

The limitations of mouth alcohol detection systems in breath alcohol testing: Case reports

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ABSTRACT

Contamination of a person's breath alcohol with alcohol from sources other than the lungs can falsely elevate the results of a breath alcohol test. This is known as "mouth alcohol" contamination in breath alcohol testing. To combat the issue of mouth alcohol contamination, manufacturers of breath alcohol analyzers have incorporated slope detection algorithms into their devices known as "slope detectors." Despite this effort, breath alcohol analyzers sometimes fail to detect mouth alcohol contamination. Three case reports presented in this paper strongly suggest undetected mouth alcohol contamination. The significant legal consequences of a falsely elevated breath alcohol concentration (BrAC) due to mouth alcohol contamination require further research into the ability of slope detectors to identify mouth alcohol. Greater transparency and independent scientific examination of the algorithms involved in mouth alcohol detection systems are needed to ensure accuracy and fairness in breath alcohol testing.

1. Introduction

The breath alcohol test is a widely used forensic tool for determining a person's breath alcohol concentration (BrAC). One of the concerns in breath alcohol testing is the possibility of alcohol from sources other than the breath falsely elevating the test. Potential sources of contamination include residual alcohol left in the mouth from a recent drink [1–3]; alcohol from the stomach coming back into the mouth through regurgitation, burping, vomiting, or hiccuping [4–7]; and alcohol from other sources such as hand sanitizers, E85 gasoline, inhalers, mouthwash, tobacco, food, drinks, and dental appliances [8–19].

After a person drinks alcohol, some of the alcohol from the drink will remain in the mouth for up to 15 minutes [20]. This residual alcohol is known as "mouth alcohol" in breath alcohol testing and can falsely elevate the results of the test. A more insidious form of mouth alcohol contamination may come from alcohol erupting from a person's stomach into the mouth from the reflux of stomach contents from a burp, belch, vomit, hiccup, or the microaspiration of stomach contents into the airways [4,21–24]. The danger of contents from the stomach erupting into a person's mouth is that this type of contamination may go unnoticed by the person administering the breath alcohol test. When administering a breath alcohol test, a careful and continuous 15-min pre-test observation period must be conducted to ensure the subject does not burp, belch, vomit, hiccup, or contaminate the mouth with food, drink, or another source of contamination [4,24,25].

Several small-scale investigations into the problem of mouth alcohol contamination from alcohol erupting from the stomach have concluded that the problem is unlikely to occur [26–28]. However, other investigators have found evidence of such contamination and called for more research [23,29–31]. To combat the issue of mouth alcohol

contamination, manufacturers of breath alcohol analyzers have programmed algorithms into their devices to monitor the slope of the BrAC as the subject exhales. These algorithms are often called "slope detectors" and are designed to monitor for unusual patterns in the BrAC as the subject blows into the breath alcohol analyzer.

In a standard breath alcohol expirogram, the BrAC rises rapidly at first, followed by a slowing increase in BrAC as the subject continues to exhale, as seen in Fig. 1 below.

In infrared breath alcohol testing, the breath alcohol analyzer monitors the profile of the BrAC as the subject exhales. If the slope of the BrAC is unusually wavy, declines, or shows rapid spikes, the analyzer is programmed to flag the sample for mouth alcohol and alert the operator to the problem [32–34].

Another method of monitoring for mouth alcohol contamination involves simultaneously measuring other compounds in the breath, such as carbon dioxide or water, and comparing the relative concentrations of each to exhaled ethanol as the subject blows. If the ratio of ethanol is higher than expected, the device will flag for mouth alcohol contamination [35,36].

For devices that use a fuel cell for measurement, a method of mouth alcohol detection was proposed where duplicate sensors measure the breath at slightly different times as the subject exhales [37]. If the difference between the two measurements is greater than a predetermined threshold, the device will flag for mouth alcohol contamination.

Several investigations have been conducted into breath alcohol analyzers' ability to flag mouth alcohol contamination accurately and have been found to be lacking [31,37–39]. For example, Simpson found that one slope detector's ability to detect mouth alcohol was around 52 % [39].

