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Abstract

The transfer across the swine uterus and placenta of [1-14C] octanoic acid, [9,10(n)- H] palmitic acid, and [1- 14C] linoleic acid was studied in five gilts and their fetuses during late gestation, following a single bolus injection. Only trace amounts of labeled fatty acids were found in fetal plasma lipid. There were no measureable differences in free fatty acids (FFA) from umbilical artery, and veinous blood. Concentration of FFA in fetal blood was about 40% of the level of uterine values (187, 194, 73, and 82 ÂµEg/1 for uterine artery, uterine vein, umbilical artery, and umbilical vein). In addition, fetal plasma contained larger amounts of 14:0, 16:1, 18:1, and 20:4, whereas maternal plasma contained larger amounts of 18:0 and 18:2. These results indicate that only trace amounts of FFA cross the swine utero-placental unit during late gestation, which are probably not enough to increase energy supply or lipid storage of the fetus.; Swine Day, Manhattan, KS, November 21, 1985

Keywords

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TRANSFER OF FATTY ACIDS ACROSS THE SWINE UTERUS AND PLACENTA

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Summary

The transfer across the swine uterus and placenta of [1-^{14}C] octanoic acid, [9,10(n)-^{3}H] palmitic acid, and [1-^{14}C] linoleic acid was studied in five gilts and their fetuses during late gestation, following a single bolus injection. Only trace amounts of labelled fatty acids were found in fetal plasma lipid. There were no measureable differences in free fatty acids (FFA) from umbilical artery, and veinous blood. Concentration of FFA in fetal blood was about 40% of the level of uterine values (187, 194, 73, and 82 µEg/l for uterine artery, uterine vein, umbilical artery, and umbilical vein). In addition, fetal plasma contained larger amounts of 14:0, 16:1, 18:1, and 20:4, whereas maternal plasma contained larger amounts of 18:0 and 18:2. These results indicate that only trace amounts of FFA cross the swine utero-placental unit during late gestation, which are probably not enough to increase energy supply or lipid storage of the fetus.

Introduction

Unlike the newborn of other species, the pig rapidly develops hypoglycemia during starvation or stress. The ensuing high mortality rates resulting from this condition may be partially reduced by increasing energy storage late in the fetal period. By dietary manipulations, the circulating levels of FFA in the sow can be significantly increased. This increase in FFA in the sow may result in increased amounts of FFA crossing the utero-placental unit and may potentially be used as an energy substrate by the fetus for increased lipid deposition.

The objectives of this study were to determine if FFA cross the swine uterus and placental tissue during late gestation for fetal use.

Experimental Procedure

Three sows were used to determine utero-placental transfer of linoleic and palmitic acids (Exp. 1, 2, 3), and two sows (Exp. 4 and 5) were used to evaluate the transfer of octanoic acid. Feed was withheld from all sows overnight prior to surgery.

Sows were anesthetized (sodium pentabarbitol) and the uterus exposed through a paramedial incision. A catheter used to inject the isotope solution (outside diameter, 1.22 mm) was inserted through the utero-ovarian artery to a position 28 cm anterior to the internal iliac branch of the abdominal aorta.

Labelled [1-^{14}C] octanoic acid[1], [9,10(n)-^{3}H] palmitic acid[2], and [1-^{14}C] linoleic acid[1] were purchased from commercial sources and used without further purification. Sows used in Exp. 1, 2, and 3 were injected with 100 µCi of [^{3}H] palmitic and 100 µCi of [^{14}C] linoleic acids added to 4 ml of sterile serum obtained from the same sows. The sows in Exp. 4 and 5 each received 250 µCi of [^{14}C] octanoic acid, in 4 ml of sterile serum.

Blood samples were collected simultaneously from the uterine artery (UA), uterine vein (UV), umbilical artery (FA), and umbilical vein (FV) at 2 and 5 minutes and every 5 minutes thereafter until 50 minutes post-injection. Samples were centrifuged (4 C) to obtain plasma, which was stored at -20C until assayed.

