METABOLISM OF WOMEN DURING THE REPRODUCTIVE CYCLE

XI. VITAMIN C IN DIETS, BREAST MILK, BLOOD AND URINE OF NURSING MOTHERS [1]

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As part of a comprehensive investigation of the vitamin and mineral composition of human milk and the metabolism of women during the reproductive cycle we have determined nursing mothers' intakes of vitamin C, their secretion of the vitamin in milk, excretion in the urine, and the amounts in the cord blood as well as the levels in the blood of both mother and child. Other investigations have not included analyses of 24-hour collections of food, milk, and urine during the 10 days of the puerperium and at intervals during mature milk production, accompanied by determinations of vitamin C in the blood of the same subjects and their infants. The intake of vitamin C provided for the infant by his mother's milk will be discussed in another paper.

EXPERIMENTAL

The subjects of the investigation were multiparas with medical records of good or excellent health and of having successfully nursed their other children. Every effort was

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made to standardize any procedure involving controllable factors. Vitamin C was determined by analysis of samples representing the total intake of vitamin-C-containing foods for 24-hour periods, thus obtaining quantitative estimations of the amounts ingested. Qualitatively the diets were similar for all women during all 5-day periods (Kaucher et al., '45, '46); however there were differences in consumption owing to variations in appetites and food composition. Analyses of complete 42-hour collections of milk and urine obtained during the first 10 days postpartum and during each day of 5-day periods at intervals during lactation avoided portrayal of diurnal changes in concentration in the results. In addition, vitamin C was determined in placental tissue (Pratt et al., '46), in blood from the umbilical cord and in capillary blood obtained from both mother and infant on the first and tenth days after delivery, and the first and last days of 5-day periods of study. To obtain comparable data, the blood samples were taken from mother and child in the morning after expression of the milk but before breakfast.

Analyses of food, milk and urine were made by the method of Roe and Kuether ('43); of blood, by the method of Farmer and Abt ('36). Preceding publications have given details of selection of subjects (Macy, Williams, Pratt and Hamil, '45), diet and procedures of sampling and preparation of food composites and milk (Kaucher et al., '45), the method of manually expressing milk (Davies, '45) and collection and analysis of urine (Roderuck, Williams and Macy, '46). The concentration of vitamin C in immature and mature human milk has been presented (Munks et al., '45).

RESULTS

The volumes of milk secreted and urine excreted by 4 women during each of the first 10 days postpartum, the intakes of vitamin C per day and the amounts of vitamin C in the immature milk and in the urine for each day are given in table 1.

Within each 5-day period there were wide variations from day to day in vitamin C intake, depending upon the kinds of

TABLE 1

Vitamin C intake, secretion and excretion during first 10 days postpartum.

SUBJECT	INTERVAL POSTPARTUM	VOLUME		VITAMIN C		
		Milk	Urine	Intake	Milk	Urine
	days	*ml*	*ml*	*mg*	*mg*	*mg*
V.K.	1	9	3086	148	..	24.9
	2	90	3651	112	..	15.7
	3	484	2596	77	50	13.4
	4	547	2427	128	54	11.6
	5	560	2331	83	50	12.4
	6	663	2249	126	60	10.3
	7	781	3380	115	61	8.3
	8	775	3840	63	70	9.6
	9	794	3115	176	70	9.8
	10	797	3328	51	61	3.5
V.L.	1	30	1757	138	1	23.9
	2	56	2686	98	4	14.9
	3	353	2759	86	25	11.4
	4	794	1823	204	50	13.4
	5	844	1847	98	55	14.1
	6	955	2710	200	63	18.2
	7	1047	2841	161	69	14.2
	8	1098	2066	87	76	14.2
	9	1118	2151	183	73	11.8
	10	1200	1669	99	83	9.2
J.M.	1	35	2182	216	2	8.9
	2	385	1386	147	23	6.4
	3	870	1519	96	44	8.2
	4	1011	1201	201	56	6.5
	5	1121	1283	114	62	8.5
	6	1125	1172	169	51	4.7
	7	1287	1161	151	75	6.4
	8	1136	1520	92	55	6.6
	9	1258	....	254	83	..
	10	1336	1553	59	87	7.5
V.S.	1	6	1869	204		34.7
	2	92	1874	98	8	24.9
	3	420	2887	98	37	28.2
	4	600	2063	207	49	35.4
	5	697	2065	112	54	26.4
	6	756	1502	156	54	22.8
	7	818	2524	154	65	22.0
	8	837	2237	98	67	20.9
	9	932	1984	.196	76	19.2
	10	924	2287	89	65	15.0

