Intestinal absorption of polyenephosphatidylcholine in man

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Abstract The metabolic fate of 1 g of $^{3}H/^{14}C$-labeled dilinoleoglycerophosphocholine was studied in five patients after oral administration. The ^{3}H label was in choline and ^{14}C was in the two linoleic acid residues. More than 90% of both isotopes was absorbed from the intestine. Seventy to 90% of the ^{3}H radioactivity in blood was linked to phosphatidylcholine (PC) whereas ^{14}C was associated with both PC and nonpolar lipids. At peak activity, the $^{3}H/^{14}C$ ratio of plasma PC was twice that of oral PC; this suggests that most oral PC was hydrolyzed to lysolecithin before absorption. The mean maximum concentration in total blood volume was 20% of the administered dose for ^{3}H and 28% for ^{14}C. Examination of lipoproteins revealed that the specific activity of PC in high density lipoprotein (HDL) was 2 to 6 times higher than in apoB-containing lipoproteins, and 2 to 20 times than that of red blood cells or total blood. Thus, absorbed PC seemingly was incorporated preferentially into the HDL fraction of plasma.—**Zierenberg, O., and S. M. Grundy.** Intestinal absorption of polyenephosphatidylcholine in man. *J. Lipid Res.* 1982. **23:** 1136–1142.

Supplementary key words phosphatidylcholine absorption • pharmacokinetics • PC incorporation into lipoproteins

Lecithin, phosphatidylcholine (PC), can enter the upper small intestine in either the diet or bile. In contrast to triglycerides (TG), absorption of PC has not been studied extensively. PC is known to be hydrolyzed in the intestinal lumen by phospholipase to lysolecithin, and the latter can be taken up by the intestinal lumen. Studies in rats (1) have shown that lysolecithin can be reesterified in the intestinal mucosa and absorbed in lymph chylomicrons; this work suggests that about 50% of orally administered PC is absorbed as lysolecithin, where another 50% is degraded to glycerophosphocholine (GPC) or phosphorylcholine and is taken up via the portal vein. Other studies in animals (2–4) also suggest that up to 20% of intact PC may be absorbed. The fate of newly absorbed PC has been examined previously in various experimental animals (1–4), and apparently it is incorporated "preferentially" into HDL-PC.

The present study was performed to examine the pathways of PC absorption in man. To accomplish this, PC labeled in both its fatty acids with ^{14}C and in its choline moiety with ^{3}H were given orally, and radioactivity was followed sequentially in total blood in five patients and in lipoprotein fractions in three patients. The results indicated that significant portions of lysolecithin or GPC were reesterified in the intestinal mucosa and reentered the blood stream as PC. Although PC in both lipoproteins and red blood cells (RBC) became labeled, a major portion of radioactivity appeared to enter high density lipoproteins (HDL). Our findings therefore suggest that the fate of PC in man closely resembles that reported in several animal species.

METHODS

Labeled phosphatidylcholine

Di-[1′-^{14}C]linoleoyl-3-*sn*-glycerophosphocholine (^{14}C-PC) (sp act 8 mCi/mmol) and diacylglycerophospho-N-($C^{3}H_{3}$)-choline (sp act 60 mCi/mmol) was synthesized in our laboratory according to established procedures (5, 6). The latter was synthesized from polyenephosphatidylcholine (PPC, purified soybean lecithin, Nattermann, Cologne); PPC contains greater than 80% of the acyl groups as linoleic acid. It was labeled in the choline moiety by exchange of an unlabeled methyl group for a ^{3}H-labeled methyl group according to Stoffel, Lekim, and Tschung (5). Radiochemical purity was checked by radio TLC and was greater than 98% pure. One hundred fifty μCi of ^{3}H-PPC and 50 μCi of ^{14}C-PC were mixed with 1 g of PPC, and 350 mg of the

Abbreviations: PPC, polyenephosphatidylcholine; PC, phosphatidylcholine; SPM, sphingomyelin; GPC, glycerophosphocholine; TG, triglyceride; DG, diglyceride; CE, cholesteryl ester; FFA, free fatty acids; VLDL, very low density lipoprotein; LDL, low density lipoprotein; HDL, high density lipoprotein; RBC, red blood cells; TLC, thin-layer chromatography.

