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THE TRANSFER OF ALCOHOL TO HUMAN MILK

Effects on Flavor and the Infant's Behavior

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Abstract *Background.* The amount of alcohol ingested by a breast-fed infant is only a small fraction of that consumed by its mother, but even this small amount may have an effect on the infant. We investigated whether the ingestion of alcohol by a lactating woman altered the odor of her milk and whether exposure to a small amount of alcohol in the mother's milk had immediate effects on the behavior of the infant.

Methods. Twelve lactating women and their infants were tested on two days separated by an interval of one week. On each testing day, the mother expressed a small quantity of breast milk and then drank either orange juice or orange juice containing a small quantity of ethanol (0.3 g per kilogram of body weight). Additional milk samples were obtained at fixed intervals after the ingestion of the beverage and analyzed to determine their ethanol content. The samples were also evaluated by a panel of adults to determine whether any difference in the odor of the milk was detectable after alcohol ingestion. The infants were weighed before and after nursing to assess the amount of milk they ingested, and their behavior during breast-feeding was monitored by videotape.

Results. Short-term alcohol consumption by lactating women significantly and uniformly increased the perceived intensity of the odor of their milk as assessed by the panel; this increase in the intensity of the odor peaked 30 minutes to 1 hour after the alcohol was consumed and decreased thereafter. The alteration in the odor of the milk closely paralleled the changes in the concentration of ethanol in the milk (mean range, 0 to 6.9 mmol per liter [0 to 32 mg per deciliter]). The infants sucked more frequently during the first minute of feedings after their mothers had consumed alcohol (67.0±6.5 sucks, as compared with 58.4±5.9 sucks for feedings after the consumption of the nonalcoholic beverage; $P<0.05$), but they consumed significantly less milk (120.4±9.5 ml vs. 156.4±8.2 ml, $P<0.001$) during the testing sessions in which their mothers drank the alcoholic beverage.

Conclusions. Although the mechanisms underlying this reduction in milk intake remain to be elucidated, this study shows that short-term alcohol consumption by nursing mothers has an immediate effect on the sensory characteristics (odor) of their milk and the feeding behavior of their infants. (N Engl J Med 1991;325:981-5.)

TRADITIONALLY, alcohol has been recommended to nursing mothers as an aid to lactation.[1] Folklore relates that drinking small quantities of alcohol shortly before nursing increases milk yield, facilitates milk let-down, and relaxes both mother and infant.[2-4] No scientific evidence supports any of these contentions, however. The absence of medical concern about alcohol consumption during lactation may reflect the fact that when the fetal alcohol syndrome was identified in the 1970s,[5] less than 25 percent of mothers in the United States breast-fed their infants.[6] Furthermore, in contrast to the drastic consequences of prenatal exposure seen in infants with fetal alcohol syndrome,[7] the long-term effects of exposure to alcohol in the mother's milk, if any, are subtle.[8]

Experimental data indicate that breast-fed infants are exposed to alcohol in their mother's milk,[9,10] but the amount ingested by the infant is a minute fraction of that consumed by the mother.[11] The immediate effects of such exposure on the infant are unknown. In addition, it is not known whether alcohol, a substance detected by the human nose at low concentrations,[12] alters the flavor of human milk when transmitted in this fashion.

In this study, we tested the hypothesis that alcohol consumption by the nursing mother affects the sensory qualities of her milk and the behavior of her infant in the short term. To test this hypothesis, we recruited 12 nursing women, who drank an alcoholic or a nonalcoholic beverage (orange juice or orange juice containing a small amount of ethanol) on two separate days; we evaluated the odor of their milk and assessed the behavior of their infants on both occasions.

METHODS

Subjects

Twelve healthy, nonsmoking women (seven primiparous and five multiparous) who were breast-feeding their infants and who had consumed at least one alcoholic beverage during lactation were recruited from the University of Pennsylvania area and from local La Leche groups. The mothers ranged in age from 21 to 38 years

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(median, 30), and their infants (eight girls and four boys) ranged in age from 25 to 216 days (median, 120). Two additional mother–infant pairs were tested but were excluded from the analysis; one mother did not comply with the nursing schedule, and the other had difficulty expressing milk. Informed consent was obtained from each woman; all study procedures were approved by the Committee on Studies Involving Human Beings at the University of Pennsylvania.