foods included in the diet for the different days. The lowest vitamin C intake for any day was 51 mg, the highest was 254 mg. The average daily consumption for the 10 days was 134 mg, an amount lower than the 150 mg recommended by the Food and Nutrition Board of the National Research Council ('45). However, it is important in evaluating the data on vitamin C to remember that the values represent intakes determined by analysis of food *as eaten*, by 1 method of determination, whereas the Recommended Allowances are based upon data obtained by various analytical methods and were planned to include ample amounts as "safety factors."

It is evident that the amounts of vitamin C secreted in the milk each day were not related to the daily fluctuations in intake, but paralleled the increased production of milk, secondarily influenced by the slightly augmented ascorbic acid concentration (Munks et al., '45). The high excretions of vitamin C in the urine by 3 of the mothers after delivery, followed by decreases of 50% or more within the first 10 days postpartum, parallel the decreased urinary excretions of vitamin C reported for newborn infants (Hamil et al., '47) and support the belief that the tissues of both mother and fetus require greater concentrations of vitamin C for saturation during pregnancy than during lactation.

Subject V.S., who had been taking 100 mg of ascorbic acid per day throughout pregnancy, in addition to an excellent diet and supplements of other vitamins (Roderuck, Williams and Macy, '46; Roderuck, Coryell, Williams and Macy, '46) secreted milk with the highest concentration of vitamin C each day of the puerperium and also excreted greater amounts in urine (15.0 to 35.4 mg) than did any of the other women. Subject J.M., whose milk flow was established more rapidly than that of the other 3 women and reached the highest level during the first 10 days, excreted much less vitamin C in urine during the first few days after delivery, but continued to excrete at approximately the same level regardless of the increased secretion in milk.

Despite the similarity of the women's average daily intakes during each 5-day period and the relationship between volume of milk produced and its vitamin C content, the data in table 1 do not indicate a relationship between volume of milk or its vitamin C content and excretion of the vitamin in urine. Nor was urine volume a factor in excretion of vitamin C, which ranged from 3.5 mg in 3328 ml to 35 mg in 1869 ml of urine. Several possibilities are suggested by the urine values. If the level of tissue saturation required during lactation is lower than that demanded by pregnancy, the decline of over 50% in the daily excretion of vitamin C by 3 women during the first 10 days postpartum may represent an "unloading" from the maternal tissues. If this is true it would indicate that the tissues of subject J.M. had not been saturated during the prepartum period or that the amount which she might have "unloaded" after delivery was expended during labor and childbirth. That the woman's prepartum nutritional status was not poor is evidenced by the medical records, by her quick establishment of lactation, and the secretion in milk of greater amounts of vitamin C per day than any other woman. The fact that J.M. maintained a level of excretion in urine ranging from 5 to 9 mg of vitamin C per day also indicates that the decreased excretions by the other women are not attributable to the demands of increased milk production. The possibility that J.M. was excreting required minimal amounts in urine is doubtful because the urinary vitamin C of V.K. and V.L. declined to comparable levels by the tenth day postpartum.

The vitamin C contents of the serum of the cord blood and the blood of mother and infant, shown in table 2, contribute additional information on the utilization of the vitamin. Except for subject L.F., the cord blood of all women had a greater concentration of vitamin C than did blood taken from mothers and infants on the first day postpartum. In all but one instance (J.M.) blood vitamin C levels for both mother and child were lower on the tenth than on the first day postpartum, and the levels in the infant's blood were as high or higher than those in their mothers' blood. The cord blood values ranged from 0.4 to 2.2 mg vitamin C per 100 ml. The infant blood contained 0.2 to 2.2 mg and the maternal blood from 0.2 to 1.4 mg per 100 ml during the first 24 hours postpartum. These values are within the range given by other workers. On the tenth day postpartum the infant and maternal vitamin C blood serum concentration ranged from 0.4

TABLE 2

Blood serum vitamin C during the first 10 days postpartum. (mg/100 ml.)