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TABLE 1. Clinical data

Patients	Sex	Age	Body Weight	Plasma Triglycerides	Plasma Cholesterol			
					Total	VLDL	LDL	HDL
		yr	*kg*	*mg/dl*	*mg/dl*			
BC	F	59	77	378	323	65	225	33
RR	M	53	130	178	226	32	159	35
WV	M	59	81	289	303	65	192	46
RK	M	56	79	411	269	55	138	76
LD	M	59	98	149	276	24	214	38

labeled mixture was filled into each hard-gelatin capsule for administration to patients.

Patients

Five patients were hospitalized throughout the study in the Special Diagnostic and Treatment Unit (metabolic ward) of the Veterans Administration Medical Center, San Diego. Their sex, age, weight, and concentrations of plasma lipids and lipoprotein-cholesterol are shown in **Table 1**. All of the patients had normal gastrointestinal function. Four of the five had moderate elevations in their plasma TG. All gave informed consent to the study.

Pharmacokinetics of PC absorption into blood

Each patient received three capsules of labeled lecithin (1 g of PC, containing 150 μCi of ^{3}H-PPC and 50 μCi of ^{14}C-PC) after an overnight fast. This was followed by a normal breakfast containing approximately 20 g of fat. Ten ml of blood was drawn at 1, 2, 3, 4, 6, 8, 12, 24, 48, 72, and 96 hr. Sodium EDTA (14 mg/10 ml blood) was used as an anticoagulant. The blood was immediately extracted with 190 ml of isopropanol at 4°C for 2 hr. The mixture was centrifuged at 3,000 rpm for 15 min. The supernatant was removed and evaporated, and the final residue was dissolved in 2 ml of toluene. Seven hundred μl of the dissolved residue was counted in a Searle Mark III Liquid Scintillation System using a Triton-containing scintillation solution. Losses of lipids during extraction of blood were corrected in the following way. Eighty μl of each blood sample was injected into 1 ml of chloroform–methanol 2:1 (v/v), mixed thoroughly, and left at room temperature for at least 24 hr. Five hundred μl of each chloroform–methanol extract was subjected to TLC; the PC band was scraped off, and its phosphorus content was determined. The PC concentration in 30 μl of the isopropanol extract was also measured. Comparison of the two data allowed calculation of the isopropanol yield of the extraction procedure. This was usually between 60 and 90%. The radioactivity data were corrected by this factor.

Radioactivity absorbed into the total blood volume was estimated using the corrected radioactivity data of the blood extracts. Total blood volume was calculated from the hematocrit and plasma volume; the latter was estimated as described previously (7).

Distribution of radioactivity between blood lipoproteins

From some patients 20 ml of additional blood was drawn after 6, 8, 12, and 24 hr. Plasma was isolated after centrifugation (2,500 rpm, 15 min, 4°C) in a Sorvall centrifuge RC-5B. The plasma was treated with Mn^{2+}/heparin to precipitate lipoproteins (VLDL, LDL, chylomicrons) containing apoB as described in the Lipid Research Clinics Manual of Laboratory Operations (8). Hyperlipidemic plasma was diluted with saline 1:1 (v/v) to obtain an optimal precipitation. The time between drawing of blood and precipitation of the apoB lipoproteins was less than 30 min. The precipitate was centrifuged into a pellet, homogenized with 5 ml of saline and extracted with 100 ml of chloroform–methanol 2:1 (v/v) overnight at 4°C. The supernatant from the heparin/Mn^{2+} precipitation was extracted with 190 ml of chloroform–methanol 2:1 using the same procedure. Both extracts were evaporated, and residues were dissolved in 2 ml of chloroform–methanol 2:1. Seven hundred μl of each extract was counted for radioactivity.

For one patient (L.D.) the blood coagula from the initial separation also was extracted. Comparison of radioactivity in coagula and different plasma lipoprotein fractions allowed calculation of distribution of radioactivity between plasma and coagula.