Radioactivity was determined for and extracted plasma lipid. Additional aliquots of plasma were extracted and the major lipid fractions separated by thin-layer chromatography (TLC). Individual plasma FFA were quantitated by gas-liquid chromatography.

Results and Discussion

The concentrations of FFA in UA, UV, FA, and FV plasma are shown in Table 1. Maternal artery-vein concentrations were similar as were fetal artery-vein levels; however, concentrations were different ($P<.05$) between maternal and fetal plasma.

Table 2 shows the percentage composition of the total fatty acids in maternal and fetal plasma. Fetal plasma contained greater amounts ($P<.05$) of 14:0, 16:1, 18:1, and 20:4 than maternal plasma, whereas maternal plasma contained significantly ($P<.05$) more of 18:0 and 18:2.

Maternal infusions of [^{14}C] linoleic and [^{3}H] palmitic acids lead to high radioactivity in maternal plasma lipid within 2.5 minutes following injection of the labelled material (Figures 1 to 6). Radioactivity dropped sharply, resulting in minimum activity in maternal plasma within 10 to 20 minutes post-injection. From this time to the conclusion of the sampling period, there was a steady increase in radioactivity in the maternal plasma lipids, indicating metabolism of linoleic and palmitic acids. However, [^{3}H] and [^{14}C] radioactivity was extremely low in the lipid fraction of fetal plasma, with the highest activity less than 0.7% and 1.2% of the peak maternal values, respectively. This suggests that only trace amounts of these fatty acids are crossing the utero-placental barrier.

The results of injections of [1-^{14}C] octanoic acid into gilts in late gestation are summarized in Figures 7 and 8. These results are similar to those from sows receiving palmitic and linoleic acids. As with the previous experiments, very little [^{14}C] radioactivity was detected in the fetal plasma lipids, with the highest fetal plasma lipid values being less than 1.2% of the peak maternal values.

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[1] New England Nuclear, Boston, MA.

[2] Amersham Corp., Arlington Heights, IL.

Following the injections, radioactivity subsequently appeared in the maternal plasma lipid fractions: phosopholipids, cholesterol, FFA, triglyceride, and cholesteryl esters, as measured by TLC. Table 3 shows that the majority of [^{14}C] octanoic, [^{3}H] palmitic acid, and [^{14}C] octanoic acids were associated primarily with the FFA fraction during the first 5 minutes following injection of the labelled bolus. However, after 15 minutes, the greatest portion of the label was found in the triglyceride fraction, and after 30 minutes the labelled materials were associated almost totally with the triglyceride fraction. The phospholipid, cholesterol, FFA, and cholesteryl esters each contained small amounts of radioactivity as well. At no time was labelled material observed in the esterified lipids in fetal plasma, but rather the small amount detected was found in the free fatty acid fraction.

Table 1. Concentrations of Free Fatty Acids in Maternal and Fetal Plasma.[a]

Item	Plasma FFA, (μEq/l)[b]
Uterine artery	187[c]
Uterine vein	194[c]
Umbilical artery	73[d]
Umbilical vein	82[d]

[a]Each mean represents 6 sows and fetuses.

[b]Standard error is 8.

[cd]Means with different superscripts differ significantly (P<.05).

Table 2. Percentage Composition of the Total Fatty Acids in Maternal and Fetal Blood Plasma.

Fatty Acid Designation	Fatty acid composition (% of methy esters)[a]				
	Uterine Vein	Uterine Artery	Fetal Vein	Fetal Artery	SE
14:0	.6[b]	.7[b]	2.8[c]	3.2[d]	.1
16:0	18.4[b]	20.3[bc]	21.4[c]	22.1[c]	1.0
16:1	2.1[b]	2.4[b]	8.2[c]	8.6[c]	.3
18:0	18.3[b]	18.0[b]	11.4[c]	11.3[c]	.5
18:1	17.8[b]	17.7[b]	33.3[c]	34.0[c]	1.2
18:2	19.8[b]	20.7[b]	4.2[c]	6.9[c]	2.2
18:3	.5[b]	.6[bc]	.6[bc]	.7[c]	.1
20:4	1.7[b]	1.7[b]	6.1[c]	6.0[c]	.1

[a]Each mean represents 7 sows and fetuses.