Each woman estimated the number and type of alcoholic drinks she consumed both during pregnancy (range, 0 to 9 drinks per nine months) and during lactation (range, 0.5 to 20 drinks per month). Information obtained from a questionnaire completed by each woman later in the study corroborated these findings, although these numbers probably underestimate alcohol use.[13] At the end of the study, we asked each mother to forgo drinking one alcoholic beverage in the near future so that her infant would not be exposed to additional alcohol as a result of the mother's participation in the study.

Procedure

Each mother–infant pair was tested on two days separated by an interval of one week (±1 day). The mothers were instructed not to wear perfumes or to use scented soaps or deodorants on the testing days, and they were asked to refrain from drinking any alcohol during the three days before each testing day. Because our previous work suggested that sulfurous volatiles alter the odor of human milk,[14] the women were also instructed not to eat foods containing sulfur (such as garlic, onions, and broccoli) during these three days.

Each mother arrived at the Monell Chemical Senses Center in Philadelphia at approximately 9:30 a.m., having last fed her infant at approximately the same time on each testing day. Within a half-hour of arrival, she expressed a base-line sample of approximately 15 ml of milk, usually from one breast only, with an electric breast pump (Medela, Crystal Lake, Ill.). After the first expression, the mother drank either orange juice or ethanol in orange juice (0.3 g per kilogram of body weight); this amount of alcohol is less than that which inhibits the milk-ejection reflex,[15] and approximates the ethanol content of one can of beer for the average-sized woman. The beverage was consumed within 15 minutes as a 15 percent solution (vol/vol) in orange juice or an equal volume of orange juice alone. Half the women drank the ethanol in orange juice during the first day of testing and orange juice alone during the second; the order was reversed for the remaining six women. No effect of order was observed for any of the variables we investigated.

Milk samples were again obtained 30 minutes and 1, 2, and 3 hours (±15 minutes) after the beverage was consumed; each sample was immediately placed on ice in an airtight, sterilized glass container. The collection time was varied in order to disrupt nursing as little as possible. If the infant continued to nurse beyond this 15-minute period, however, milk was not collected. The amount of milk expressed by each mother did not differ on the two testing days (control [nonalcoholic beverage] vs. alcohol, 65.3±3.6 vs. 65.8±3.2 ml; paired $t(11\ df) = -0.25$; P not significant).

Evaluation of the Milk

The ethanol concentration of each milk sample was determined shortly after the last milk sample of the day was collected by means of a nicotinamide adenine dinucleotide–alcohol dehydrogenase enzymatic assay (332-UV, Sigma Chemical, St. Louis).[16] To determine whether adults could detect any difference in the odor of the breast milk after alcohol consumption, a sensory panel evaluated the odor of the milk samples (this method has been described elsewhere[14]). The panel consisted of 17 adults (12 women and 5 men), all of whom had normal olfactory thresholds for ethanol.[12] Because odor is a primary component of flavor, it can be confidently predicted that if the odor of milk changes, its flavor changes also. We did not have the panelists taste the milk because the human immunodeficiency virus has been isolated in human milk.[17]

Shortly after the last sample was collected, the five samples of milk were brought to room temperature and 10 ml of each was placed in a separate 250-ml polypropylene squeeze bottle with a flip-up cap. Six to eight panelists, blinded to the conditions under which the milk was collected, evaluated pairs of milk samples. All 10 possible pairs of samples (from each woman) were presented twice, 1 pair at a time in random order, to each panelist individually. The task of the panelist was to indicate which of the pair smelled "more like alcohol" or "stronger."

The null hypothesis tested was that the perceived odor of the five samples would not vary throughout the collection period, regardless of the woman's alcohol consumption. To test this, we determined the number of times each sample was chosen by each panelist as smelling "more like alcohol" or "stronger"; this number could vary between 0 and 8. (If all five samples smelled the same, for example, the average expected number for each sample would be 4, or 50 percent). A Friedman two-way analysis of variance by ranks was performed to determine whether there was a significant association between the time a milk sample was collected and the panelists' choice of a sample as smelling "more like alcohol" or "stronger."[18]