Distribution of radioactivity between blood and lipoprotein lipids

Three hundred μl of each isopropanol blood extract and 300 μl of each lipoprotein extract were separated in a single direction on TLC plates (LK 6F, Whatman) using the solvent system chloroform–methanol–water 65:25:4 (v/v/v). Lipids (PC, lysolecithin, sphingomyelin, phosphatidylethanolamine, triglyceride, cholesteryl esters, and free fatty acids) were detected after separation by exposure of the plates to iodine vapor. The areas were scraped off, extracted with scintillation cocktail, and counted. In addition to radioactivity distribution between the lipids, the ^{3}H/^{14}C-ratio of the PC fraction was obtained. To exclude the possibility that silica gel might alter the ^{3}H/^{14}C-ratio of PC, standards of the administered ^{3}H/^{14}C-PPC also were applied to TLC, and radioactivity was measured. There was no difference in the ^{3}H/^{14}C-ratio for the standard before and after the TLC.

Determination of the specific activity of the PC in blood and lipoprotein extracts

Specific activities of blood PC fractions were calculated using the PC concentrations and radioactivity measurements of the blood extracts corrected for the percentage of blood radioactivity in the PC fraction. About 800 μl of each of the lipoprotein extracts was separated by TLC. PC was scraped off and eluted with chloroform–methanol 2:1. Phosphorus concentrations and radioactivities were determined in aliquots of the PC eluate. Phosphorus was determined according to the method of Rouser, Fleischer, and Yamamoto (9).

Analysis of urine and feces

Stools were obtained from all patients for 7 days. Each sample was homogenized after dilution with water. Aliquots (2 g) were extracted with 20 ml of chloroform–methanol 2:1 at 60°C overnight. The extracts were dried under a stream of nitrogen, subjected to hydrogen peroxide oxidation overnight at 60°C, and subsequently counted after dissolving the residue with scintillation cocktail. Urine also was collected daily for 7 days. The radioactivity was measured using the extraction-oxidation method described for the feces.

RESULTS

Excretion of oral PC and its metabolites

Excretions of radioactivity in feces were measured over a period of 7 days after oral administration of ^{3}H- and ^{14}C-PC. The average excretions of ^{3}H and ^{14}C in feces were 2 ± 0.7% and 4.5 ± 1.5%, respectively, of the administered doses; thus, over 90% of PC or its metabolites disappeared during intestinal transit. Also, 6 ± 0.8% of ^{3}H from the choline moiety was excreted as $^{3}H_2O$ or water-soluble metabolites in urine over 7 days; only trivial amounts (1.2 ± 0.4%) of ^{14}C appeared in urine.

Appearance of PC and metabolites in blood

The pharmacokinetics of $^{3}H/^{14}C$-PC are shown in **Fig. 1**. After a lag time of approximately 2 hr, labeled lipids could be measured in blood. In four or five pa-