[bcd]Means with different superscripts differ significantly ($P<.05$).

Table 3. Incorporation of Radioactivity into Plasma Lipid Fractions Following Maternal Injection of [^{14}C] Linoleic Acid, [^{3}H] Palmitic Acid, or [^{14}C] Octanoic Acid.

(a) Incorporation of [^{14}C] linoleic acid (percent of total)[a]

Lipid fraction	Time (min) 5	15	30
Phospholipid	1.9 ± .3	4.0 ± .3	4.6 ± .5
Cholesterol	2.4 ± .5	3.5 ± .1	2.7 ± .2
Free fatty acids	86.3 ± 2.6	24.0 ± 2.8	3.6 ± .4
Triglycerides	1.2 ± .2	61.0 ± 1.8	83.6 ± 4.1
Cholesteryl esters	2.3 ± .4	2.3 ± .2	3.6 ± .1

(b) Incorporation of [^{3}H] palmitic acid (percent of total)[a]

Lipid fraction	Time (min) 5	15	30
Phospholipid	2.5 ± .8	2.6 ± .4	1.6 ± .2
Cholesterol	3.5 ± .4	3.2 ± .5	1.2 ± .1
Free fatty acids	84.0 ± 1.5	36.7 ± 1.3	13.2 ± .9
Triglycerides	1.6 ± .4	56.4 ± 2.7	82.8 ± 3.9
Cholesteryl esters	4.2 ± .5	1.1 ± .3	0.9 ± .3

(c) Incorporation of [^{14}C] octanoic acid (percent of total)[b]

Lipid fraction	Time (min) 2	15	30
Phospholipid	1.4 ± .5	3.2 ± .6	2.4 ± .3
Cholesterol	2.7 ± .3	8.3 ± .4	5.5 ± .1
Free fatty acids	90.2 ± 1.2	21.5 ± 4.0	2.5 ± .2
Triglycerides	1.8 ± .4	60.1 ± 2.6	85.4 ± 3.6
Cholesteryl esters	2.0 ± .3	4.0 ± .1	1.7 ± .5

[a]Mean ± SE for 3 sows at each time.
[b]Mean ± SE for 2 sows at each time.

