academy of Forensic Sciences in Seattle, WA, February 1995.
Received 4 June 2001; and in revised form 6 April 2002; accepted 6 April 2002; published 14 Aug. 2002.

tal cardiac episodes within hours of that of the decedent and during the shift of the same suspect nurse. Given the collective suspicions surrounding these incidents, the county coroner/medical examiner claimed jurisdiction in the case and initiated a forensic examination

Anatomical findings from the forensic examination revealed generalized muscle and organ degeneration and neuropathological changes consistent with the decedent's documented medical history. However, the decedent had a healthy, 350-g heart with only mild coronary atherosclerosis, which failed to support the conclusions of the medical autopsy. Specimens from the forensic examination were sent to the laboratory for toxicological examination along with instructions from the medical examiner to be alert to the possibility of excessive concentrations of drugs that might be used during resuscitation.

TABLE 1—*Toxicological findings in specimens.*

	Diazepam	Lidocaine	Phenyoin	Promethazine
Blood, iliac	0.09 mg/L	22.2 mg/L	4.2 mg/L	0.14 mg/L
Blood, pelvic	0.05 mg/L	24.6 mg/L	NA	NA
Liver	0.23 mg/kg	43.6 mg/kg	P*	4.2 mg/kg
Kidney	NA†	28.3 mg/kg	17.5 mg/kg	NA
Brain	NA	23.1 mg/kg	NA	NA
Heart	NA	13.1 mg/kg	NA	NA
Gastric Contents	NA	4.0 mg total	NA	NA

* Present, not quantified.
† NA, Not analyzed.

Materials and Methods

Lidocaine hydrochloride USP was obtained from Elskins-Sinn, Cherry Hill, NJ. All other drug standards and reagents were obtained from commercial sources and were analytical or reagent grade. Solvents were HPLC or spectral grade.

Basic drugs and acidic and neutral drugs were separately quantified in specimens by liquid-liquid extraction and gas chromatography (GC/FID) analysis (15,16). Tentative identification was based upon retention time relative to the internal standard. Quantification was based upon peak area integration and internal standardization. Calibration curves were prepared by supplementing blank blood with known drug concentrations and processing similarly. Drug identification was confirmed by analyzing the residual GC/FID extracts by gas chromatography/mass spectrometry (GC/MS).

Results and Discussion

The medical examiner performed an examination on a body that had previously been subject to a medical autopsy, and the organs were retrieved from a plastic bag present in the decedent's thorax and abdominal area. Therefore, tissues remained together in pooled blood, which allowed for the possibility of cross-contamination of specimens prior to their collection in separate containers and submission to the laboratory. Accordingly, tissues were washed and trimmed of their outer portions in order to leave a "medullar" specimen for analysis, although no separate experiments were conducted to determine whether cross-contamination had, in fact, occurred or whether such trimming would have been an effective remedy. Blood was collected from a pool in the pelvic area. Separate blood was also collected from the iliac arteries and veins by cross-clamping, elevating, and "milking" the legs and withdrawing with a syringe and 18-gauge needle. This latter specimen was collected in order to provide one that had not been exposed to organ contamination.

Quantification of lidocaine was achieved by GC/FID with the standard curve being linear over the range 0.1 to 3.0 mg/L. Specimens were diluted as necessary in order to have their concentrations fall within this range. Mepivacaine served as the internal standard. Components with the mass spectral characteristics of the metabolites, MEGX, and 2,6-X were also observed in blood. However, no attempt was made to quantify these, as reference standards were unavailable. Diazepam, promethazine, and phenytoin were also identified and quantified in blood at therapeutic levels. The analytical findings for specimens from the decedent are summarized in Table 1.

Lidocaine is routinely detected in blood specimens received in this laboratory. For the period July 1990 through July 1992, the time of the reported case, 164 cases were received with concentrations ranging from <0.1 to 197 mg/L. Similarly and more recently, for the period October 1997 through February 2002, 227 cases were received with concentrations ranging from <0.1 to 23 mg/L. The frequencies of distribution are similar and are represented in Fig. 1. Lower concentrations are typical in antemortem blood and reflect use as a local anesthetic. Lidocaine in postmortem blood typically reflects failed attempts at resuscitation and is present at concentrations depending upon the dose and period of survival. Seemingly toxic concentrations could exist following administration to a patient with a failed circulatory system because distribution would be limited to a portion of the total blood volume (7). The cluster of specimens with concentrations in the range of 10 to 20 mg/L reflects 50 to 100 mg doses in decedents with a typical blood volume of approximately 5 L (17). Consequently, lidocaine levels in iliac and pelvic blood specimens in the reported case at 22.2 and 24.6 mg/L, respectively, did not initially and solely lead to the conclusion of lidocaine toxicity. However, the medical examiner's review of the medical records determined that lidocaine had not been administered during resuscitation. Accordingly, tissue analyses were conducted to establish the distribution of lidocaine (see Table 1). The presence of diazepam, phenytoin, and promethazine were accountable in the medical records.