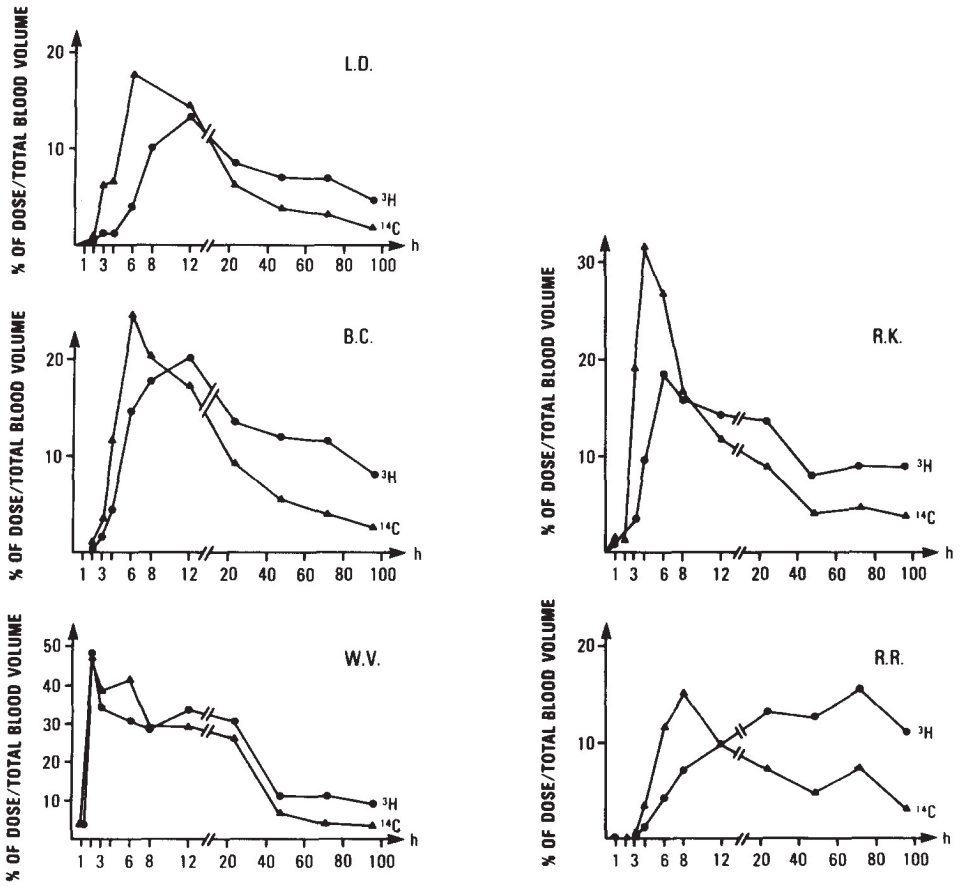

Fig. 1. Absorption kinetics of ^{3}H (●·●·●) and ^{14}C (▲·▲·▲) following oral ingestion of $^{3}H/^{14}C$ PC. Percent dose per total blood volume is plotted against time (hr).

TABLE 2. Distribution of radioactivity among blood lipids after PC administration[a]

Hr	Lysolecithin + Sphingomyelin		PC		TG + CE		
	^3H	^{14}C	^3H	^{14}C	^3H	^{14}C	$^3H/^{14}C$ of PC
			%[b]				ratio[c]
4	8 ± 3	2 ± 1	80 ± 10	24 ± 16	4 ± 2	68 ± 16	4.5 ± 0.9
6	6 ± 2	2 ± 1	78 ± 8	22 ± 7	4 ± 2	72 ± 7	6.4 ± 1.2
8	7 ± 2	2 ± 1	84 ± 5	30 ± 6	3 ± 1	66 ± 6	6.9 ± 0.4
12	11 ± 4	4 ± 2	82 ± 5	37 ± 6	2 ± 1	55 ± 6	7.7 ± 0.8
24	10 ± 1	2 ± 1	86 ± 3	39 ± 8	1 ± 1	54 ± 8	10.3 ± 2.0
48	13 ± 2	2 ± 1	82 ± 2	23 ± 3	1 ± 0	71 ± 5	21.9 ± 5.2
72	13 ± 3	2 ± 2	79 ± 3	24 ± 7	2 ± 1	71 ± 7	25.0 ± 4.0
96	20 ± 2	5 ± 3	74 ± 2	23 ± 6	3 ± 1	70 ± 6	28.1 ± 3.9

[a] Mean of five patients ±SEM.
[b] Percent of total blood radioactivity.
[c] PC administered: $^3H/^{14}C$ ratio: 3.5.

tients the peak of ^{14}C was reached earlier than that of ^3H; the ^{14}C maximum was between 4 and 12 hr, and ^3H peaked between 6 and 24 hr. At the peak of radioactivity in total blood, activity of ^3H was 19.9 ± 3.9% (SEM) of the given dose and ^{14}C was 27.9 ± 4.4%. The half-life of decay in radioactivity between 24 and 96 hr averaged 65.7 ± 8.1 hr (±SEM) for ^3H and 31.6 ± 9.8 hr for ^{14}C (not using data from patient R.R.). The elimination of the ^3H-label from blood can be described by an open one-compartment model in all five patients.

Radioactivity distribution in blood

Distribution of radioactivity between plasma and RBC at 24 hr was measured in patient L.D. For both isotopes, about three-fourths of the radioactivity (75% for ^3H and 77% for ^{14}C) was in plasma with only about one-fourth in RBC. In contrast, the plasma contained only 54% of total PC of blood. Thus, there appeared to be an unequal distribution of radioactivity between PC in plasma and RBC.