SUBJECT	CORD	INTERVAL POSTPARTUM	MOTHER	CHILD
		days		
V.K.	1.3	1	0.6	1.0
		10	0.4	0.8
V.L.	2.2	1	0.6	0.7
		10	0.4	0.4
J.M.	0.4 [1]	1	0.2	0.2
		10	0.1	0.5
V.S.	1.5	1	0.3	1.0
		10	0.3	0.6
L.F.	1.6	1	1.4	2.2
		10	0.8	1.9
V.G.	..	1	1.3	2.2
		10	0.6	1.2
C.O.	1.5	1	0.7	..
		10	0.1	0.4

[1] Placental.

to 1.9 mg and from 0.1 to 0.8 mg, respectively. The values for cord, mothers' and infants' blood were within the ranges, respectively, found for 24 other healthy mothers and their infants during the first week of life (Hamil et al., '47).

The values in tables 1 and 2, supported by the values presented earlier (Hamil et al., '47) for vitamin C in cord and maternal blood during the first week postpartum, emphasize the inconclusiveness of determinations of vitamin C levels in either blood or urine, or both, as an index of nutritional status with respect to vitamin C during lactation. Among women receiving diets undoubtedly superior to those of most mothers during the puerperium, with appetite-inhibiting factors eliminated (coffee, tea, candy, etc.), vitamin C in the maternal blood and urine may be at levels generally considered to indicate scurvy (J.M.), yet not interfere with secretion of large volumes of milk containing ample amounts of the vitamin. Levels of vitamin C in the blood may also be low in subjects known to have been "saturated" before delivery (V.S.) although large amounts are being excreted in the urine. Recent work indicates that the ascorbic acid content of the white blood cells parallels the retention and may be a reliable index of total body concentration of ascorbic acid (Lowry et al., '47) in normal adults. Whether similar results would be obtained with nursing mothers is not known.

The variations in the vitamin C contents of milk, blood, and urine from healthy mothers receiving excellent diets containing 51 to 254 mg of vitamin C per day, determined under conditions as closely controlled as possible, indicate a wide range of normal, individual physiologic differences. Data obtained under the conditions of the study are not comparable to those procured with subjects receiving low intakes of vitamin C from inferior diets or high intakes from supplemental sources; nor can they be compared closely with results obtained with non-lactating women or those obtained with dietary intakes calculated from tables of food values. Further research is needed to clarify the influences exerted by the many factors involved in the vitamin C metabolism of pregnant and nursing women. Among these are the possibility of fetal synthesis of the vitamin, physiologic adjustment of the maternal body from conditions of pregnancy to those of lactation, including possible reorganization of the glands of internal secretion, the level of requirement for the vitamins as opposed to maximum level of storage (saturation), and differences in the requirements before pregnancy, during gestation, and the lactation period.

The intakes of vitamin C by 6 women during 13 5-day periods in which they were secreting mature milk, are given in table 3, with the volumes of milk secreted and urine excreted

TABLE 3

Daily vitamin C intakes, secretion in mature milk and excretion in urine.

SUBJECT	INTERVAL POSTPARTUM	VOLUME		VITAMIN C Daily total		
		Milk	Urine	Intake	Milk	Urine
	days	*ml*	*ml*	*mg*	*mg*	*mg*
V.G.	78	683	1663	178	36	4.8
	79	846	1359	112	44	4.3
	80	923	1419	70	51	5.4
	81	874	844	194	52	6.5
	82	913	1120	86	49	6.2
	161	759	989	94	39	5.4
	162	848	801	118	43	7.3
	163	912	813	75	46	5.8
	164	985	1005	130	46	8.2
	165	1000	1359	108	51	2.0
	239	610	853	136	48	61.2
	240	624	731	112	48	34.5
	241	661	736	84	50	43.2
	242	738	958	104	41	47.5
	243	772	770	72	54	33.4
	302	414	1350	189		39.2
	303	389	1068	140	30	33.4
	304	383	949	120	30	30.3
	305	389	1099	171	30	42.0
	306	394	933	96	27	23.0
V.K.	95	544	3072	115	36	10.6
	96	615	3443	106	39	11.2
	97	701	2587	91	45	6.9
	98	691	3206	139	44	10.4
	99	684	1710	61	44	8.3
	144	272	2739	132	22	12.8
	145	315	1286	136	26	11.5
	146	343	1476	180	29	13.3
	147	323	827	155	25	13.5
	148	372	907	121	28	10.6
V.L.	68	736	3408	180	49	10.4
	69	743	4154	140	46	11.8
	70	802	2838	195	53	12.8
	71	833	1903	175	49	6.8
	72	829	1940	120	51	10.5

