CHOLESTEROL IN HUMAN MILK

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INTRODUCTION

Cholesterol occurs in human milk as a result of the nature of the lactation process (1,2). When the fat globule is extruded from the mammary cell, it is enveloped by membranes from the endoplasmic reticulum of the cell. The membranes contain cholesterol and are the source of most of the cholesterol in milk. About 15% of the cholesterol is esterified as these compounds are nonpolar, they are found in the hydrophobic core of the fat globule. Cholesterol, relatively hydrophylic because of the free hydroxyl group, is found in the membrane enveloping the globule.

Cholesterol is the precursor of sex hormones, bile acids and vitamin D-3 and is found usually in the membranes of virtually every cell in the body. It is synthesized in the body in addition to the dietary source. High levels of cholesterol in plasma and hence in the diet have been associated with increased risk of atherosclerosis. It has been hypothesized that the "high" quantities of cholesterol in human milk when consumed by the infant might potentiate against the progression of atherosclerosis in adulthood. This is the cholesterol challenge hypothesis and is discussed by the Hamoshs in this volume (3). I will briefly describe this and other nutritional aspects, ie. does the infant need the cholesterol in human milk?

METHODS OF ANALYSIS

Methods which have been used for analyses of cholesterol in human milk are precipitation with digitonin and gravimetry, colorimetry, chromatographic, and enzymatic procedures. However, a useful colorimetric determination, employing o-phthalaldehyde, has been used to determine cholesterol in human milk (4). The milk is saponified directly and the cholesterol extracted with hexane for analysis. This is the best method currently available for routine analysis of cholesterol in human milk since the only instrument needed is a colorimeter. For research purposes, gas (5) and high performance liquid (6) chromatographic procedures are preferred since the traces of sterols other than cholesterol will be detected.

A. S. Goldman et al. (eds.), *Human Lactation 3*

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A range of contents obtained by reliable methods is 10-20 mg of total cholesterol per dl. With a fat content of 4%, these amounts become 250 to 500 mg/100g of fat. Assuming a 24hr milk volume of 800 ml, the infant can consume 80 to 160 mg of cholesterol per day. The lower fat content and volume of colostrum is somewhat compensated by a greater amount of cholesterol per day (7). In contrast, most infant formulas do not contain cholesterol but will have varying amounts of phytosterols.

FACTORS AFFECTING CONTENTS

These are primarily stage-of-lactation and diurnal patterns, both related to changes in fat content and basically, the total surface area of the fat globules. Bitman (7) observed a continual decline in cholesterol from 1.3% of total lipids at day 3 postpartum to 0.4 at day 84 in milks from term and preterm mothers. This was accompanied by an increase in both volume and fat content of the milk. Increases in cholesterol content during the day are due to rises in the fat content (8).

Claims that diet influences the cholesterol content of milk are not supported by any published data (9). Reports that the phytosterol content of milk is raised by consumption of more of these sterols in the diet have not been confirmed (6,10,11). It appears that the identifications were wrong, and, without doubt, sampling was uncontrolled (10). Traces of desmosterol and other sterols have been detected (6,11).

Another potential, and as yet unconfirmed source of variation, is the various lotions that many women apply to their nipples during the time they are breastfeeding. Some of these contain cholesterol, lanosterol and many other lipids and could be the cause of erroneous results. A lump of ointment containing 10 mg of cholesterol entrained into a 50 ml sample of milk, would add 20 mg/dl of the sterol to the milk when analyzed. Investigators should take the obvious measures to exclude those contaminants.

NUTRITIONAL ASPECTS

Cholesterol is a ubiquitous component in almost all cells in the body where it is found mostly in the membranes. The sterol is the precursor of bile acids, sex hormones and vitamin D-3; the latter occuring in skin as a result of exposure to ultraviolet radiation in sunlight. It is also involved in the myelinization of cells in the developing brain and nervous system. In membranes, it provides rigidity in association with phospholipids. The major questions to be considered are can the infant synthesize sufficient cholesterol to provide for its requirements and does dietary cholesterol at this stage in life potentiate the body to process cholesterol more efficiently later? Implicit in the last question is the possible relationship of the exposure of infants to dietary cholesterol and the development of atherosclerosis.

In an attempt to answer these questions, we must know how much cholesterol is consumed by the nursing infant. In colostrum, the total amount is low because of the small volume of milk available although the cholesterol content is relatively high. Even though we do not have data on the cholesterol contents of pooled mature 24 hr milks, we can approximate the quantity of cholesterol in these samples. If we arbitrarily select an amount of 400 mg cholesterol/100g fat and use 800 ml of milk x 4.5% fat we have 36g of fat and 144 mg of cholesterol (1,2,9). This figure is high because the "average" fat content of human milk is 3.0-4.0%.