Correlation of ethanol concentrations in blood and saliva

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Summary

1. The concentrations of ethanol in blood, mixed saliva obtained before and after rinsing and drying the mouth and parotid saliva have been monitored in 12 healthy subjects after the ingestion of alcohol.

2. A highly significant linear correlation was found between blood and the three types of saliva examined from 20 min after completion of drinking.

3. Blood and mixed saliva samples were obtained from 20 patients attending the Casualty Department with evidence of ethanol intoxication. A similar correlation was obtained.

4. These results show that salivary ethanol may be used as an index of blood ethanol concentrations, provided that the salivary sample is not obtained within 20 min of the ingestion of alcohol.

Key words: blood, ethanol, ethanol intoxication, saliva.

Introduction

The determination of blood ethanol concentration has an established place in modern society, but accurate measurement has hitherto required the withdrawal and analysis of blood. There are several non-invasive methods relying on the measurement of ethanol or its metabolites in urine or expired air, but all are relatively inaccurate (Wright, Jones & Jones, 1975). It has been found that the concentration of certain drugs in mixed saliva is dependent on the plasma protein binding of the drug (Feller & Petit, 1977) and accurately reflects their blood concentrations. Iribe, Miyazawa, Nakajima & Kamoshna (1967) have suggested that the measurement of ethanol in saliva might allow accurate and non-invasive determination of the blood ethanol concentration. We have measured the concentration of ethanol in blood and saliva of 12 healthy subjects and 32 patients attending the Casualty Department and with signs of ethanol intoxication.

Subjects and methods

In 12 healthy male subjects aged between 20 and 35 years, blood and salivary ethanol concentrations were measured after the oral consumption of 100 ml (659 mmol of ethanol) (six subjects) or 200 ml (1319 mmol of ethanol) (six subjects) of vodka over 15 min. Samples were obtained immediately on completing the drink, at 10 min intervals for the first 60 min and at 30 min intervals for a further 3 h. Mixed saliva, pure parotid saliva and mixed saliva obtained after rinsing the mouth with tap water and drying by chewing a gauze swab were examined. The pure parotid saliva was obtained by using a parotid suction cup as described by Stephen & Spiers (1976); the parotid glands being stimulated by squirting 1 ml of 476 mmol/l citric acid solution on to the tongue. Mixed saliva was obtained by the subject spitting into a plastic test tube; Parafilm was chewed if necessary to stimulate salivation. In two subjects mixed saliva was also obtained after buccal stimulation using 40 μmol of citric acid crystals. Samples were stored at 4°C and analysed within 12 h of collection. Ethanol concentrations were estimated by gas-liquid chromatography (Cooper, 1971). We have
found this method to give the same results with saliva, plasma and whole blood.

In 33 patients attending the Casualty Department with clinical evidence of ethanol intoxication a sample of blood and mixed saliva was obtained, after they gave their informed consent.

Curves were analysed by least-squares regression and 95% confidence limits calculated by the method given by Documenta Geigy (1975).

Results

Volunteer subjects

In all cases the blood ethanol rose to a maximum at 30 to 60 min after completing the drink and thereafter fell to less than 5 mmol/l (23 mg/100 ml) at 4 h. The rise in blood ethanol was inversely proportional to body weight. The whole blood ethanol concentration was always identical with that of the plasma ethanol concentration in every sample. From 20 min to 4 h after completing the drink a highly significant correlation was found between the concentration of ethanol in whole blood and the three types of saliva examined.

Blood ethanol concentration (mmol/l) in the samples taken 20 min to 4 h after the drink was taken as $y$, so that:

\[
y = 1.05x_1 - 0.03 \quad (n = 70, \ r = 0.97)
\]
\[
y = 0.95x_2 - 0.009 \quad (n = 70, \ r = 0.97)
\]
\[
y = 0.95x_3 - 0.148 \quad (n = 184, \ r = 0.95)
\]

(Fig. 1),

where $x_1$ is parotid salivary ethanol concentration, $x_2$ mixed salivary ethanol concentration and $x_3$ mixed salivary ethanol concentration after rinsing (all expressed in mmol/l).

The entire time course of plasma and salivary ethanol concentrations in one subject is shown in Fig. 2. Examination of any of the types of saliva allowed prediction with 95% confidence of the whole blood ethanol concentration to within 3.26 mmol (15 mg/100 ml).

In most subjects all types of saliva samples obtained immediately after the drink and also 10 min later gave ethanol concentrations which were higher than simultaneously determined whole blood concentrations. Citric acid stimulation of mixed saliva did not improve the correlation.

Casualty Department patients

The ethanol concentrations in these patients reached much higher concentrations [up to 69.9

Fig. 1. Correlation of ethanol concentrations between blood and (a) parotid saliva, (b) mixed saliva and (c) post-rinse mixed saliva. Solid line is the least-square regression. The broken lines indicate 95% confidence limits. Samples were obtained from 12 healthy subjects from 20 min to 4 h after drinking 100 ml (659 mmol of ethanol) or 200 ml (1319 mmol of ethanol) of vodka.
Ethanol concentrations in saliva and blood

**FIG. 2.** The association between salivary and plasma ethanol concentrations in one subject. The subject had taken 100 ml (659 mmol of ethanol) of vodka over 15 min.

**TABLE 1.** Concentrations of ethanol in blood and mixed saliva of 32 patients attending Casualty Department

Patients were numbered from 1 to 32 in accordance with blood ethanol concentration.

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...mmol/l (322 mg/100 ml) compared with the healthy volunteer subjects. A good correlation between blood and mixed saliva was obtained.

Blood ethanol concentration (mmol/l) = 1.13 [mixed saliva ethanol concentration (mmol/l)] + 0.08 for 32 samples, r = 0.96.

There was a closer correlation of results at lower ethanol concentrations. Poorest associations of values were obtained at higher ethanol concentrations for the reasons discussed below (Table 1).

**Discussion**

In the volunteer subjects a close correlation was found from 20 min onwards between blood and the three types of saliva examined. The correlation for mixed saliva without any preparation of the mouth was as good as for pure parotid juice or mixed saliva obtained after rinsing and drying the mouth. Poor correlation was found between blood and all types of saliva obtained immediately on completion of the drink and 10 min later. This is almost certainly due to imbibed alcohol lingering in the mouth and contaminating the saliva samples.

The high ethanol concentration and general condition of the Casualty Department patients posed several problems which undoubtedly partly explain the less satisfactory correlation. As a result of their inebriated state it was impossible to obtain an accurate history to determine the time of their last drink. The ethanol-induced drowsiness sometimes resulted in considerable delay between obtaining the blood sample and obtaining a satisfactory saliva sample. In addition, several of the 'mixed' saliva samples obtained from the Casualty
Department patients consisted of a proportion of blood and/or sputum.

The examination of mixed saliva obtained at 20 min after completion of drinking onwards allows the accurate non-invasive determination of the blood ethanol concentration. Suitable samples may be difficult to collect in severely intoxicated patients.

References