TABLE 3 (*continued*)

SUBJECT	INTERVAL POSTPARTUM	VOLUME		VITAMIN C		
				Daily total		
		Milk	Urine	Intake	Milk	Urine
	days	*ml*	*ml*	*mg*	*mg*	*mg*
V.L.	152	684	2457	227	47	68.9
	153	671	1970	145	43	26.9
	154	673	1637	105	43	23.9
	155	686	1484	218	44	46.8
	156	686	1232	85	39	17.2
J.M.	75	598	2517	153	27	6.3
	76	677	2081	110	29	6.4
	77	740	2155	171	29	0.0
	78	742	2646	157	34	7.6
	79	783	1925	100	38	4.0
	173	205	2993	183	12	5.0
	174	231	1922	156	13	3.6
	175	296	2089	79	16	4.0
	176	301	1169	129	16	4.2
	177	309	1841	108	15	5.1
B.S.	204	864	1630	158	32	6.0
	205	927	1350	133	35	7.2
	206	918	1231	79	37	6.3
	207	938	1219	200	41	6.2
	208	918	1352	78	40	5.9
	259	734	1665	146	37	7.6
	260	612	1299	95	29	7.0
	261	631	1037	76	30	7.7
	262	725	979	166	34	4.8
	263	678	1113	89	36	7.8
V.S.	70	234	1897	315	23	141.3
	71	276	1846	202	29	78.4
	72	334	2308	200	31	75.1
	73	315	1938	275	30	118.3
	74	361	1269	148	32	48.7

per 24 hours and their contents of the vitamin. During 10 of the periods the mothers' volumes of milk were increased 54 to 241 ml per day as the result of regular and complete emptying of the breasts by manual expression (Macy, Hunscher, Donelson and Nims, '30). Also for some of the women there was an improvement of diet during the experimental periods. Although the diets for all 5-day periods were comparable, qualitatively, and appetites were satisfied by proportionate adjustment of all foods except milk, the vitamin C intakes as determined by analysis varied greatly owing to differences in concentration of the vitamin in the same foods. For example, V.L., J.M., and V.S. received diets of equal amounts, respectively, of the same foods (table 3). Calculated from the literature their average daily intakes of vitamin C during the 5-day periods ranged from 166 to 169 mg. The analyses for the different intervals of study averaged from 131 to 228 mg per day.

There were large differences in the vitamin C intakes for the 5 days of each study period owing to inclusion of foods with high contents of the vitamin in some of the menus. However, the concentration of vitamin C in mature milk was quite constant, averaging 5 mg per 100 ml (Munks et al., '45), and in general the daily secretion of the vitamin paralleled changes in milk volume. Although for the well-nourished mothers no direct relationship was found between the variable vitamin C intakes and the amount secreted in the 24-hour collections of milk, other work has shown vitamin C secretion to be generally dependent on diet (King, '38; Smith, '38; Escudero and Pierangeli, '43). Escurdero and Pierangeli have reported that with an intake of approximately 70 mg vitamin C per day from food during the last month of pregnancy and the colostral period, the colostrum averaged 2.2 mg % vitamin C. Women receiving 240 mg produced colostrum containing 5.5 mg per 100 ml. Selleg and King ('36) found that the relatively slow and limited rise in C value when patients received a special orange juice supplement provides an indication of a maximum and approximately optimum level of secretion, above which an excessive dietary intake results chiefly in a rapid urinary excretion without disturbing the lactation level. Such results emphasize the ample provision of vitamin C by the diets eaten by the nursing mothers in this study.

