# PERCENTAGE SLOPE OF MAXIMAL ETHANOL CONCENTRATION IN BLOOD AS A MEASURE OF ETHANOL ELIMINATION IN CONTROLLED ALCOHOLEMIA

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**ABSTRACT:** Alcoholemia was induced in 12 healthy volunteers by the ethanol administration (in the dose of 0,84 g/kg b.w.) in the form of vodka, then wine and beer. The ethanol level was determined (GC method, head-space technique) in venous blood samples collected every half an hour after alcohol consumption. The elimination of ethanol was evaluated on the basis of $\beta_{60}$ coefficient, an hour percentage slope and cumulated percentage slope of maximal concentration (% $C_{max}$).

Examinations allowed to compare both the effect of various alcoholic beverages on the elimination course and the efficiency of these coefficients.

**KEY WORDS:** Ethanol; Elimination; GC; Alcoholic beverages.

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## INTRODUCTION

In the experimental studies concerning the dynamics of the elimination phase the most commonly calculated coefficient is an hour elimination coefficient ($\beta_{60}$). On the basis of its values the effects of the following factors were studied: body mass, individual variation when body masses are identical, 24-hour rhythm, frequency of ethanol consumption and maximal concentration [1, 3, 4, 5, 6]. However, $\beta_{60}$ is an absolute value since it expresses only a slope of blood ethanol concentration during one hour. It does not allow to determine the values, the differences of which were used to calculate it and the moment of the phase it concerns. Moreover, its interpersonal variations and, as many authors stress, its dependence on the blood concentration obtained reduce its value as a marker [2, 7, 8].

This raises the question whether in the studies comparing the elimination phases one cannot use another marker, which would be independent of various maximal concentrations obtained, and thus could more fully reflect its dynamics and allow to detect any possible differences in its rate. As practice shows, theoretical calculations based on the Widmark formula do not guarantee similar maximal concentrations in the whole group subjected to examinations receiving the same ethanol dose, even if so-called total organism water is taken into consideration.

According to the authors of this paper trying to solve this problem it would be useful to treat the determined ethanol concentration in blood as 100%. Then, the analysis of the dynamics of ethanol concentration changes in blood could be carried out on the basis of an hour {1} and/or cumulated {2} percentage slope of this maximal concentration [% $C_{max}$] in the successive hours of the elimination phase.

The formulas would be:

$$\%C/h \quad \frac{\beta_{60} \quad 100\%}{C_{max}}, \qquad \{1\}$$

where: $C_{max}$ – maximal ethanol concentration during controlled alcoholemia; $\beta_{60}$ – a coefficient value calculated in the successive hours (or any hour) of the elimination phase:

$$\%C_{max} \quad \frac{(C_{max} \quad C_x) \; 100\%}{C_{max}}, \qquad \{2\}$$

where: $C_x$ – ethanol concentration found during controlled alcoholemia in the successive hours (or any hour) of the elimination phase.

Using three markers of elimination, i.e. $\beta_{60}$ coefficient, an hour percentage slope and cumulated percentage slope of maximal concentration [% $C_{max}$], the phases of blood ethanol elimination were examined in the individuals who consumed three different alcoholic beverages – vodka, wine or beer. These examinations allowed to compare both the effect of various alcoholic beverages on the elimination course and the efficiency of these coefficients.

## MATERIAL AND METHODS

The experiment included 12 healthy men whose age ranged from 18 to 37 years. Two hours after light breakfast they were given ethanol in a single oral dose of 0.84 g/kg body weight, which, according to the Widmark formula (considering 20% deficiency) should theoretically result in maximal ethanol concentration in blood of 1.0‰. In the first stage, the individuals were given 40% vodka prepared by diluting 96% alcohol with mineral water. After a week, the same volunteers consumed 11.5% semi-dry, white wine, and after next 7 days – 5.6% beer. The consumption time for vodka was 15 min, for wine and especially for beer up to 30 minutes. Two hours after the end of drinking, the volunteers were provided with light snack. From this moment on they could drink (tea, mineral water) suitably to their needs. Four hours later a hot meal was provided. Before the ethanol consumption, the volunteers were cannulated and samples were taken every half an hour. The blood collection was finished when the ethanol concentration was < 0.1‰.