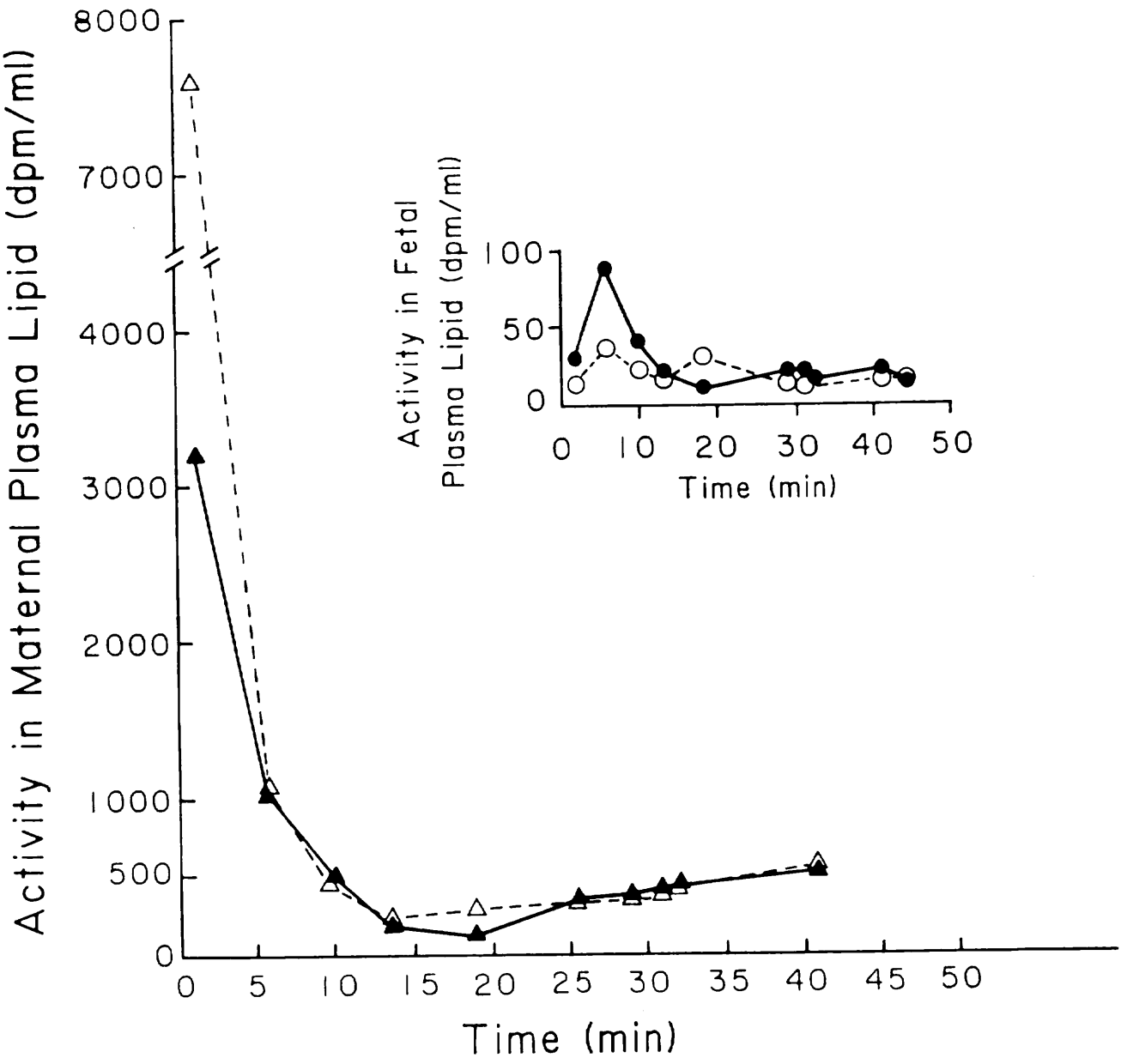

Figure 1. Radioactivity in maternal and fetal plasma lipid following maternal injection of 100 μCi of [^{14}C] linoleic acid (Exp. 1). Solid circle (●) represents FV; open circle (○) represents FA; solid triangle (▲) represents UV and open triangle (△) represents UA.