Levels of excretion in the 24-hour collection of urine were not related to differences in level of intake among the women of this study, nor to the vitamin C secretion in milk, again indicating that individual characteristics conditioned by prior nutritional status with respect to the vitamin were the major controlling factors. It has been shown that in addition to tissue saturation excretion of vitamin C in urine may be influenced by the individual's kidney threshold for the vitamin (Faulkner and Taylor, '38), by the fluid intake, and by environmental temperature and humidity (Shields and coworkers, '46) all of which were beyond the control of the present study. It is likely that other individual characteristics are involved, so it is not surprising to find wide variations in the urinary vitamin C among individuals and for the same individual at different times during lactation.

The concentrations of vitamin C in the blood serum of both the mothers and infants during the 5-day periods of mature milk production are given in table 4. The average values correspond for all determinations on mothers' blood during mature milk secretion (0.45 mg) and during the first 10 days postpartum (0.56), and the distributions are similar. The average of the values for the breast-fed infants when 2 to 10 months old (1.1 mg) approximates that for the first 10 days postpartum (1.0 mg). Fourteen of the samples from the mothers were obtained on the first days of study periods; 5 were obtained after the women had received the study diet for 5 days. The values for all 5 were the same or higher than those of the first days of study, respectively, attesting the adequacy of the study diet and perhaps indicating its superiority over their usual food intakes. However, this conclusion is precluded by the secretions in milk, the levels in the infants' blood, and by the excretions in the urine, especially those of V.S. who had been ingesting 100 mg of ascorbic acid per day with a good diet, prior to the study, who secreted milk with the highest concentration of the vitamin (10 mg per 100 ml), yet whose blood level on the first day (0.1 mg) was lower than any other value obtained and increased during the 5 days with an intake undoubtedly lower than that of her previous supplemented diet.

It is evident that milk secretion requires that the requisite substances be supplied through the blood, either from the products of digestion or from the tissues. The best estimates

TABLE 4

Blood serum vitamin C during mature milk secretion. (mg/100 ml.)

SUBJECT	INTERVAL POSTPARTUM	MOTHER	CHILD
	days		
V.G.	78	0.3	0.5
	161	0.2	1.7
	239	0.6	0.8
	244 [1]	1.0	
	302	0.2	1.1
	307 [1]	0.6	..
V.K.	95	0.8	3.0
	144	0.7	0.9
V.L.	68	0.3	1.5
	152	0.8	1.4
	157 [1]	0.8	..
J.M.	75	0.2	0.7
	172	0.2	0.6
	177 [1]	0.6	..
B.S.	85	0.2	1.0
	204	0.2	0.8
	259	0.4	0.6
V.S.	70	0.1	0.8
	75 [1]	0.4	..

[1] After receiving study diet for 5 days.

are that 400 to 500 volumes of blood are required to produce 1 volume of milk (Kay, '45). Obviously, withdrawal from the blood parallels the rate of secretion, which is determined by the fullness of the gland. It is likely that, for vitamin C at least, the blood level is more easily replenished from the supply provided by food than by mobilization from body stores.

Whether the level of the vitamin in the blood of nursing mothers changes rapidly in response to emptying of the breasts and also varies in relation to the intervals between meals is being investigated.

The net gain or loss of vitamin C to the body, estimated by subtraction of the values for urine and milk from the intakes, indicates the amount of the vitamin used in metabolism and stored in the tissues, or the deficit which has been withdrawn from the tissues. The quantity of vitamin C excreted through the skin would seem inappreciable, since recent work has shown that at comfortable temperatures the loss may amount to 0.8 mg daily and even under conditions of induced profuse sweating the quantity is only 2.7 mg per day (Shields, et al., '46). In the 10-day puerperium the total quantities of vitamin C consumed by V.K., V.L., J.M., and V.S. were 1079, 1354, 1499 and 1412 mg, respectively (table 1). During the same period the women secreted into their milk, totals of 476, 499, 538 and 475 mg of vitamin C. Their urine contained 120, 145, 64 and 250 mg, leaving for metabolic function and tissue storage 483, 710, 897 and 687 mg, respectively. There were wide individual variations among these 4 women as shown by the range of 113 to 205 mg per day which was unaccounted for immediately following recovery from the trauma of labor and delivery, about twice the 25 to 50 mg daily observed in persons in a state of saturation (King, '38). It is conceivable that during this recuperation period there are appreciable changes in the acid-base equilibrium of the body. This is supported by evidence that the quantity of vitamin excreted in the urine may be varied merely by changing the acid-base balance of the food intakes (Hawley and co-workers, '36).