Ethanol concentration was measured by means of the GC method, head-space technique using gas chromatograph FISONS 8160 with a capillary column RESTEK BAC-1 (30 m long, wave length 0.53 mm 0.3 mm), automatic head-space and electric thermoregulator (centrifugation alternately in both directions). The following conditions were used: carrier gas – helium 1.8 ml/min., column temperature – 40°C, injector temperature – 150°C, detector temperature – 200°C, hydrogen flow – 25 ml/min, air pressure on the manometer – 45 kPa, sample heating temperature – 60°C, thermoregulation time – 6 min.

The statistical analysis of the results was based on the "Statistica" program using the Kruskal – Wallis and Mann – Whitney tests.

## RESULTS

It was assumed that the beginning of the elimination phase in each individual was maximal concentration ($C_{max}$) or final $C_{max}$ (if the same concentration was found in the successive measurements), no matter what the real time of its appearance was. It was found out that the range of maximal values after these beverages was broad being 0.57 up to 1.12‰. The duration of the elimination phase (i.e. till the concentration lower than 0.1‰ was reached) also varied from 3.5 to 7.0 h.

For each alcoholemia after the consumption of three alcoholic beverages, $\beta_{60}$ coefficients were calculated and the averages were compiled in Table I.

Mean $\beta_{60}$ values in the first four hours of this phase were within the limits of 0.13–0.16‰. It is noteworthy that during the last hour of the elimination phase, no matter what alcoholic beverage was consumed, $\beta_{60}$ was lower than during previous hours.

That is why the statistical analysis concerned only the results obtained in four successive hours from $C_{max}$ (Table I). No significant differences in $\beta_{60}$ values were found with respect to the kind of alcohol consumed.

The next stage of our analysis was to calculate an hour percentage slope of maximal concentration (% $C_{max}$/h), (Table II).

The analysis shows that during first four hours of ethanol elimination after the consumption of three alcoholic beverages used in the experiment, this slope ranged from 17 to 23%/h. This comparison also did not show any differences in the rate of elimination of these beverages.

Since $\beta_{60}$ as well as an hour percentage slope of $C_{max}$ ($C_{max}$/h) are the measures of changes taking place during one hour, each elimination curve was transformed so as to reflect cumulated percentage slope of maximal concentration of ethanol in the successive hours of this phase (Figure 1 and Table III).

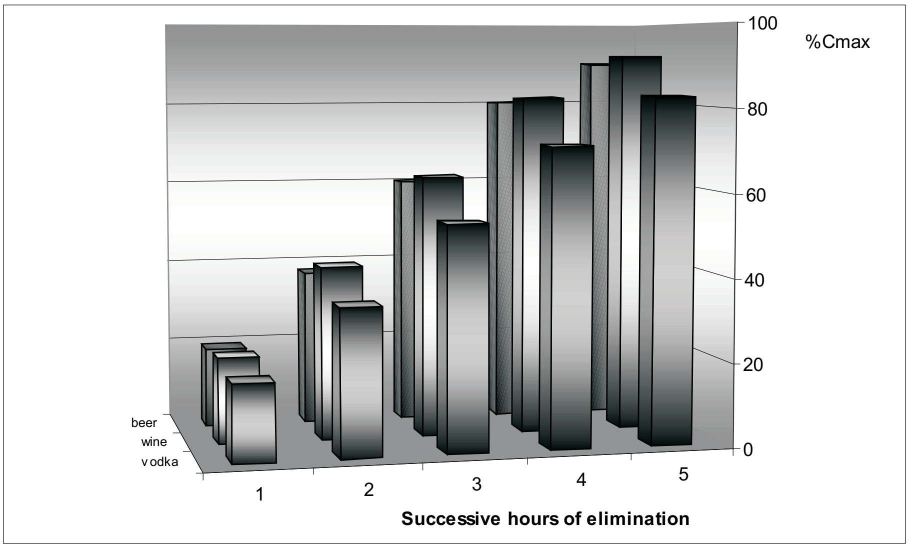


Fig.1. The average ethanol elimination values (% $C_{max}$) after vodka, wine and beer consumption.