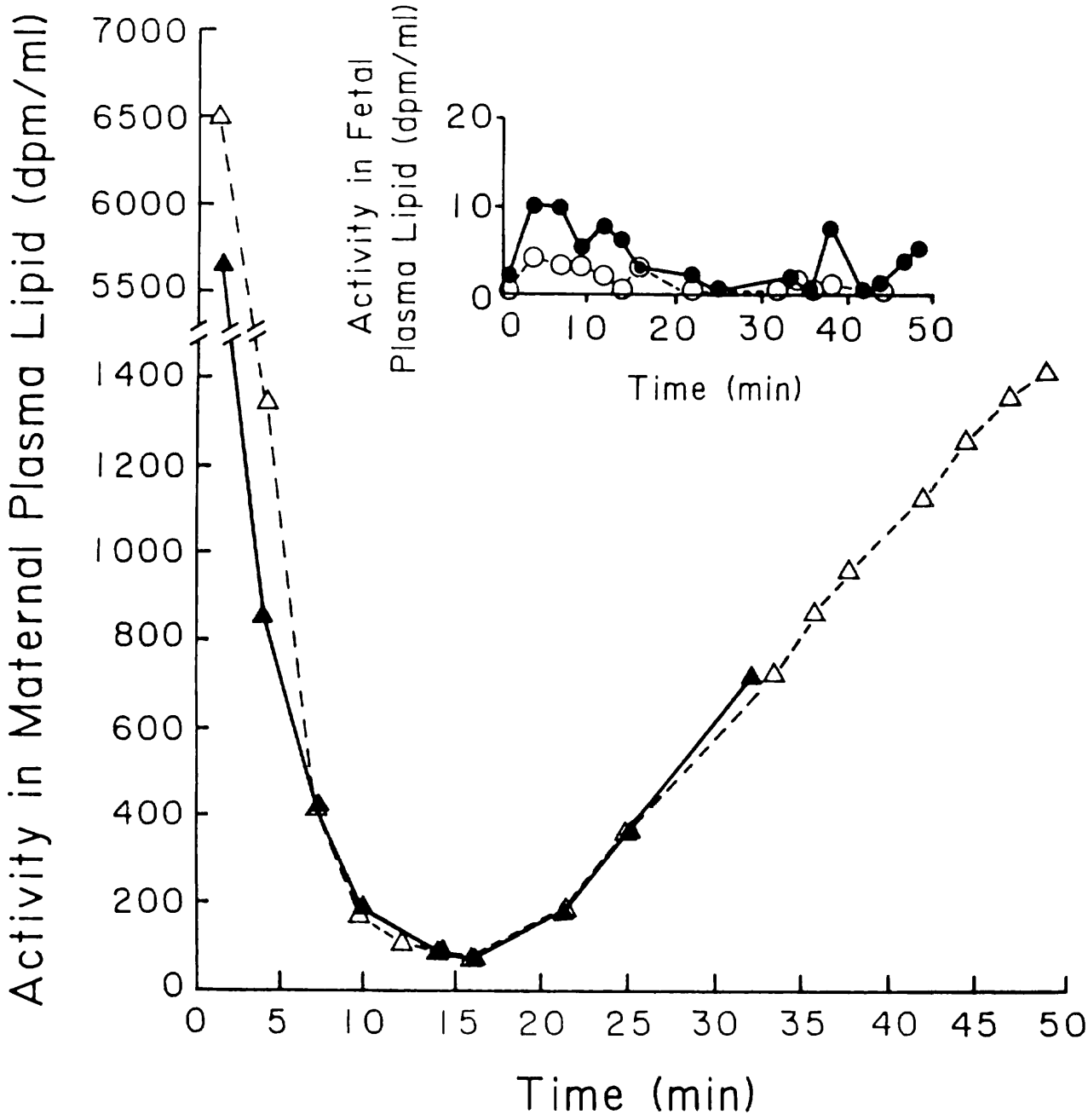

Figure 2. Radioactivity in maternal and fetal plasma lipid following maternal injection of 100 μCi of [^{14}C] linoleic acid (Exp. 2). Solid circle (●) represents FV; open circle (○) represents FA; solid triangle (▲) represents UV and open triangle (△) represents UA.