Evaluation of the Infants' Behavior

Each infant was breast-fed at the frequency customary for each mother–infant pair. The babies fed on demand. The mother chose which breast the baby suckled from first and whether the second breast was offered. Immediately before and after each feeding, the baby was weighed (without a change in clothing) on a Mettler PM 15 top-loading balance (Greifensee, Switzerland) to determine the weight of the milk consumed.[19,20] The volume of milk consumed by the infant (in milliliters) was estimated by dividing the weight of the milk consumed by 1.031, the specific gravity of mature human milk. In addition, the baby's face was videotaped during each nursing period. During replays, observers who were blinded to the conditions of the feeding recorded the length of time the infant spent attached to the nipple and the number of times he or she sucked.[14] The degree of agreement between the two scorers was high for both variables (time attached: $r(17\ df) = 0.99$, $P<0.001$; number of sucks per feeding: $r(14\ df) = 0.99$; $P<0.001$). Because alcohol consumption by a nursing mother may be associated with increased sleepiness in the infant, we also recorded when and for how long the child slept during each testing session, and mothers kept similar records until the child awoke the next morning.

All summary statistics reported in this article are expressed as means ±SE, and all P values represent two-tailed tests.

Results

Evaluation of the Milk

The consumption of ethanol by each of the 12 lactating women significantly altered the intensity of the odor of their milk as perceived by a panel of adults (Friedman test, all χr^2s >9.2; $P<0.001$ for all comparisons). The intensity of odor peaked 30 minutes to 1 hour after the mother drank the alcoholic beverage and decreased thereafter. The ethanol content of the mother's milk also changed significantly as a function of the length of time since the consumption of alcohol (multivariate analysis of variance $F(34,4\ df) = 15.68$, $P<0.0001$), in a manner directly paralleling the changes in the milk's sensory properties (Fig. 1).

In contrast to the altered odor of the milk after the consumption of alcohol, there was no perceived change in the odor of milk from 10 of the 12 mothers on the day the nonalcoholic beverage was consumed (Fig. 1, inset). For the remaining two mothers, however, the intensity of the odor of the milk declined

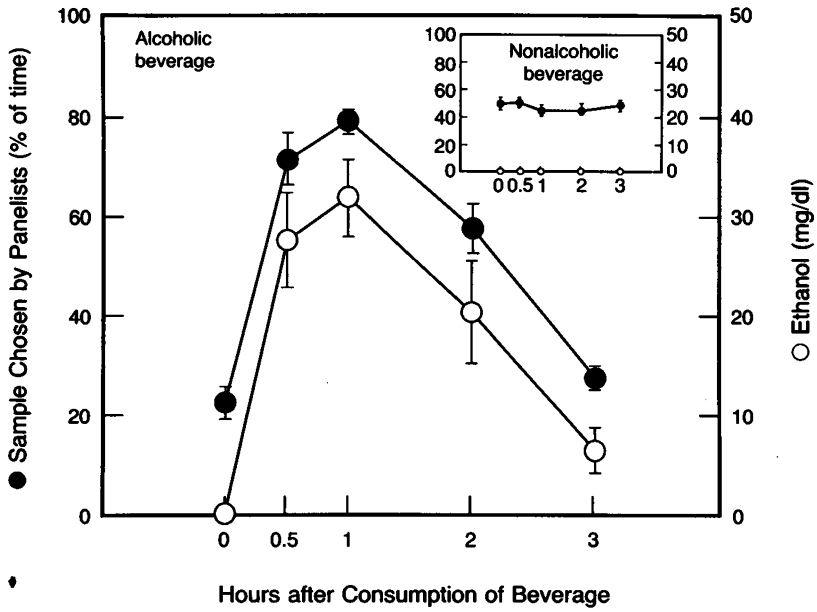

Figure 1. Ethanol Content of Milk Samples Obtained at Base Line and 30 Minutes and 1, 2, and 3 Hours after the Ingestion of an Alcoholic or Nonalcoholic Beverage (Open Circles) and Percentage of the Time Panelists Chose the Samples as Smelling "More Like Alcohol" or "Stronger" (Closed Circles).