At present, there is no consensus regarding the parameters required

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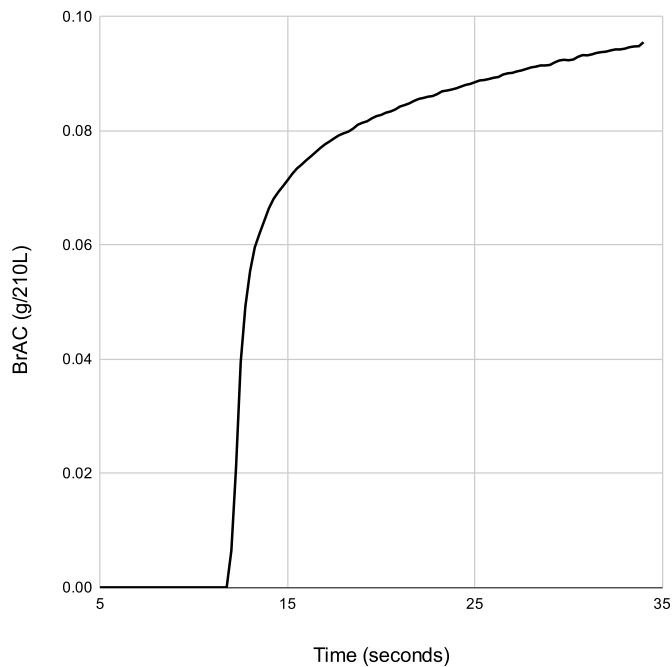


Fig. 1. Standard breath alcohol expirogram.

for a breath alcohol analyzer to flag for mouth alcohol contamination. In addition, the parameters are typically kept secret, with manufacturers claiming that the algorithm is a proprietary trade secret.

Occasionally, individuals charged with driving while under the influence (DWI) will request an independent forensic scientist to examine the results of their test. These individuals tend to express disbelief about the accuracy of their breath alcohol test results. In these cases, there is often a disconnect between the measured BrAC and the number of drinks consumed. Frequently, these individuals have a history of acid reflux, gastroesophageal reflux disease (GERD), burping after drinking, or other gastrointestinal issues that could cause the release of stomach contents into the mouth.

Careful examination of the expirograms of such tests sometimes reveals anomalies such as waviness or negative slopes in the BrAC that strongly indicate mouth alcohol contamination of the breath sample [32,40].

2. Method

Below are three case reports of individuals arrested for DWI. The case reports were selected from cases in which the author was hired to evaluate the breath alcohol test. The cases presented were selected due to the unusual expirograms and case histories, which strongly indicated mouth alcohol contamination. Expirogram data for the case reports are available in an online repository [41].

3. Case reports

3.1. Case report 1

Fig. 2 shows a breath alcohol expirogram from an individual who ate pizza and two margaritas before being stopped while driving by an officer. The passengers riding with the individual expressed disbelief that the driver's BrAC was above the legal limit.

The individual reported regularly experiencing acid reflux and took acid reducers and proton pump inhibitors such as ranitidine and omeprazole in an attempt to control acid reflux. Medical records showed an antrum biopsy of the stomach and revealed histological patterns suggesting chemical injury to the mucosa due to bile/alkaline reflux.