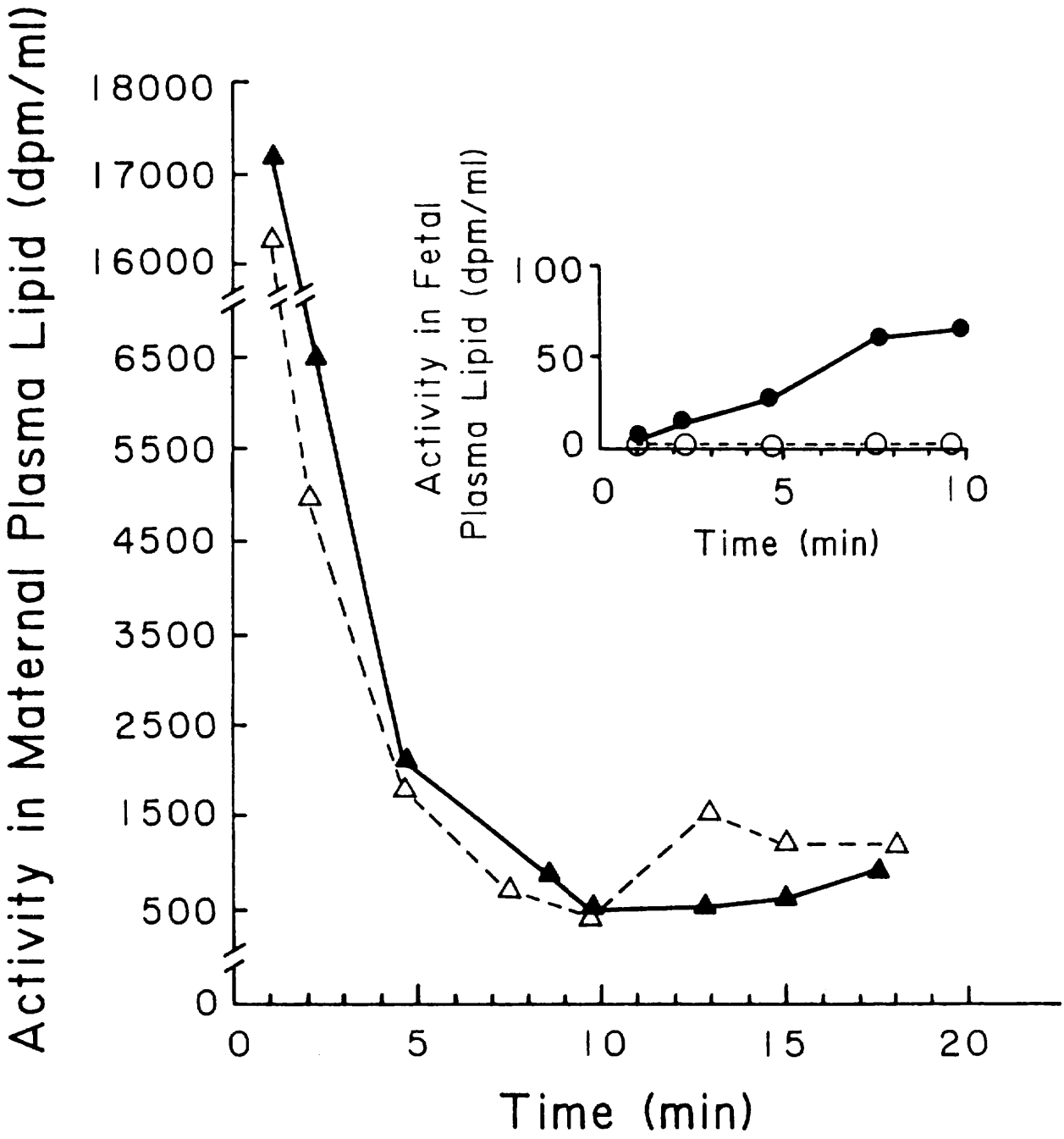

Figure 3. Radioactivity in maternal and fetal plasma lipid following maternal injection of 100 μCi of [^{14}C] linoleic acid (Exp. 3). Solid circle (●) represents FV; open circle (○) represents FA; solid triangle (▲) represents UV and open triangle (△) represents UA.