According to a forced-choice paradigm, panelists were presented individually with pairs of milk samples and asked to indicate which of the pair smelled "more like alcohol" or "stronger." A value of 50 percent would be expected if there were no difference in the odor of the samples and hence the panelists responded at random. Values below 50 percent for the samples collected at base line and after 3 hours are a consequence of these samples' being paired with a stronger-smelling sample (e.g., one collected 30 minutes or 1 or 2 hours after alcohol consumption). The bars indicate standard errors. To convert values for ethanol to millimoles per liter, multiply by 0.2171.

significantly throughout the test period ($P<0.05$ by Friedman test). Both mothers chose not to eat anything during the three-hour testing period. Ethanol was not detected in any of the milk samples collected on the day the mothers consumed the nonalcoholic beverage (Fig. 1, inset).

The Infants' Behavior

The infants consumed significantly less milk during the three-hour testing session in which their mothers drank alcohol (120.4±9.5 ml) than during the session in which the mothers drank the nonalcoholic beverage (156.4±8.2 ml, paired $t(11\ df) = -4.69$, $P<0.001$) (Table 1). This decrease in intake was observed in all but 1 of the 12 infants tested (Fig. 2). Because there was no significant difference in the number of feedings (control vs. alcohol: 2.5±0.2 vs. 2.2±0.2, paired $t(11\ df) = 1.91$, P not significant) or the total length of time during which the infant was attached to the nipple (control vs. alcohol: 28.6±7.7 vs. 28.2±7.3 minutes, paired $t(11\ df) = 0.15$, P not significant), the observed decrease in milk intake by the infants was not due to a decrease in the duration of the feedings.

The infants sucked significantly more frequently during the first few minutes of the feedings on the day when their mothers consumed the alcoholic beverage ($F(8,1\ df) = 12.11$, $P<0.008$; the videotapes of three infants were not clear enough for the frequency of sucking to be determined). Further analyses showed a significant increase in the number of sucks during the first minute (paired $t(8\ df) = -4.62$, $P<0.002$) and a trend for minute 2 (paired $t(8\ df) = -1.74$, $P = 0.12$) and minute 3 (paired $t(8\ df) = -1.82$, $P = 0.10$) (Table 1). There was no significant difference, however, in the total number of sucks on the two days of testing (control vs. alcohol: 856.7±103.4 vs. 877.2±102.3, $t(8\ df) = 0.23$, P not significant).

With regard to the infants' sleeping behavior, there was no significant difference in the total amount of time infants slept during the three-hour testing sessions (control vs. alcohol: 65.10±10.96 vs. 62.97±12.04 minutes, paired $t(11\ df) = 0.15$, P not significant) or for the remainder of the day until the child awoke the next morning (14.45±1.71 vs. 13.47±1.76 hours, paired $t(11\ df) = 1.18$, P not significant). However, the number of times the infants slept increased on the days when the mothers consumed alcohol (6.6±0.7 vs. 7.8±0.9, paired $t(11\ df) = -2.31$, $P<0.05$). In other words, the infants slept for shorter periods but more often during the day when their mothers consumed alcohol.

Dose of Alcohol Delivered to the Infant

The amount of alcohol ingested by the infants in our study (estimated by multiplying the volume of

Table 1. Effect of Maternal Alcohol Consumption on the Feeding Behavior of Nursing Infants.*

Variable	Nonalcoholic Beverage	Alcohol
Total amount of milk consumed (ml)	156.4±8.2	120.4±9.5†
Total time attached to nipple (min)	28.6±7.7	28.2±7.3
No. of feedings	2.5±0.2	2.2±0.2
Mean no. of sucks per feeding	307.1±56.4	352.3±64.8
Minute 1	58.4±5.9	67.0±6.5†
Minute 2	56.2±6.5	61.2±5.4
Minute 3	49.8±5.8	58.0±4.9
≥Minute 4	142.7±38.2	166.1±48.0

*The amount of milk consumed, the total time spent attached to the nipple, the number of feedings, and the number of sucks per feeding are shown for each of two three-hour testing sessions. During one session, the nursing mother drank orange juice containing 0.3 g of ethanol per kilogram (alcoholic beverage); during the other, she drank an equal volume of orange juice alone (nonalcoholic beverage). Plus–minus values are means ±SE.

†$P<0.05$ for the comparison with the session during which the mothers drank the nonalcoholic beverage.