Table 2 presents the mean distribution of radioactivity among the different lipids of whole blood for all patients at various time intervals. Since RBC are almost devoid of TG and cholesteryl ester (CE), radioactivity in these lipids must have been confined almost entirely to plasma lipoproteins. For phospholipids, on the other hand, radioactivity would be distributed between plasma lipoproteins and RBC. As shown in Table 2, 70–85% of ^3H radioactivity was in PC throughout the entire study. At the end of the study, the percentage activity was greater in lysolecithin + sphingomyelin than near the beginning. Very little ^3H radioactivity was found in TG or CE. At 4 hr, approximately 70% of ^{14}C radioactivity was in nonpolar lipids (TG + CE); this percentage decreased to 50–60% at the peak of activity (8–24 hr), but it increased again when PC was metabolized over the next 4 days. Almost all ^{14}C not in TG + CE was found in PC. The patterns for $^3H/^{14}C$-ratios in total blood PC were essentially the same in all five patients. During the first 4 hr, ratios were only slightly above those of the administered PC, but they increased progressively thereafter. In four of five patients the $^3H/^{14}C$ ratio at the peak of radioactivity was nearly twice that of the oral PC (**Table 3**).

Radioactivity in plasma lipoproteins

To determine the distribution of radioactivity between HDL and apoB-containing lipoproteins, heparin-Mn^{2+} precipitation was carried out immediately after obtaining blood samples in three patients (W.V., R.K., and L.D.). Since separations were done rapidly, isotope exchange was assumed to be small. Data for these patients are presented in **Table 4**. In patients W.V. and R.K., more than half the ^3H activity was found in HDL, and in patient L.D., approximately 40% was in HDL. In contrast to results for ^3H, most of the ^{14}C activity, which was derived from the fatty acids of PC, was found in lipoproteins containing apoB.

Table 5 shows the distribution of radioactivity among lipid fractions of HDL and apoB-containing fractions in patient L.D. While most of ^{14}C radioactivity was associated with nonpolar lipids (CE and TG) in apoB-containing lipoproteins, the PC of HDL had a much greater

TABLE 3. $^3H/^{14}C$ ratio of PC fraction in blood (at peak maxima of ^3H)

Subject	$^3H/^{14}C$ PC (blood)	$^3H/^{14}C$ PC (administered)
BC	8.6	3.6
RR	14.9	3.6
WV	5.7	3.2
RK	5.5	3.5
LD	6.9	3.5

TABLE 4. Distribution of radioactivity among serum lipoproteins

Patient	Hr	^3H HDL	^3H LDL, VLDL, chylos	^{14}C HDL	^{14}C LDL, VLDL, chylos
			%		
WV	6	56	44	32	68
	8	63	37	10	90
	12	64	36	15	85
	24	54	46	18	82
RK	6	68	32	11	89
	8	80	20	26	74
	12	62	38	29	71
LD	8	37	63	13	87
	12	37	63	22	78
	24	37	63	25	75

fraction of ^{14}C than did other lipid fractions. On the other hand, almost all ^3H radioactivity was associated with PC of each lipoprotein. In addition, no difference was found in the $^3H/^{14}C$-ratio between HDL and other lipoproteins.

Specific activity of PC in lipoproteins and blood

In two patients, specific activities of PC were measured in lipoprotein fractions as well as in total blood (**Table 6**). In R.K., the 6-hr activity of PC in HDL was about 30% of the administered dose. It was not measured at 6 hr in L.D. In both patients specific activities at 8 hr had declined to 7–13%, and to 2–7% after 12 hr. In most plasma samples the ^3H and ^{14}C activities were much higher in HDL than in the apoB-containing lipoproteins.

The specific activity of PC in total blood was calculated in a different way by using total radioactivity in blood, radioactivity distribution between lipids, and PC concentration in the blood extract. For this reason numerical data may not be as accurate as specific activities of lipoprotein fractions. Nevertheless, they can be used for comparison of specific activities between lipoprotein and total blood. The activity was much higher in lipoproteins than in total blood. Hence incorporation of labeled PC into lipoproteins, especially HDL, occurred preferentially to RBC. This was shown by analysis of ^3H specific activities of PC in apoB-containing lipoproteins, in HDL, and in the blood pellet of the same blood sample (L.D., 24 hr). Even 24 hr after PC intake, the specific activity was still slightly higher in HDL (1.5×10^3 dpm $^3H/\mu$mol PC) than in apoB lipoproteins, (1.3×10^3 dpm $^3H/\mu$mol PC), and 2.5 times higher in lipoproteins than in RBC (6.1×10^2 dpm $^3H/\mu$mol PC).

