Is Nurse Interpretation of the ECG QRS Width Reliable?

Tonia Zimmerman · Michael C. Beuhler ·
William Kerns II

Published online: 4 January 2012
© American College of Medical Toxicology 2011

Abstract Electrocardiogram (ECG) data are critical in formulating management strategies following sodium channel antagonist overdose. Poison centers frequently rely on verbal reports of the ECG obtained from bedside nurses. No previous study has addressed the quality of ECG data obtained in this manner. Therefore, we sought to test the ability of nurses to recognize and measure a widened QRS complex, the hallmark of myocardial sodium channel toxicity. Thirty-six emergency department and critical care nurses employed at a tertiary care hospital participated in this prospective study. The study subjects were divided into three groups and asked to interpret 12 ECGs (five normal and seven wide QRS). For each ECG, participants (1) determined if the QRS was narrow or wide and (2) measured the QRS duration. The groups differed in delivery of instruction regarding QRS measurement. Group 1 received visual instructions; group 2 received scripted verbal instructions, and group 3 served as controls, receiving no specific QRS measurement instructions. The nurse data was compared with physician interpretation (consensus of three physicians). Between-group analysis tested for impact of potential real-time educational intervention. Overall, the nurses identified a wide QRS complex most of the time (77%), but had difficulty in accurately measuring the QRS duration (44%). Real-time visual or verbal instruction did not improve accuracy (p =NS between groups). The results suggest that verbal ECG data from nurse callers is not

sufficient to make an accurate clinical assessment in the setting of sodium channel poisoning.

Keywords Electrocardiogram · Nurse · Wide QRS · Sodium channel blockade

Introduction

In a 1985 landmark paper, the 12-lead electrocardiogram (ECG) QRS duration proved to be a more reliable marker than serum drug levels in assessing severity of cyclic antidepressant toxicity [1]. Investigators found that a widened QRS was a harbinger of seizures and ventricular dysrhythmias. As a result of this report, the ECG was firmly established as a rapid, bedside diagnostic screen identifying those patients at highest risk for serious manifestations associated with cyclic antidepressant toxicity. Several additional reports validated the prognostic value of the QRS duration [2–4]. The ECG also serves as one of the standard treatment indicators for alkaline therapy in cyclic antidepressant and other sodium channel antagonist overdoses.

Although the predictive value of the QRS duration was confirmed in the aforementioned studies, there has been no scrutiny of healthcare provider's ability to recognize the prolonged QRS pattern associated with sodium channel antagonism. A recent study raised the specter of the caller's inability to relay accurate ECG interpretation to a poison center [5]. The investigators found several clinically significant interpretation omissions including unrecognized widened QRS patterns. Our regional poison center fields calls from both physician and nurse healthcare providers. While an advice call is most commonly initiated by a physician, the poison center relies primarily on nurse providers for follow-up calls. Hence, a large proportion of poison center information,

T. Zimmerman · M. C. Beuhler · W. Kerns II
Carolinas Poison Center,
Charlotte, NC, USA

M. C. Beuhler · W. Kerns II (✉)
Department of Emergency Medicine, Carolinas Medical Center,
P.O. Box 32861, Charlotte, NC 28232-2861, USA
e-mail: russ.kerns@carolinashealthcare.org

including ECG data, is obtained from nurses. Given the prognostic and treatment value of the QRS pattern, it would be ideal that bedside nursing staff recognize QRS widening and share this information with the poison center. However, the accuracy of information obtained from the bedside nurses specifically answering the targeted question of the presence of QRS width is unknown. It is also unknown if any specific instruction could increase that accuracy. Therefore, we sought to evaluate the ability of nurse providers to recognize a prolonged QRS duration and test the ability of various instruction modalities to improve recognition.

Methods

The study received exempt status by the institutional review board as set forth in the Code of Federal Regulations. It was performed in a classroom environment proctored by the investigators. Emergency department and critical care nurses were recruited for the study because they are the most likely nurse providers to care for an acute overdose patient at the investigator's institution, and they frequently perform bedside ECGs. Study participants received a small monetary compensation for time and travel. The study objective was threefold: (1) Are nurses able to view a 12-lead ECG or lead II rhythm strip and determine if the QRS complex is narrow or wide? (2) Are nurses able to accurately measure QRS duration? (3) Do brief instructions impact the accuracy of measuring the QRS duration?

To accomplish the study, participants were divided into three groups. Each participant was given a packet of 12 of ECGs and directed to answer two questions for each ECG: "Is the QRS wide? Yes or No" and "What is the QRS duration?" They were supplied a standard data sheet to record their answers. All three groups received standard, scripted instructions on how to complete the study data sheet. There was no time limit.