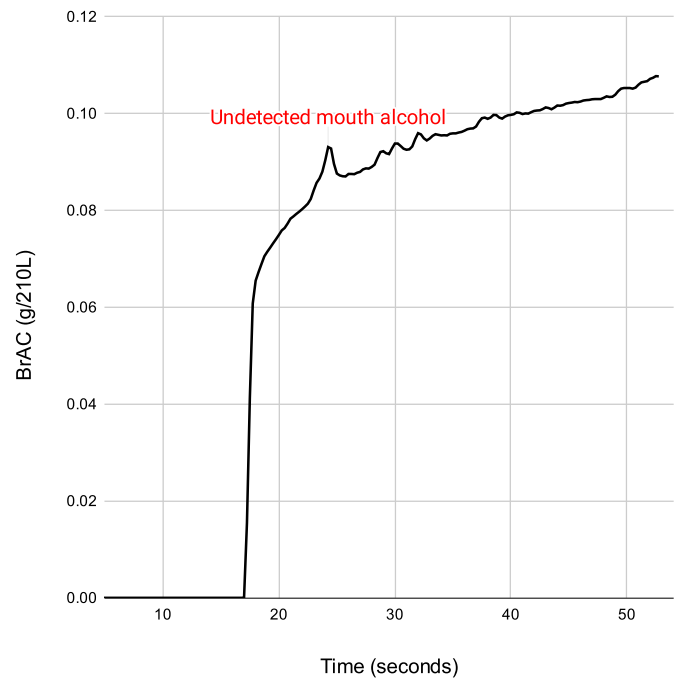


Fig. 2. Case report 1.

A breath sample provided by the subject during the investigation showed a noticeable aberration from a normal breath alcohol expirogram but was not flagged as mouth alcohol by the analyzer used, the DataMaster DMT (Intoximeters, Inc, St. Louis, MO, USA).

3.2. Case report 2

Fig. 3 shows a breath alcohol expirogram from an individual who burped several times during the pre-test 15-min observation period. The individual reported experiencing indigestion from food and wine, burping, and feeling stomach contents refluxing into the throat near the time of the test. There was no formal medical diagnosis of GERD, but the

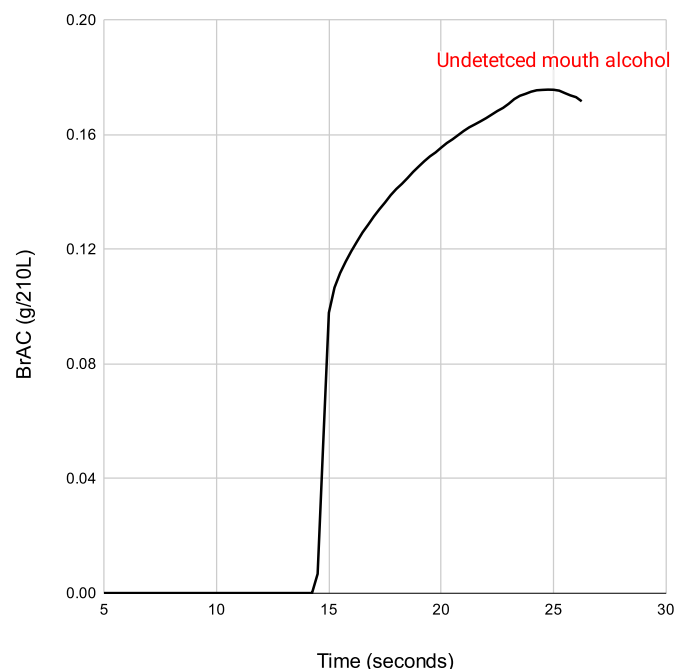


Fig. 3. Case report 2.

subject did report regular stomach distress and acid reflux due to a side effect of taking the drug Ozempic [42]. The instrument used was the DataMaster DMT.

The negative going slope near the end of the breath expirogram indicates mouth alcohol contamination [43]. This breath sample was measured to over double the legal limit in the USA (0.16 g/210), which carries additional penalties in some jurisdictions of the United States.

3.3. Case report 3

Fig. 4 shows an expirogram from a subject who did not have a history of GERD or acid reflux. However, the officer conducting the 15-min pre-test observation period did not carefully observe the subject during the pretest observation period. The instrument used was the DataMaster DMT.

The breath alcohol analyzer did not detect mouth alcohol during its first series of oscillations in the BrAC. Only on the last oscillation did the device's algorithm flag for mouth alcohol contamination.

Another possible explanation for the aberrations in the BrAC of this expirogram is that the instrument may have been malfunctioning. One cannot rule out the possibility of problems with the infrared detector or light source, spurious voltage changes due to electrical interference, or some other environmental factor. Whether the expirogram irregularities were due to mouth alcohol contamination or an instrument malfunction, further investigation is warranted.

