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Dermal and pulmonary absorption of ethanol from alcohol-based hand rub

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SUMMARY

Background: Ethanol intoxication of healthcare workers (HCWs) using alcohol-based hand rubs (ABHRs) in the workplace is a potentially serious issue. This study quantified the level of ethanol absorption among HCWs after hygienic hand disinfection.

Methods: Eighty-six HCWs from Nancy University Hospital were tested before and after a 4-h shift. Participants used ABHR containing 70% ethanol. Levels of ethanol, acetaldehyde and acetate in blood and urine were determined using gas chromatography. A breathalyzer was used to measure the level of ethanol in expired air.

Results: Ethanol [mean concentration 0.076 (standard deviation 0.05) mg/L] was detected in the expired air of 28 HCWs 1–2 min post exposure. Ethanol, acetaldehyde and acetate were undetectable in blood after a 4-h shift, and urine tests were negative in all participants.

Conclusion: Ethanol exposure from ABHR, particularly inhalation of vapours, resulted in positive breathalyzer readings 1–2 min after exposure. Dermal absorption of ethanol was not detected. Pulmonary absorption was detected but was below toxic levels.

Introduction

Alcohol-based hand rubs (ABHRs) are currently the first choice for hand hygiene in healthcare settings because they have better antimicrobial activity than antiseptic soaps,[1,2] are effective, easy to use and improve compliance.[3,4] Their use is recommended before and after patient contact, and for procedures such as intravenous cannulation, provided the hands are not visibly soiled.[5] Most commercially available ABHRs contain 60–95% alcohol in the form of ethanol, propan-1-ol, propan-2-ol or a combination of these.[6,7]

A small amount of alcohol is absorbed from ABHRs and can be detected in the blood.[8,9] As ethanol intoxication of healthcare workers (HCWs) at work is potentially serious, particularly for pregnant women and motorists, it is important to elucidate the effects of frequent use of ABHRs on blood levels. Most countries have legal blood alcohol levels for drivers of 0.0–0.8 mg/mL (a potentially fatal concentration).[10] Estonia, Hungary, Latvia, the Czech Republic, Romania and Slovakia have zero tolerance regarding blood alcohol levels in drivers. Also, alcohol consumption varies with religion and culture.[11] Muslim HCWs may be concerned about exposure to alcohol,[12] producing a potential barrier to the use of ABHRs.

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Absorbed alcohols diffuse widely. Ethanol is mainly metabolized in the liver, with smaller quantities found in kidney, muscle, lung, intestine and possibly brain. Ethanol is oxidized to acetaldehyde and then converted to acetate. This study measured ethanol absorption from ABHR in several categories of HCWs to determine if routine use during a 4-h shift under real-life conditions might cause toxicity. Levels of ethanol, acetaldehyde and acetate were measured in blood, urine and expired air.

Materials and methods

Participants were chosen at random. HCWs completed a questionnaire recording their position, age, gender, height, weight, alcohol consumption, use of medication, and medical and surgical history. Height and weight were used to calculate body mass index (kg/m^2). HCWs on regular medication or with visible lesions on their hands were excluded, as were those with alcohol sensitivity or a history of alcohol or drug abuse. Ethical approval was obtained from the Committee for the Protection of Human Subjects 'Est III' (France) and the French Health Products Safety Agency. Participants signed an informed consent form after receiving detailed information about the experimental procedures. Participants were asked to refrain from alcohol consumption for 48 h before the study. All participants had received the same training regarding use of ABHRs, including the volume of product to use and the duration of hand rubbing.

Exposure study

Ethanol exposure of 86 HCWs aged 18—50 years was assessed under normal working conditions at the University Hospital of Nancy, France. Participants applied 3 mL of ANIOSGEL 85 NPC (Laboratories Anios, Lille, France) to their hands and rubbed them together until dry (30 s), several times during a 4-h shift. Each participant started with a 100-mL bottle of ABHR of known weight. ANIOSGEL contains ethanol (700 mg/g or 755 mL/L), water, glycerine, acrylates/C10-30, alkyl acrylate crosspolymer, bisabolol, caprylic/capric triglycerides PEG-4, esters, PEG-8 caprylic/capric glycerides, aminomethylpropanol and methylpropanediol.

Ethylotest breathalyzer

The level of ethanol in expired air was measured using an electronic Ethylotest Alco-Sensor FST (Intoximeters, Inc., St. Louis, MO, USA), which can detect 0.00—2 mg/L (+/−0.01 mg/L). Measurements were taken before a 4-h work shift (pre-exposure) and 1—2 min after the shift.

Blood and urine collection

Blood and urine samples were collected before a 4-h shift (pre-exposure) and 5—10 min, after the last application of ABHR. The skin was disinfected with a non-alcoholic antiseptic. Blood was collected in a Vacutainer (Becton Dickinson, Franklin Lakes, NJ, USA), and urine was collected in a 60-mL bottle. Samples were stored for up to 2 h at 4 °C before analysis.

Analysis of ethanol, acetaldehyde and acetate concentrations

Levels of ethanol, acetaldehyde and acetate were measured with a gas chromatograph (GC 3900, Varian Analytical Instruments, Walnut Creek, CA, USA) equipped with an injector 1177 EFC 21 split/splitless, and a flame ionization detector with capillary column (CP-SIL 19CB; 25 m × 0.53 mm, 2 μm; Varian Analytical Instruments). The gas chromatograph was set with hydrogen at 25 mL/min and air at 300 mL/min. The nitrogen carrier gas flow was set at 5 mL/min. The temperatures at the injector and detector were set at 220 and 200 °C, respectively. In each case, calibration was performed using an internal standard method. Methanol was used as the internal standard. Samples were analysed using a modified Varian protocol, which involves direct injection of the biological specimen into the gas chromatograph with little pretreatment. Plasma or urine is mixed with the internal standard solution and injected in the gas chromatograph. Each sample was analysed in duplicate. Contamination of the gas chromatographic column with non-volatile material was prevented by using a glass liner in the injector as a precolumn. The glass liner (without glass wool) was replaced after approximately 50 injections.

The reagents used (ethanol 96%, methanol 99.5% and acetaldehyde 99.5%) were obtained from Merck (Darmstadt, Germany).

Preparation of biological samples

The standard sample solution was a mixture containing methanol and ethanol with the concentration ratio. Sealed blood sample tubes were centrifuged for 5 min at 800 ***g***. Urine was centrifuged at 1000 ***g*** for 15 min at 4 °C. The samples were stored in closed microsample containers at −20 °C until analysis. One hundred microlitres of samples were taken and mixed with 100 μL of internal standard (methanol), and stored in a closed microsample container. Standard sample preparation was prepared by diluting 100 μL of ethanol with 100 μL of methanol.

A 1-μL syringe (Hamilton Microliter Syringes, Interchim, Hamilton, Bonaduz, Switzerland) was flushed several times to remove the air in the needle, 0.5 μL of sample was measured in the syringe and injected manually in the split injector of the gas chromatograph.

Data calculation

Results were obtained using Galaxie Version 1.9 SP1 (Varian Analytical Instruments). The peak heights were used to calculate the concentrations of ethanol and its metabolites in the samples. The concentration of ethanol in plasma is 1.17 times the concentration in the whole blood. The detection limit of ethanol and acetaldehyde was 0.1 mg/L. Peaks were identified for acetaldehyde, methanol and ethanol.

Statistical analysis

Data were analysed using Statistical Package for the Social Sciences Version 17 (SPSS Inc., Chicago, IL, USA).