While each participant made the gestalt determination of QRS duration (objective 1), the groups differed in instruction regarding actual measurement of the QRS complex. This allowed for study of objectives 2 and 3. The differing instruction techniques were designed to simulate potential rapid educational tools such as a faxed information form or standard verbal instructions that poison center staff could read to callers. Instructions were based on teaching participants to measure QRS duration by counting the small blocks of the QRS complex and then multiplying by 40 ms. All instructions, including general directions for completing the study and specific instructions on how to measure the QRS interval were scripted and delivered by one of the investigators to insure consistency for each study group. Group 1 received scripted verbal instructions on how to measure the QRS duration that were complemented by a

printed handout developed to provide visual guidance on how to measure a QRS interval. Group 2 received only scripted verbal instructions on QRS interval measurement. Group 3 served as controls and received only the general instructions for completing the study and no formal instruction on QRS measurement. The assignment of the group intervention type to individual study sessions was done by one of the researchers blinded to the identity of the individual study subject.

Twelve de-identified ECGs were obtained from patients treated at the investigators' institution. The study ECGs included eleven 12-lead ECGs and one lead II rhythm strip that were selected for clarity and ease of visual analysis (Fig. 1). These ECGs were deemed to be either normal (QRS duration less than 100 ms, $n=5$) or wide (QRS duration greater than 120 ms, $n=7$). The abnormal ECGs were obtained from records of confirmed sodium channel antagonist cases and the normal ECGs from patients without a toxic exposure. As the investigators wished to maximize ability to distinguish normal versus abnormal, no ECGs with intermediate QRS width (101–119 ms) were chosen for the study. The consensus ECG interpretation and averaged value for the QRS width by three board-certified emergency physicians served as the standard for comparing nurse data. If there was any disagreement between physicians as to "wide" versus "narrow," the final determination was based on the majority of the three physician's assessment. We elected to have the physicians measure the limb lead QRS rather than utilize the computer generated value because previous work validated limb lead duration only [1, 4]. The computer-generated QRS duration reflects the average of all 12 leads.

The mean and standard deviation of the physician measurement of the QRS complex was determined and used as the gold standard for the study. Descriptive statistics were performed for each study group regarding the accuracy of determining the QRS width. This was repeated separately for the narrow and wide QRS ECGs. We determined a priori that a subject was considered to have measured the QRS correctly if the measurement was within 20 ms or 1.96 times the standard deviation of the gold standard measurement. Statistical analysis was performed using two-way ANOVA and two-tailed Fisher's exact test [6–8]. The p values were reported as calculated. Because there are three treatment subgroups, a lower than usual p value of 0.017 was considered significant to correct for multiple comparisons. Ninety-five percent binomial confidence intervals (95% CI) were constructed for the percentages correct [9].

Results

Thirty-six nurses participated and completed the study. See Table 1 for the characteristics of the study groups.

Fig. 1 Sample wide complex 12-lead ECG utilized in the study

Emergency department nurses and ICU nurses were represented equally in all three groups ($p=NS$ by two-way ANOVA). The physicians determining the gold standard agreed unanimously about narrow vs. wide for 11 of the 12 ECGs, and the average standard deviation of their QRS complex width determinations was 10 ms.

Nurses were able to correctly identify a narrow QRS complex as narrow 99% [95% CI, 96–100%] of the time but were correct in the actual QRS width measurement only 50% of the time. There was a significant difference between the rate of identifying a narrow complex and the rate of measuring it correctly [$p<0.00001$; 95% CI, 42–58%]. See Table 2. With wide ECGs, they were able to correctly identify a wide QRS as abnormal only 60% [95% CI, 54–66%] of the time and were correct in the actual width measurement 39% of the time; this difference was also significant [$p<0.00001$; 95% CI, 33–46%].

If the nurse reported the ECG as narrow, no conclusions could be drawn about the actual QRS width as there was only a 63% [58–69%] chance of a narrow complex truly being present. If the nurse reported that an ECG complex

QRS was widened, it had a 99% [95–100%] of in fact having a wide complex. However, if the QRS width was wide, they failed to report this fact 40% of the time. Also, they had a lower accuracy in determining the actual QRS interval measurement for wide complexes compared with the narrow ones (Table 2).

There was no study intervention effect on interpretation accuracy (Table 3). IE: Neither written nor verbal instruction increased the percentage of correct QRS width measurement or the percentage of correctly identified narrow or wide complexes ($p=NS$ for comparisons between group pairs).

Discussion

Overall, the participants correctly differentiated a normal versus wide QRS complex most of the time. Their gestalt determination of wide versus narrow was better than their ability to actually measure the QRS. These data indicates that interpretation and measurement of the ECG QRS width in the setting of cyclic antidepressant toxicity presents a challenge to nurse providers.