TABLE I. THE COMPARISON OF $\beta_{60}$ VALUES DURING THE ELIMINATION PHASE USING THE KRUSKAL – WALLIS TEST

| Successive hours of elimination | Type of alcoholic beverage | | | | | |
|---|---|---|---|---|---|---|
| | Vodka | Wine | Beer | Total | Kruskal-Wallis test | |
| | $\overline{X} \pm SD$ | $\overline{X} \pm SD$ | $\overline{X} \pm SD$ | $\overline{X} \pm SD$ | H | p |
| 1.0 | 0.16 ± 0.06 | 0.16 ± 0.06 | 0.13 ± 0.04 | 0.15 ± 0.05 | 2.545 | 0.280 |
| 2.0 | 0.14 ± 0.03 | 0.16 ± 0.04 | 0.13 ± 0.03 | 0.14 ± 0.04 | 5.518 | 0.063 |
| 3.0 | 0.15 ± 0.04 | 0.16 ± 0.04 | 0.16 ± 0.03 | 0.16 ± 0.03 | 0.553 | 0.759 |
| 4.0 | 0.15 ± 0.03 | 0.15 ± 0.04 | 0.14 ± 0.03 | 0.15 ± 0.03 | 1.030 | 0.598 |
| 5.0 | 0.13 ± 0.02 (10) | 0.11 ± 0.06 (8) | 0.11 ± 0.04 (9) | – | – | – |
| 6.0 | 0,11 ± 0,05 (9) | – | – | – | – | – |

$\overline{X}$ – average value; SD – standard deviation; ( ) – number of individuals different than twelve; H – value of test function; p – probability level.

TABLE II. THE COMPARISON OF HOUR PERCENTAGE SLOPES OF MAXIMAL CONCENTRATION [% $C_{max}$/h] OF ETHANOL DURING THE ELIMINATION PHASE USING THE KRUSKAL – WALLIS TEST

| Successive hours of elimination | Type of alcoholic beverage | | | Total | Kruskal-Wallis test | |
|---|---|---|---|---|---|---|
| | Vodka | Wine | Beer | | | |
| | $\overline{X}$ ± SD | $\overline{X}$ ± SD | $\overline{X}$ ± SD | $\overline{X}$ ± SD | H | p |
| 1.0 | 18.5 ± 3.4 | 20.6 ± 7.2 | 19.1 ± 6.1 | 19.4 ± 5.7 | 0.659 | 0.719 |
| 2.0 | 16.6 ± 6.1 | 21.1 ± 5.3 | 18.5 ± 4.9 | 18.8 ± 5.6 | 3.839 | 0.147 |
| 3.0 | 18.6 ± 7.0 | 21.1 ± 5.4 | 22.7 ± 4.2 | 20.8 ± 5.7 | 5.628 | 0.060 |
| 4.0 | 17.6 ± 2.9 | 19.0 ± 3.7 | 19.8 ± 4.1 | 18.8 ± 3.6 | 1.680 | 0.432 |
| 5.0 | 14.5 ± 2.0 (10) | 13.7 ± 7.0 (8) | 14.9 ± 4.3 (9) | – | – | – |
| 6.0 | 11.3 ± 4.2 (9) | – | – | – | – | – |

$\overline{X}$ – average value; SD – standard deviation; ( ) – number of individuals different than twelve; H – value of test function; p – probability level.