DISCUSSION

The purpose of this study was to determine the fate of oral PC in man. Previous studies in animals suggest that a small portion of oral PC can be taken up intact (2–4), but the remainder is partially or completely degraded. At least 50% of the latter fraction appears to be absorbed in PC produced by reesterification of intestinal lysolecithin (1). The current study employed PC labeled with ^3H in choline and ^{14}C in two fatty acid residues to trace the appearance of radioactivity into the blood stream. From the resultant isotopic curves it should be possible to define grossly the pathways and fate of oral PC.

In the current study, a large portion of the radioactivity from labeled oral PC appeared in PC of plasma lipoproteins and RBC. At the peak of blood radioactivity, about 20% of the total administered dose of ^3H-PC was in the blood stream, yet this is the minimum amount of blood PC derived from oral PC. The total likely was 2–3 times greater, but because of exchange and recycling, an accurate estimate could not be made. Some labeled PC in plasma lipoproteins must have exchanged with PC of cells; about 25% of ^3H counts in blood was

TABLE 5. Radioactivity distribution between lipid fraction of HDL and apoB-containing fractions (Patient LD)

Lipoprotein	Hr	Lysolecithin + SPM ^3H	Lysolecithin + SPM ^{14}C	PC ^3H	PC ^{14}C	TG, CE, FFA, DG ^3H	TG, CE, FFA, DG ^{14}C	$^3H/^{14}C$ of PC
				%				*ratio*
HDL	8	21	11	65	46	3	29	5.1
B-LP[a]	8	7	2	88	15	2	81	5.8
HDL	12	24	12	70	50	1	33	7.0
B-LP	12	34	12	50	15	2	61	7.5
HDL	24	20	19	73	34	1	38	10.6
B-LP	24	12	3	82	28	2	64	11.5

[a] B-LP = apoB-containing lipoproteins (LDL, VLDL, and chylomicrons).

with RBC, and more PC likely was lost to other tissues through exchange (or transfer). Thus, the primary fate of the "backbone" of oral PC seemingly is new mucosal PC for transport into plasma.

There are three possible mechanisms by which oral PC might give rise to plasma PC: *a*) oral PC could be hydrolyzed to lysolecithin in the gut lumen and resynthesized into PC in the mucosa; *b*) it could be hydrolyzed to glycerophosphocholine or phosphocholine with resynthesis to PC; and *c*) it could be absorbed intact. Since oral PC had ^{14}C in both fatty acids and ^{3}H in choline, these mechanisms should be distinguishable. First, if the $^{3}H/^{14}C$ ratio in oral and plasma PC were identical, oral PC would have been absorbed intact; second, a doubling of the ratio would denote hydrolysis of oral PC to lysolecithin and resynthesis of PC with one unlabeled fatty acid; and third, complete absence of ^{14}C from blood PC would signify loss of both fatty acids.

For 4 hr after the oral dose, the $^{3}H/^{14}C$-ratio in blood PC was somewhat less than twice that of the administered dose. This is compatible with some (but certainly not all) PC being absorbed without hydrolysis to lysolecithin. Nevertheless, ^{14}C fatty acids released by hydrolysis in the gut could have been reesterified to lysolecithin in the mucosa, falsely suggesting absorption of some intact PC.

At maximum PC radioactivity in blood, the $^{3}H/^{14}C$ ratio was approximately twice that given by mouth. This is consistent with reesterification of most lysolecithin with an unlabeled fatty acid. The lack of a higher ratio at this time implies that esterification of glycerophosphocholine with two unlabeled fatty acids was not a significant source of plasma PC.

