Technical Note

Evaluation of the Post-Rotational Nystagmus Test (PRN) in Determining Alcohol Intoxication

Majda Zorec Karlovšek* and Jože Balažič
Institute for Forensic Medicine, Medical Faculty, University of Ljubljana, Korytkova 2, 1000 Ljubljana, Slovenia

Abstract

This study evaluated the accuracy of the post-rotational nystagmus test (PRN) on the basis of the results of 1006 PRN tests performed at the Institute for Forensic Medicine in Ljubljana between 1998 and 2002 during standardized medical examinations in cases of suspected drunk driving. The evaluation of PRN test results with blood alcohol concentration (BAC) as a reference was based on classification into the following categories and characteristics: true positives (TP), true negatives (TN), false positives (FP), false negatives (FN), sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV), and accuracy. An optimal cut-off value of 10 s for post-rotational nystagmus time was chosen with the help of a receiver operating characteristic (ROC) curve for the BAC limit of 0.5 g/kg. The results of the decision analyses were: TP = 584, FP = 43, FN = 229, TN = 150, sensitivity = 0.718, specificity = 0.777, PPV = 0.931, NPV = 0.396, and accuracy = 0.730. The area under the ROC curve (AUC) was 0.813. Based on the AUC, the post-rotational nystagmus test is a good test for predicting alcohol intoxication over 0.5 g/kg. As a part of the physician’s examination, it contributes significantly to the description of the clinical state.

Introduction

With a legal blood alcohol concentration (BAC) limit of 0.5 g/kg (since 1965), Slovenia’s road traffic legislation has increasingly oriented the work of forensic toxicologists towards quality assurance of blood and breath alcohol analyses and interpretation of the results. In comparison, the results of physicians’ examinations have been neglected.

The introduction of a standardized test battery for identifying suspected offenders driving under the influence (DUI) at the roadside raised our interest in a new evaluation of the post-rotational nystagmus (PRN) test, or Taschen test (1,2), which is part of the physician’s examination for detecting alcohol intoxication.

PRN is induced by suddenly stopping the rapid rotation of the body; large slow movements of the eyeballs occur in the direction opposite the direction of rotation. Some people may have pathological nystagmus as a consequence of trauma, stroke, and diseases affecting the vestibular system, which controls balance, coordination, and orientation. Involuntary jerking of the eye with small amplitudes after stopping the rotation is not an important indicator of alcohol intoxication (3).

In addition to alcohol, some central nervous system (CNS) depressants also have an influence on PRN time. To perform this test, the person is turned with open eyes in a tight circle 5 times in 10 s around his axis (i.e., while sitting on a swivel chair), and then the time from when the chair stops to when the person fixes his gaze on an object (e.g., a pencil or finger) that the physician holds at a distance of approximately 25 cm from his eyes is measured.

The aim of the study was to evaluate the ability of the PRN test to correctly classify those with BAC values above and below 0.5 g/kg.

Materials and Methods

The retrospective study included the results of 1006 PRN tests performed by 13 medical doctors trained and experienced in medical examination for DUI cases at the Institute for Forensic Medicine in Ljubljana in the years 1998 through 2002. Cases involving a combination of alcohol and drugs were excluded. A duplicate BAC determination was made with two different headspace gas chromatographic procedures, and the mean was the value used for forensic purposes and also for our study.

We assumed that the mean BAC represented the real BAC at the time of performing the PRN test. The time interval between the PRN test and blood sampling ranged from at least 5 min to a maximum of 15 min.

The evaluation of PRN test results with BAC as a reference was based on statistical methods including correlation analyses as well as decision analyses. The following categories and char-
acteristics are determined and/or calculated: true positives (TP), true negatives (TN), false positives (FP), false negatives (FN), sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV), and accuracy for different cut-off values of the PRN test. With the help of a receiver operating characteristic curve (ROC curve) for BAC limit values (0.5 g/kg as well as 0.8 and 1.0 g/kg), the optimal cut-off values for PRN time were selected (4).

Results and Discussion

Males represented 92.25% of all subjects tested. The average age in the group was 35.5 years (range 14 to 83 years). BAC values were between 0.00 and 3.16 g/kg, mean 1.12 g/kg, median 1.14 g/kg. The distribution of BAC values was not Gaussian. Of those tested, 10.93% of persons were sober, that is, with BAC values lower than 0.1 g/kg. BAC values equal to or lower than the administrative limit of 0.5 g/kg were found in 183 subjects. The prevalence of intoxicated persons (BAC values above 0.5 g/kg) was 0.808.

Measured values of post-rotational nystagmus time ranged from 1 to 45 s, mean value 14 s, median 13 s. The distribution of PRN values is presented in Figure 1. The values of PRN time and BAC show a positive correlation (Figure 2) that is statistically significant (r = 0.54, p < 0.01). For the regression line, the following formula was obtained: PRN = 6.0 x BAC + 7.25.

The distributions of PRN groups with BAC < 0.5 g/kg and BAC > 0.5 g/kg overlap (Figure 1). Low PRN times could be seen in the group with BAC below 0.5 g/kg and also in alcohol-intoxicated persons; high PRN times could also be found among sober persons. Looking for the optimal cut-off value of the PRN test, different cut-off values from 6 to 16 s were selected and, with the help of decision matrices, the values for sensitivity, specificity, and accuracy were calculated (Table I).