Unfortunately, neither verbal nor written instructions improved accuracy. These results indicate that development of any real-time written or verbally directed education tools for callers would probably not improve the quality of orally communicated poison center ECG data. Efforts may be better focused by obtaining hard data in addition to phone discussion. Our results concur with the recent study

Table 1 Characteristics of the three study groups

Characteristic	Written	Verbal	Control	Total
ICU	7	5	6	18
ED	4	8	6	18
Total	11	13	12	36

Table 2 Proportion of correctly interpreted QRS widths for all study subjects

	Determine if QRS complex was wide (Y/N)	Measurement of the QRS complex width	<i>p</i> values
All ECGs (36)	77%	44%	<i>p</i> =0.0001
Wide ECGs only (36)	60%	39%	<i>p</i> =0.00001
Narrow ECGs only (36)	99%	50%	<i>p</i> =0.00001

questioning the accuracy of poison center callers ECG interpretation [5]. Although that study was not specific for cyclic antidepressant toxicity and included a broad range of ECG abnormalities, it noted an overall 50% deficiency in ECG interpretation and in 25% of cases, a change in management might have occurred with the correct ECG interpretation. These investigators suggested that poison centers should obtain transmitted copies of ECGs for first-hand review by medical toxicologists. We would agree with their recommendation and would add the corollary that no simple intervention will allow for an improvement in their interpretation.

Limitations

There are several limitations of this study.

All of the nurse participants were from a busy, tertiary care institution that serves as a regional cardiology and toxicology referral center thus limiting generalizability of the study findings to hospitals with less experience. Subject past experience and training may have influenced results. Data regarding years of experience of the study subjects was collected but was insufficient to formally analyze as a study outcome. With this in mind, the lesser experienced nurses appeared to perform slightly better than experienced nurses. The average number of years of experience was 8 years for all participants. Participants with ≤ 10 years experience ($n=21$) had a 77% rate of correctly identifying an abnormal ECG, while those with ≥ 11 years of experience ($n=10$) had a 73% correct rate. The extent of formal ECG training for participants was not quantified due to the impossibility of confirming such training.

Table 3 Proportion of correctly interpreted QRS widths by study group

	Group 1 Written	Group 2 Verbal	Group 3 No instruction	
Is the QRS wide (yes/no)	77%	75%	77%	NS
Measurement	49%	40%	43%	NS

The classroom study environment was by necessity artificial and could have resulted in individuals expending increased effort in their interpretation when compared with their usual bedside clinical duties. The selected ECGs were chosen to have distinctly narrow or wide QRS complexes and excluded ECGs with mildly prolonged QRS duration. We believe that the artificial setting and unambiguous ECGs likely biased the study to greater performance, thus suggesting that an even lower probability of proper real-time ECG interpretation by nurses in the clinical setting. The written and verbal instruction given to two groups was not validated by measures such as pre- and post-testing prior to use in the study. However, we felt that the instruction was sufficient to cover the concept of counting ECG blocks and then mathematically converting to duration.

The study results imply that less accurate data supplied to a poison center will result in sub-optimum treatment recommendations similar to a previous report [5]. However, our findings cannot be extrapolated to the appropriateness of treatment or clinical outcomes. Our study goal was simply one of recognition and not subsequent treatment decisions.

Conclusions

Given the limitations of the study, the results suggest that verbal report of the width of ECG QRS complex by nurse callers may not be sufficient to make an accurate clinical assessment in the setting of cyclic antidepressants poisoning. Poison centers may need to explore additional steps to acquire accurate ECG data in order to formulate optimum treatment recommendations.

Acknowledgment The investigators wish to thank the American Association of Poison Control Centers for financial support in the form of the 2008 SPI Research Award.

Funding Tonia Zimmerman received the AAPCC SPI Research Award 2008 to fund this study.

Prior presentation This study was presented in abstract form at the 2009 NACCT.

Conflicts of interest The investigators have no conflicts of interest.

References

- Boehnert MT, Lovejoy FH (1985) Value of the QRS versus the serum drug level in predicting seizures and ventricular arrhythmias after an acute overdose of tricyclic antidepressants. *New Engl J Med* 313:474–479
- Niemann JT, Bessen HA, Rothstein RJ, Laks MM (1986) Electrocardiographic criteria for tricyclic antidepressant cardiotoxicity. *Am J Cardiol* 57:1154–1159
- Caravati EM, Bossart PJ (1991) Demographic and electrocardiographic factors associated with severe tricyclic antidepressant toxicity. *J Toxicol Clin Toxicol* 29:31–43
- Liebelt EL, Francis PD, Woolf AD (1995) ECG lead aVR versus QRS interval in predicting seizures and arrhythmias in acute tricyclic antidepressant toxicity. *Ann Emerg Med* 26:195–201
- Prosser JM, Smith SW, Rhim ES, Olsen D, Nelson LS, Hoffman RS (2011) Inaccuracy of ECG interpretations reported to the poison center. *Ann Emerg Med* 57:122–127
- Two way ANOVA analysis. Macro utilized on August 5, 2011 from <http://faculty.vassar.edu/lowry/anova2x3.html>
- Agresti A (1992) A survey of exact inference for contingency tables. *Stat Sci* 7:131–153
- Langsrud O (2004) Fisher's exact test. Macro utilized on August 22, 2009 from <http://www.matforsk.no/ola/fisher.htm>
- Exact binomial and Poisson confidence intervals. Macro utilized on February 5, 2010 from <http://statpages.org/confint.html>