TABLE III. THE COMPARISON OF CUMULATED PERCENTAGE SLOPES OF MAXIMAL CONCENTRATION [%$C_{max}$] OF ETHANOL IN THE SUCCESSIVE HOURS [h] OF THIS PHASE, USING THE KRUSKAL – WALLIS TEST

| Hours of elimination [h] | Vodka | Wine | Beer | Total | Kruskal-Wallis test | |
|---|---|---|---|---|---|---|
| | $\overline{X}$ ± SD | $\overline{X}$ ± SD | $\overline{X}$ ± SD | $\overline{X}$ ± SD | H | p |
| After 1 | 18.5 ± 3.4 | 20.6 ± 7.2 | 19.1 ± 6.1 | 19.4 ± 5.7 | 0.659 | 0.719 |
| After 2 | 35.1 ± 6.2 | 41.7 ± 10.6 | 37.6 ± 7.7 | 38.2 ± 8.6 | 3.576 | 0.167 |
| After 3 | 53.7 ± 11.7 | 62.9 ± 11.2 | 60.4 ± 8.0 | 59.0 ± 10.8 | 4.704 | *0.095* |
| After 4 | 71.3 ± 12.0 | 81.9 ± 9.0 | 80.2 ± 10.1 | 77.8 ± 11.2 | 6.020 | **0.049** |
| After 5 | 82.7 ± 8.7 (11) | 92.0 ± 4.7 (8) | 89.9 ± 4.8 (8) | 87.6 ± 7.7 (27) | 7.477 | **0.024** |

$\overline{X}$ – average value; SD – standard deviation; ( ) – number of individuals different than twelve; H – value of test function; p – probability level.

TABLE IV. THE COMPARISON OF ETHANOL ELIMINATION [%$C_{MAX}$] IN THE SUCCESSIVE HOURS OF THE ELIMINATION PHASE USING THE MANN – WHITNEY TEST.

| Hours of elimination [h] | Group Vodka / Wine | | Group Vodka / Beer | | Group Wine / Beer | |
|---|---|---|---|---|---|---|
| | Z | p | Z | p | Z | p |
| After 1 | 0.808 | 0.419 | 0.231 | 0.817 | 0.520 | 0.603 |
| After 2 | 1.732 | 0.083 | 1.155 | 0.248 | 1.011 | 0.312 |
| After 3 | 1.790 | 0.073 | 1.848 | 0.065 | 0.751 | 0.453 |
| After 4 | 2.367 | **0.018** | 1.790 | 0.073 | 0.346 | 0.729 |
| After 5 | 2.395 | **0.017** | 1.997 | **0.050** | 1.260 | 0.208 |

Z – value of test function; p – probability level.

The concentration slope one hour after the consumption of 3 alcoholic beverages on an average was about 20%, after 2 hours – 40%, after 3 hours – 60% and, even though the values were differentiated, the differences were not significant. After the fourth hour of elimination, the percentage of ethanol eliminated was on an average 70–80% and this 10% difference appeared to be significant. The difference significance maintained after the 5th hour.

To determine the differences the Mann – Whitney test was used (Table IV) which showed that four hours after $C_{max}$ had been obtained, the mean percentage of eliminated ethanol after vodka consumption was significantly lower (about 70%) than the average percentage of $C_{max}$ found after wine or beer (about 80%). After 5 hours of the elimination phase, the percentage slope after vodka was still about 10% lower than that after wine or beer.

The results of the analysis of the elimination phase of 3 alcoholic beverages presented on the basis of the cumulated percentage slope of maximal concentration show the usefulness of the coefficient presented in the studies concerning the dynamics of this phase. It allows to make the analysis independent of various $C_{max}$ values and time variations in each individual examined. In our experiment, the analysis of the cumulated percentage slope of maximal concentration was found to be more sensitive than the analysis using only $\beta_{60}$. This enabled to show the differences in the dynamics of elimination of ethanol consumed in the form of 3 alcoholic beverages. However, it should be stressed that this coefficient may be mainly used for experimental purposes, as its calculation requires precise determination of the beginning of the elimination phase. Nevertheless, one should remember that this coefficient is a relative value ($C_{max}$ effect) contrary to an hour elimination coefficient ($\beta_{60}$). And that is why both coefficients ought to be treated as supplementary rather than opposing ones.

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