Twenty-seven of 64 daily determinations with women secreting mature milk showed more than 90 mg per day unaccounted for on days when the intakes were high (table 3), which indicates, perhaps, that the mothers were not saturated and the amount was dependent on the intake. The greatest amount unaccounted for was 166 mg per day, opposed to a loss of 15.4 mg per day from the mother's tissue stores. During a 5-day study in the eighth month postpartum, V.G. had an average intake of 101.6 mg vitamin C and a secretion of 48.2 mg in the milk. These values are similar to those of the same woman when studied at 3 and 6 months, yet the excretion of vitamin C in the urine was 44 mg per day, over 8 times the average excretion during the earlier studies and leaving only 9.4 mg vitamin C per day unaccounted for. The blood serum vitamin C concentration was 0.6% on the first day of the study and increased to 1.0 mg % on the fifth day of the study (table 4). If the daily body requirement for vitamin C is 50 to 100 mg per day or if the mother's indispensable minimum requirement was 25 mg per day (King, '38) it is difficult to understand why she excreted an average of 44 mg vitamin C per day through the kidneys, unless she previously had a high vitamin C intake which continued to be excreted even after the intake was lowered. This phenomenon has been demonstrated by Harris, Ray and Ward ('33), Harris and Ray ('35) and Hess and Benjamin ('34), who found the urinary output to depend on both the immediate vitamin C intake and also on the post-nutritional history or state of "saturation."

When studied during the tenth month of lactation the same woman's average intake was 143.2 mg per day. The vitamin C excreted in the milk had dropped almost one-half, 29.2 mg per day, owing to decreased volume. Her urine excretion, 33.6 mg per day, still was higher than during the third and sixth months. The vitamin C unaccounted for had returned to the former range of 80 mg average per day. The need for this increased retention was shown by the blood serum concentration which was only 0.2 mg per 100 ml at the beginning of the study but increased to 0.6 by the fifth day (table 4).

A similar saturation was demonstrated by V.L. during her third and sixth months postpartum. The average intakes of vitamin C were 162 and 156 mg, secretion in the milk amounted to 49.6 and 43.2 mg, and the urine excretion averaged 10.5 and 36.7 mg of vitamin C per day, respectively. At the beginning of the study at 3 months the blood serum level was 0.3 mg per 100 ml but at the beginning of the 5-day study at 6 months, when she was throwing off greater amounts of vitamin C in urine, her blood level was 0.8 mg of vitamin C per 100 ml. Large vitamin C excretions may occur even when the blood serum vitamin C is low, if the dietary intake is high. For example, V.S. in the third month of lactation excreted 92.4 mg of vitamin C per day, yet she had a blood serum level of only 0.1 mg % vitamin C on the first day of the study. Her average dietary intake was 228.0 mg vitamin C over the 5-day period and was the highest average intake during any 5-day study.

The amount of vitamin C which appears in the urine is also affected by the way in which the daily intake is distributed within the 24 hours. Widenbauer and Kühner ('37) and Ralli, Friedman and Sherry ('39) have emphasized the importance of dividing the intake into small doses throughout the day. Todhunter and Robbins ('40) have estimated the minimum daily intake of vitamin C required to maintain the tissues in a state of complete saturation to be 1.6 to 1.7 mg per kg of body weight per day for college women. Ralli, Friedman and Sherry ('39) concluded from their experiments that 100 mg per day be suggested as the requirement of women for saturation. With the exception of a woman who weighed 73.5 kg, the daily requirement of the lactating women in this study would have been 100 mg per day or less by this criterion. If one adds the amounts of vitamin C secreted in milk to the amounts calculated from their weights to be the mother's requirements, one obtains an estimated daily requirement for lactating women ranging from 106.8 to 174.1 mg of vitamin C per day. During the first 10 days postpartum the vitamin C intakes of 2 women met the estimated dietary requirement. For the woman who weighed 73.5 kg the estimated requirement was greater than the average daily intake during the first 10 days postpartum. During the third month of lactation the diet supplied this theoretical requirement for saturation in 3 of 5 women.