The dosage of lidocaine administered to the decedent was calculated by determining what total body burden of drug remained at death and what would have disappeared prior to death based upon an elimination half-life of 0.7 to 1.8 h (5). The body burden was calculated by three methods to be approximately 1500 mg, which may be an overestimation (see Calculation 2 below).

Calculation 1 was based upon the dosage being the product of the drug's apparent volume of distribution (V_d) and concentration in blood. With a V_d for lidocaine of 1.1 to 1.3 L/kg (2,5) and a decedent body weight of 54.5 kg, the dosage was calculated to be 1330 to 1740 mg.

Calculation 2 was based upon extrapolation from the measured drug levels in the harvested organs and the proportion these specimens represented of the total body weight. Although its V_d is near unity, lidocaine does not uniformly distribute throughout all tissues (3,4). As the analyzed specimens represent some of the most highly perfused organs, they may provide an inflated basis from which to extrapolate, and the calculated result may be an overestimation. Nevertheless, the dosage was calculated to be approximately 1500 mg (Table 2).

Calculation 3 was based upon an extrapolation from observed dosings and resultant blood concentrations. Doses of 1.0 and 23.8 mg/kg I.V. reportedly resulted in peak levels of 0.96 and 30 mg/L, respectively (5,13). Infused doses of 425 to 1000 mg reportedly

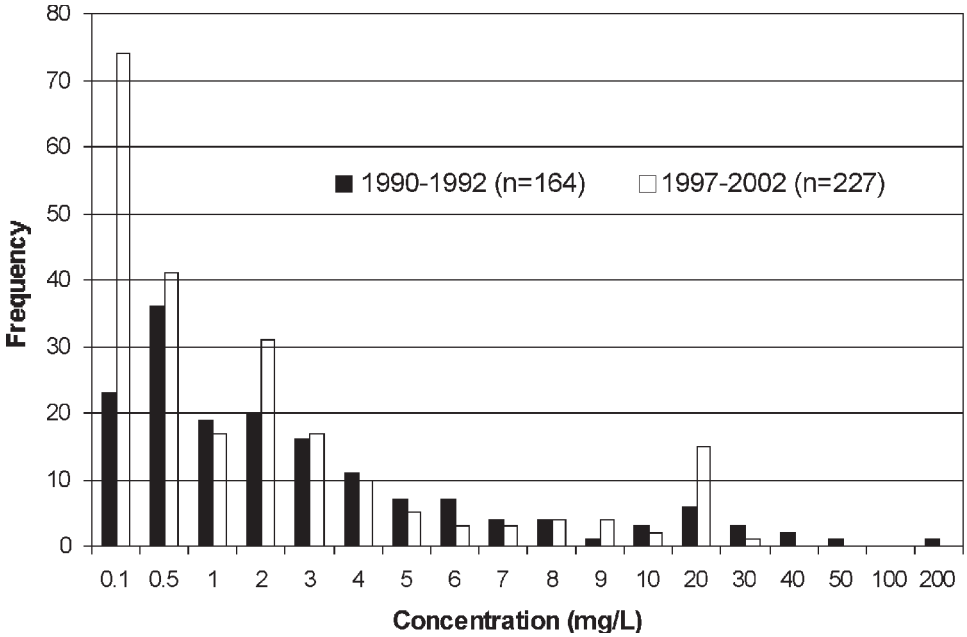

FIG. 1—*Frequency of the incidence of lidocaine in blood specimens received during the indicated periods. N = number of cases for the respective periods.*

TABLE 2—*Calculation of body burden of lidocaine (Calculation 2).*

	Amount of Specimen	Lidocaine Concentration	Lidocaine Total, mg
Blood	3.76 L*	23.4 mg/L†	88
Liver	1.98 kg	43.6 mg/kg	86
Kidneys	0.24 kg	28.3 mg/kg	7
Brain	1.10 kg	23.1 mg/kg	25
Heart	0.35 kg	13.1 mg/kg	5
Total	7.62 kg‡		211
Total Body	54.5 kg		1500§

* Assuming 69 mL of blood/kg of body weight (17).
† Mean of iliac and pelvic specimens.
‡ Blood weight assuming density of 1.05 g/mL (18).
§ Total dose in analyzed specimens / Total weight of analyzed specimens × Body weight.

produced peak blood lidocaine levels of 9.0 to 14 mg/L (5). Accordingly, the dosage for the current case was calculated to be 1100 to 1400 mg.

The decedent experienced shock with apparent reduced cardiac output during the period of resuscitation, which would have prolonged the elimination of lidocaine. As such, any reference elimination half-life was unlikely to be a significant factor in calculating the administered dose. Accordingly, the calculated dosage remained approximately 1500 mg.