The ROC curve is a plot of the true positive rate (sensitivity) against the FP rate (1 - specificity) for the different possible threshold values of the diagnostic test (Figure 3). Raising the threshold values for PRN time (from 6 to 16 s) shows an increase in sensitivity accompanied by a decrease in specificity. The competition between sensitivity and specificity leads to the estimation of the optimal cut-off value of the PRN test, which according to the shape of the ROC curve is 10 s. According to previous studies summarized by Heifer and colleagues (3,5), PRN times of healthy, sober individuals are as long as 10 s. This is in agreement with the selected PRN cut-off value in our study for the BAC limit value of 0.5 g/kg.

The area under the ROC curve (AUC) is 0.813. A rough guide for classifying the accuracy of a diagnostic test is the traditional academic point system: 0.90–1.0 = excellent (A), 0.80–0.90 = good (B), 0.70–0.80 = fair (C), 0.60–0.70 = poor (D), and 0.50–0.60 = fail (F). In line with this classification, the PRN test can be classified as a "good" one.

The introduction of higher BAC limits and higher BAC cut-off levels (0.8 g/kg and 1.0 g/kg) reduces the prevalence of intoxicated persons 391
in the group observed, followed by an increase of TN and FP, raising the sensitivity and lowering the specificity of the test. The consequences can be seen in the changes of the shape of the ROC curve and also in the changes of the AUC.

For a BAC limit value of 0.8 g/kg, the AUC is 0.809, and the optimal PRN time 11 s, and for a BAC limit value of 1.0 g/kg, the AUC is 0.785, and the optimal PRN time 12 s.

Table II contains some results of the study of age on the statistical values of the PRN test. It was expected that the 30–34, 35–39, and 40–44 year age groups would be connected with the highest average BAC and the highest prevalence of intoxicated participants. The 40–44 year age group had the highest average BAC at 1.30 g/kg, followed by the 35–39 and 30–34 year groups with a mean BAC value of 1.27 g/kg. The same groups also had the highest prevalence of BAC values over 0.5 g/kg, which varied from 0.842 to 0.857.

The age group “younger than 20 years” (n = 34) had an average BAC of 0.61 g/kg, and for statistical purposes was connected to the group with 176 participants with an age range from 20 to 24 years and an average BAC of 0.94 g/kg. This yielded a group with 210 participants (age < 24 years) and a BAC of 0.72 g/kg. Because of the small number of older participants,
only one group was formed (≥ 50 years) with 129 participants and an average BAC of 1.13 g/kg. The group of participants with an age ≥ 50 years had a higher average BAC and a higher prevalence of BAC values over 0.5 g/kg than the youngest group (under 24 years), but lower values than the middle-aged groups.

Examination of the correlation coefficients between the PRN and the BAC values indicates that the PRN values correlate weakly to moderately with BAC in most subgroups. The highest correlation coefficient \( r = 0.584 \) was achieved in the 45–49 age group, and the lowest \( r = 0.465 \) in the 24–29 year group. BAC values over 0.5 g/kg were predicted with the help of the PRN test (cut-off = 10 s) with the highest accuracy (0.805) and the highest sensitivity (0.795) in the 35–39 year group. The highest specificity (0.933) and positive predictive power (0.986) of the test was found in the 40–44 year group.

In addition to age, the drinking habits, tolerance to alcohol, and state of health of the participants played an important role in the facts observed.

In spite of a prescribed procedure, the results of the PRN test depend on the observer. The factors influencing the result are the real rotation frequency, the response time of the observer, the observer’s subjective decision about the amplitude, and the end of involuntary jerking of the eyeballs.

The number of participants in the group examined by one medical doctor, the average age, the average BAC, the prevalence of participants with a BAC over 0.5 g/kg, correlation coefficients, and decision data are summarized in Table III. The number of participants in the groups ranged from 17 to 167. The average BAC in the groups varied from 0.87 to 1.20 g/kg, and the average age varied from 31.86 to 37.55 years.

The results of work by 13 different physicians, identified with numbers from 1 to 13, showed a moderate-to-strong correlation between PRN and the BAC. The correlation coefficient was from 0.501 to 0.820. The PRN test was performed by different medical doctors with a sensitivity from 0.439 to 0.954 and a specificity from 0.385 to 1.000. The diagnostic accuracy of the PRN test in predicting BAC values over 0.5 g/kg varied from 0.543 to 0.895. The BAC and PRN data collected by medical doctors No. 1 and No. 2 had a high correlation coefficient. On the other hand, the chosen PRN cut-off value of 10 s was too high for their performance of the test, which resulted in a high percentage of FN, low sensitivity, and low accuracy of the test. The observed inter-observer variability highlighted the need for the automation of the test performance entirely or, in some cases, the determination of observer-dependent PRN cut-off values.

The PRN test is not used as a screening test at the roadside. The important role that it has as a part of the clinical examination followed by blood alcohol determination is in providing valuable information about individual effects of alcohol. Driving under the influence of alcohol in Slovenia is a misdemeanor, and the penalty is based on the BAC alone. However, the description of the state “under the influence of alcohol” in legal cases connected with traffic accidents and other criminal offences is an integral assessment of the factual system combining information acquired from statements made by the police, results of a medical examination, results of toxicological examinations, and information obtained on the person under investigation.

Conclusions

The values of PRN time and BAC show a positive correlation that is statistically significant \( r = 0.54, p < 0.01 \). The PRN test with a cut-off value of 10 s performed in line with the standardized procedure has a sensitivity of 0.718, specificity of 0.777, and accuracy of 0.730. The PRN test is considered to be “good” at separating subjects with a BAC level below and above 0.5 g/kg. The area under the ROC curve is 0.813.

References