4. Discussion

A DWI conviction carries severe penalties that can affect a person's ability to travel, get a job, obtain life insurance, and determine custody of children. The algorithms used to detect mouth alcohol vary by breath alcohol analyzer, with some having no detection mechanism. The above case studies offer several scenarios in which mouth alcohol contamination from the stomach cannot be ruled out as a cause of elevated BrAC. Further research is needed to identify and apply consistent standards for mouth alcohol detection in breath alcohol tests.

None of the major breath alcohol analyzer manufacturers sell their devices to scientists independent of law enforcement for examination or further research. Allowing independent scientists to access breath alcohol devices would enable researchers to conduct additional studies in unique situations, such as the cases with the individuals described in this paper.

The hallmark of science is openness and transparency. Manufacturers of breath alcohol test devices should reconsider their policies in light of the impartiality standards in ISO 17025 [44]. In the United States, the Sixth Amendment to the Constitution secures an individual's right to confront their accuser. Some argue that this right must be extended to machine algorithms [45–47].

In addition to slope detection, many forensic breath alcohol testing protocols require duplicate samples of breath to be tested. If the samples meet predetermined agreement criteria (e.g., $\pm 10\%$ of the mean), the samples are thought to be free of mouth alcohol [48]. The problem with this criteria is that a person may reflux or burp stomach contents on both samples, contaminating both samples. In addition, the time between the two samples may not be long enough for the dissipation of mouth alcohol. Furthermore, some jurisdictions only require one breath sample for testing.

One potential solution to the problem of undetected mouth alcohol is to program the device to make a deduction from all measurements. For example, Sweden and Norway make "security deductions" from BrAC measurements to account for low levels of undetected mouth alcohol [49–51]. However, it is unclear if the magnitude of this deduction is sufficient in all cases.

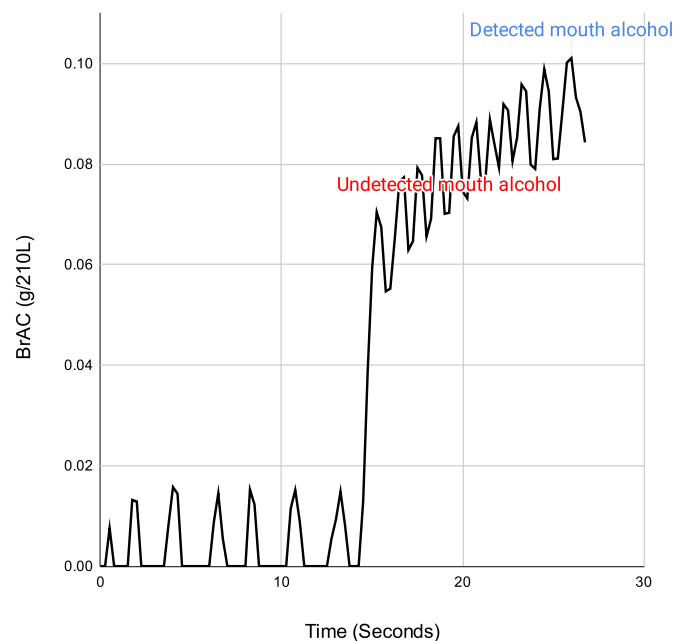


Fig. 4. Case report 3.

5. Conclusion

The above case reports highlight the need for further research into slope detection algorithms and to explore alternative methods for differentiating mouth alcohol contamination from breath alcohol.

Due to the serious legal ramifications of breath alcohol tests, forensic scientists must recognize the limitations of slope detectors and carefully consider the potential for mouth alcohol contamination to affect the test's results.

Slope monitoring is a valuable tool for the breath alcohol test, but the limitations must be acknowledged. When aberrations are found on the breath alcohol test expirogram, the possibility of mouth alcohol contamination must not be dismissed.

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Aaron Olson 

ARO Consulting LLC, United States

* PO Box 132 Hugo, MN 55038, United States.
E-mail address: aaron@aaronolson.expert.