At the ensuing trial in Circuit Court, expert medical testimony concluded that the time frame and sequela of the cardiac episode, as recorded in electrocardiograms, were consistent with lidocaine intoxication. Eyewitness testimony placed the defendant with the decedent at the time immediately prior to the cardiac episode and within the timeframe of the onset of an acute dose of lidocaine. Complicating the case was the fact that 2 g of lidocaine were coincidentally missing from the resuscitation cart, which had been later billed by the hospital to the decedent's account. The defendant argued that administration had, in fact, occurred during resuscitation and that impaired circulation and hepatic function in the decedent had resulted in a toxic dose. However, the medical staff present during resuscitation testified that lidocaine was not administered and that the cart with the missing drug was not even used until after the initial cardiac event. Lidocaine is indicated for use during resuscitation of ventricular fibrillation but is contraindicated for seizure asystole. The source of the administered lidocaine was intensely debated. Nevertheless, the defendant was convicted of murder by administering a lethal quantity of lidocaine. The Appellate Court overturned the verdict on a legal issue relating to jury selection and the case was remanded to the Circuit Court for a new trial. This second trial resulted in a hung jury. The nurse subsequently pled to manslaughter and admitted to having administered lidocaine as alleged. The nurse was sentenced to 15 years in prison, but was released on parole shortly thereafter.

References

1. Ellenhorn MJ, Bareloux DG. Antiarrhythmic agents. Medical toxicology. New York: Elsevier, 1988;183–5.
2. Gilman AG, Rall TW, Nies AS, Taylor P, editors. The pharmacological basis of therapeutics. 8th ed. New York: Permagon Press, 1990.
3. Benowitz NL, Meister W. Clinical pharmacokinetics of lignocaine (Lidocaine). Clin Pharmacokinet 1978;(3):177–201.
4. Denaro CP, Benowitz NL. Poisoning due to Class 1B antiarrhythmic drugs, lignocaine, mexiletine and tocainide. Med Toxicol and Adverse Drug Exp 1989;4(6):412–28.
5. Baselt RC, Cravey RH. Lidocaine. Disposition of toxic drugs and chemicals in man. 5th ed. Foster City, CA: Chemical Toxicology Institute, 2000;469–73.
6. Peat MA, Deyman ME, Crouch DJ, Margot P, Finkle BS. Concentrations of lidocaine and monoethylglycylxylidine (MEGX) in lidocaine associated deaths. J Forensic Sci 1985;30(4):1048–57.
7. Thompson PD, Melmon KL, Richardson JA, Cohn K, Steinbrunn W, Cudihee R, et al. Lidocaine pharmacokinetics in advanced heart failure, liver disease, and renal failure in humans. Ann Intern Med 1973;78: 499–508.
8. Buchanan JF. In: Olson, KR, editor. Lange's poisoning and drug overdose. 1st ed. Norwalk, CT;320–2.
9. Barnhart ER. Physician's desk reference. 44th ed. Oradell, NJ: Medical Economics, 1990.
10. Selden BS, Burke TJ. Complete maternal and fetal recovery after prolonged cardiac arrest. Ann Emerg Med 1988;17(4):346/91–349/94.

11. Finkelstein F, Kreeft J. Massive lidocaine poisoning. N Engl J Med 1979;301(1):50.
12. Jonville AP, Barbier P, Blond MH, Boscq M, Autret E, Breteau M. Accidental lidocaine overdosage in an infant. Clin Toxicol 1990;28(1):101–6.
13. Poklis A, Mackell MA, Tucker E. Tissue distribution of lidocaine after fatal accidental injection. J Forensic Sci 1984;29(4):1229–36.
14. Tammelleo AD. Lidocaine deaths: nurse convicted of murders. Regan Rep Nurs Law 1992;33(6):1.
15. Foerster EH, Hatchett D, Garriott JC. A rapid, comprehensive screening procedure for basic drugs in blood or tissues by gas chromatography. J Anal Toxicol 1978;2:50–5.
16. Foerster EH, Dempsey J, Garriott JC. A gas chromatographic screening procedure for acid and neutral drugs in blood. J Anal Toxicol 1979;3:87–92.
17. Wilson JD, Braunwald E, Isselbacher KJ, Petersdorf RG, Martin JB, Fauci AS, et al., editors. Harrison's principles of internal medicine. 20th ed. New York: McGraw-Hill, 1991;2, Appendix A-1.
18. Rainey PM. Clin Chem 1993;39(11):2288–92.

Additional information and reprint requests:
Jack R. Kalin, Ph.D., D-FTCB
Alabama Department of Forensic Sciences
1001 13th Street South
Birmingham, AL 35213