One of the lowest blood values, 0.1 mg vitamin C per 100 ml, was recorded for a woman who secreted the highest concentration of vitamin C in milk, 10 mg per 100 ml. Other women having blood serum values up to 0.8 mg per 100 ml did not secrete as great concentrations of vitamin C in the milk. One, V.G., was known to secrete over 7 mg per 100 ml in her milk when her blood serum vitamin C ranged anywhere from 0.2 to 1.3 mg per 100 ml. These data confirm the observation of Ingalls, Draper and Teel ('38) that there is no direct correlation between the blood serum vitamin C and the concentration in the milk. However, they state that "the fact that mothers on a diet relatively low in vitamin C will secrete in the milk amounts of ascorbic acid so large that the ascorbic acid content of the infant's plasma is higher than that of the mother's is indicative of an interesting biologic mechanism whereby the child receives the vitamin at the expense of its mother." For the lactating mother and the breast-fed infant vitamin C levels in the blood, as well as in urine, may be closely correlated with eating time. In this study blood samples were taken following collection of milk and urine at 6:00 A. M. It is possible that the low values for the mother's blood were the result of the demands for milk production during the preceding 12 hours of fasting. If this is correct then the supply in the blood would be replenished immediately after eating breakfast and the low fasting values would not indicate that the child receives vitamin C "at the expense of the mother."

Until requirements can be more clearly distinguished from "storage" or "saturation," it is obvious that for the physician nutrition during the nursing period is a problem similar to that stated for pregnancy by Lund ('45): ". . . the problem is the dietary needs of each patient. She is not to be treated according to the nutritional standards of any other person or groups of persons. She is an individual problem and it is the physician's duty to take a short, accurate dietary history and to see that he or some other qualified person explains to her the dietary problems of pregnancy." From the present study it seems that the Recommended Dietary Allowances ('45) of the Food and Nutrition Board of the National Research Council provide for adequate amounts of vitamin C to meet normal requirements during lactation and prevent depletion of body stores, provided during pregnancy the nutritional status of the mother has been adequate with respect to the vitamin.

SUMMARY

Vitamin C was determined by analysis in the food as eaten each day by healthy nursing mothers and in 24-hour collections of their milk and urine during the first 10 days postpartum and 5-day periods at intervals later in lactation. In addition, vitamin C was determined in blood from the umbilical cord and in fasting samples of capillary blood from the mothers and infants.

The amounts of vitamin C secreted in milk paralleled the increases in milk volume, while vitamin C excretion in the urine was high after delivery and for 3 or 4 mothers decreased 50% or more by the tenth day. No relationships between volume of milk or its vitamin C content and excretion in the urine were indicated.

During the periods of secretion of mature milk, the amounts of vitamin C in the milk, in general, paralleled milk volume. For the mothers studied, whose nutritional status had been good during pregnancy, no relationship was found between vitamin C intake and secretion in milk. Excretion in urine was not related to level of intake or secretion in milk.

Extreme anatomic and physiologic variability among individuals and in the same individual at different times is emphasized by the results. The data indicate also the inconclusiveness of determinations of vitamin C levels in milk, urine or fasting blood samples as an index of vitamin C nutritional status of lactating women receiving good diets. The need for further research on the physiologic influences exerted by lactation and pregnancy on vitamin C metabolism is stressed. These include adjustment of the maternal body from pregnancy to lactation, including the glands of internal secretion, the level of requirement as opposed to maximum level of storage, and differences in requirements before pregnancy,

during gestation, and during lactation. On the basis of the data presented it seems that the Recommended Dietary Allowances provide for adequate amounts of vitamin C to meet normal requirements during lactation, provided the prenatal nutritional status of the mother has been satisfactory.

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