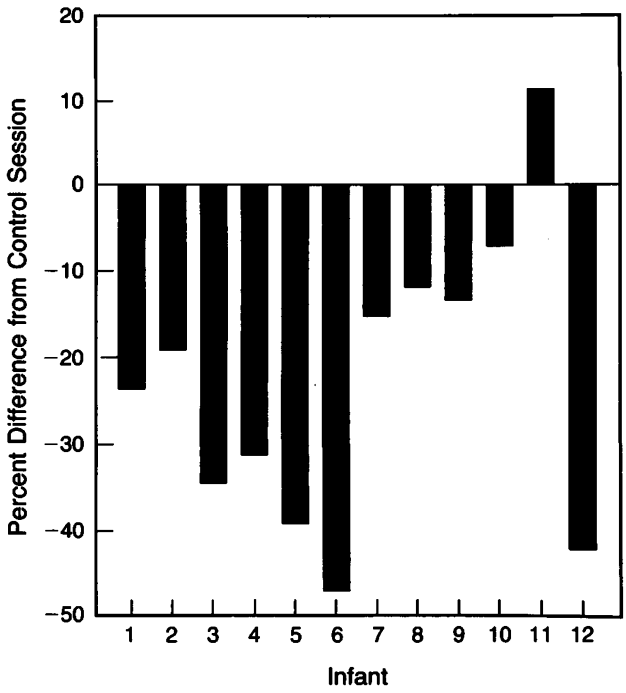

Figure 2. Percent Difference in the Amount of Milk Consumed by Each Infant during the Three-Hour Testing Session in Which the Mother Drank Alcohol as Compared with the Amount Consumed When She Drank the Nonalcoholic (Control) Beverage.
Paired t(11 df) = −4.69; P<0.001.

milk ingested by the concentration of alcohol detected in the milk at the collection period closest to the time of the feeding) ranged from 14.1 to 66.4 mg (mean ±SE, 33.4±5.6). Taking into account the body weight of each infant, the estimated dose ranged from 1.6 to 9.9 mg per kilogram (mean, 5.1±0.8), which was 0.5 percent to 3.3 percent (mean, 1.7±0.3 percent) of the maternal dose (300.0 mg per kilogram).

Discussion

In the short term, alcohol consumption significantly and consistently increased the perceived intensity of the odor of human milk. The changes in the odor over time were consistent with the changing concentrations of ethanol in the milk. Whereas the majority of panelists perceived the odor as "smelling like alcohol" or "smelling sweet," it remains to be determined whether ethanol, its metabolites, or both contributed to this change in odor. Because the flavor of human milk can be altered by dietary components (such as garlic[14] and alcohol), the breast-fed infant may be receiving sensory information about the mother's dietary choices. Whether these early sensory experiences affect later behavior in humans is unknown. In nonhuman animals, however, early and long-term exposure to flavors in the mother's milk affects later flavor preferences,[21-25] including that for alcohol.[26]

Alcohol consumption by lactating women also reduced milk intake by their infants. At least three factors, acting separately or together, could account for this change in the mother–infant interaction. First, the change in the flavor of the milk may influence the infant's behavior. This possibility is supported by our recent finding that the ingestion of garlic by mothers also alters the sensory qualities of human milk and their infants' behavior during breast-feeding.[14] Second, the changes may be a direct effect of alcohol on the infants. Although the dose of alcohol ingested by the infants was low, infants have limited capacity to oxidize ethanol,[27] a fact that renders the dose more potent.[28] The altered sleeping behavior of the breast-fed infants on the day when their mothers drank the alcoholic beverage suggests that ethanol had a pharmacologic effect on the infants.

A third possibility is a decrease in milk production by the lactating woman resulting from an alcohol-induced inhibition of antidiuretic activity.[29] Moreover, ethanol may affect the milk-ejection reflex, although, as stated earlier, previous studies have not found this to be the case for the dose used in our study.[15] A recent study demonstrated, however, that in the short term the administration of alcohol significantly reduced both suckling-induced prolactin levels in lactating rats and milk intake by their pups,[30] suggesting that ethanol may be interfering with sensory input from the nipple. Thus, the increased sucking observed in the first few minutes of feeding and the overall reduction in milk intake may reflect difficulty in obtaining milk from the breast.

Although the mechanisms for the change in mother–infant interaction remain to be elucidated, this study shows that alcohol consumption by a lactating woman influences the odor of the mother's milk and the amount of milk ingested by her infant in the short term.

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