Although oral PC definitely enters the plasma as PC via the lysolecithin pathway, the fate of all PC taken by mouth could not be measured. If some PC were degraded to glycerophosphocholine and not reesterified to PC, or if some lysolecithin were absorbed directly into the portal vein, these would have gone unobserved. The latter two mechanisms are consistent with the previous finding of Beil and Grundy (10) that the rise in plasma TG following oral administration of large amounts of PC was much less than when an equal quantity of fatty acids was fed as TG.

Biliary and dietary PC can compete equally for lymph chylomicron surface components. This was demonstrated for example by Tso et al. (11, 12) using biliary fistula rats. In addition, Mansbach (13) proposed that exogenously infused PC inhibits intestinal PC synthesis from CDP-choline. Therefore, when PC was infused, the PC synthesized via the lysolecithin pathway was incorporated mainly into lymph chylomicrons; when it was not infused, PC, synthesized via the CDP-choline pathway, made the major contribution to chylomicron-PC. Our data do not exclude the latter pathway, because a minor part of the administered PC could have been hydrolyzed to ^{3}H-labeled phosphocholine and used for PC biosynthesis again.

The route of entry of intact PC from the intestine might be considered briefly. The study of Beil and Grundy (10) showed that a significant quantity of PC was secreted with small chylomicrons (or intestinal VLDL). The fate of chylomicron-PC remains to be determined fully. As far as is known, PC is not hydrolyzed by lipoprotein lipase during lipolysis of chylomicron-TG. Still, hepatic triglyceride lipase has phospholipase activity and perhaps can degrade some chylomicron-PC. A striking finding of our study was the large fraction of ^{3}H counts found in HDL. Early, specific activity of PC was much higher in HDL than in apoB-containing lipoproteins or RBC; the same results have been obtained in animals (14). Apparently, chylomicron-PC is shunted to HDL before exchanging with other lipoproteins and RBC. This finding supports the hypothesis

TABLE 6. Specific activity of PC of lipoproteins and blood

		Lipoproteins				
Patient	Hr	HDL	LDL, VLDL, chylos	HDL	LDL, VLDL, chylos	Blood
		dpm ^{3}H/μmol PC		*dpm ^{14}C/μmol PC*		*dpm ^{3}H/μmol PC*
RK	6	8.6×10^{4}	2.6×10^{4}	25.0×10^{3}	5.1×10^{3}	1.9×10^{3}
	8	4.0×10^{4}	3.6×10^{4}	7.2×10^{3}	3.1×10^{3}	1.8×10^{3}
	12	2.1×10^{4}	1.3×10^{4}	2.6×10^{3}	1.4×10^{3}	1.9×10^{3}
	24	1.5×10^{4}	1.1×10^{4}	1.0×10^{3}	0.7×10^{3}	1.5×10^{3}
LD	6		1.6×10^{3}		5.2×10^{2}	4.0×10^{2}
	8	19.0×10^{3}	3.1×10^{3}	170.0×10^{2}	9.4×10^{2}	1.2×10^{3}
	12	6.5×10^{3}	3.8×10^{3}	29.0×10^{2}	8.6×10^{2}	2.0×10^{3}
	24		3.7×10^{3}		5.5×10^{2}	1.6×10^{3}
Oral PC		2.9×10^{5}		8.3×10^{4}		

that chylomicron surface components (i.e., PC, cholesterol, and apoproteins) contribute to HDL (15). Although high specific activities of HDL-PC probably reflect transfer from chylomicron-PC, direct secretion of labeled, nascent HDL by the intestine also may have contributed (16).

Finally, we might inquire about the later fate of the orally-administered radioactivity. Clearly, a portion of ^{14}C-labeled fatty acids was not absorbed as PC, but rather as TG or CE. The labeling of these lipids, of course, reflects hydrolysis of ^{14}C fatty acids from PC. However, another source of ^{14}C-labeled CE could be the reaction of unesterified cholesterol with labeled PC mediated by lecithin:cholesterol acyltransferase. It is likely that HDL-PC was transferred (possibly through exchange) to the apoB-containing lipoproteins because $^{3}H/^{14}C$-ratios were identical between PC in HDL and apoB-rich lipoproteins. Finally, some recycling of glycerophosphocholine was evident from the progressive rise in $^{3}H/^{14}C$-ratio and increase in ^{3}H-labeled sphingomyelin later in the study.

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