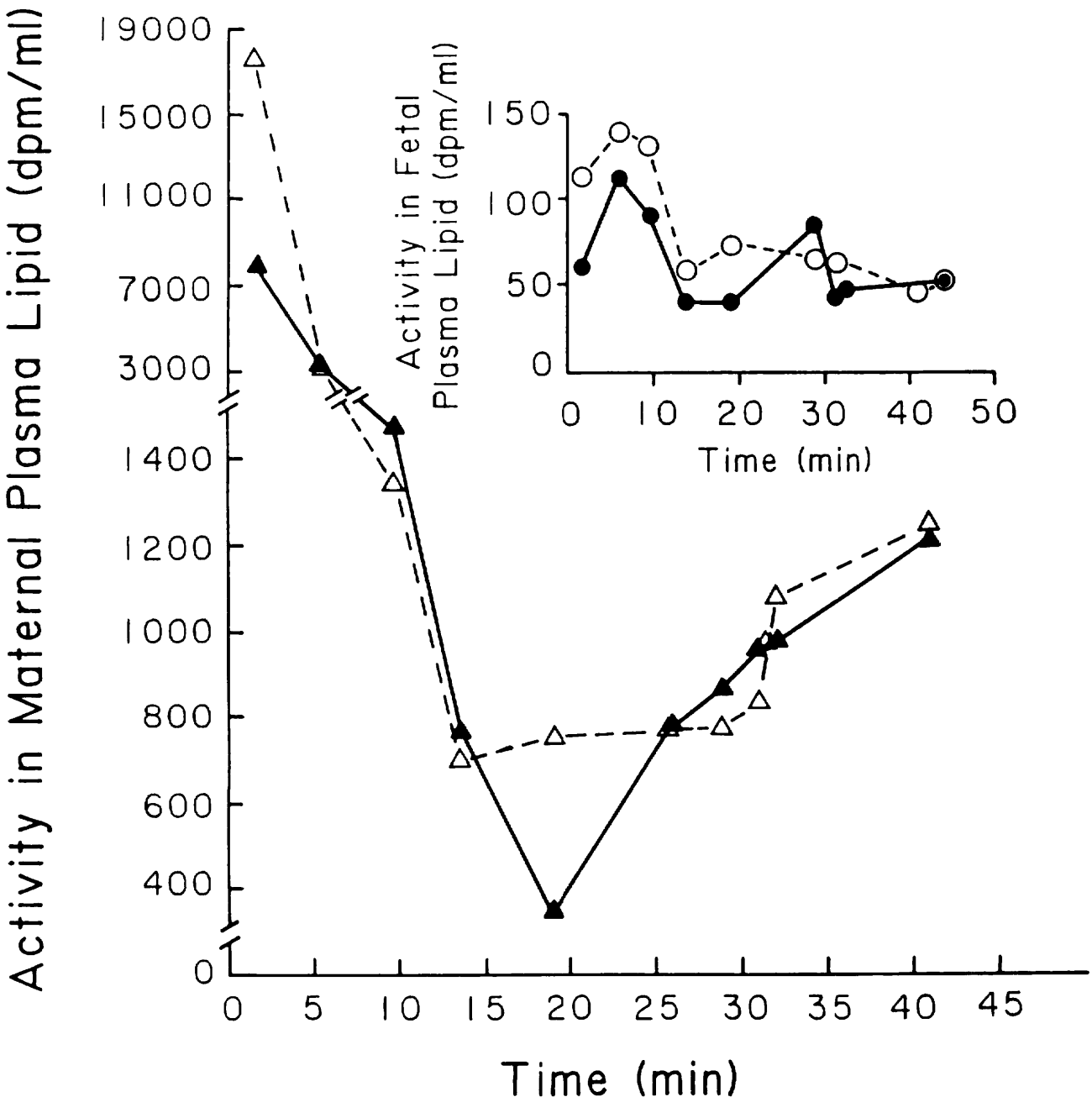

Figure 4. Radioactivity in maternal and fetal plasma lipid following maternal injection of 100 μCi of [^{3}H] palmitic acid (Exp. 1). Solid circle (●) represents FV; open circle (○) represents FA; solid triangle (▲) represents UV and open triangle (△) represents UA.

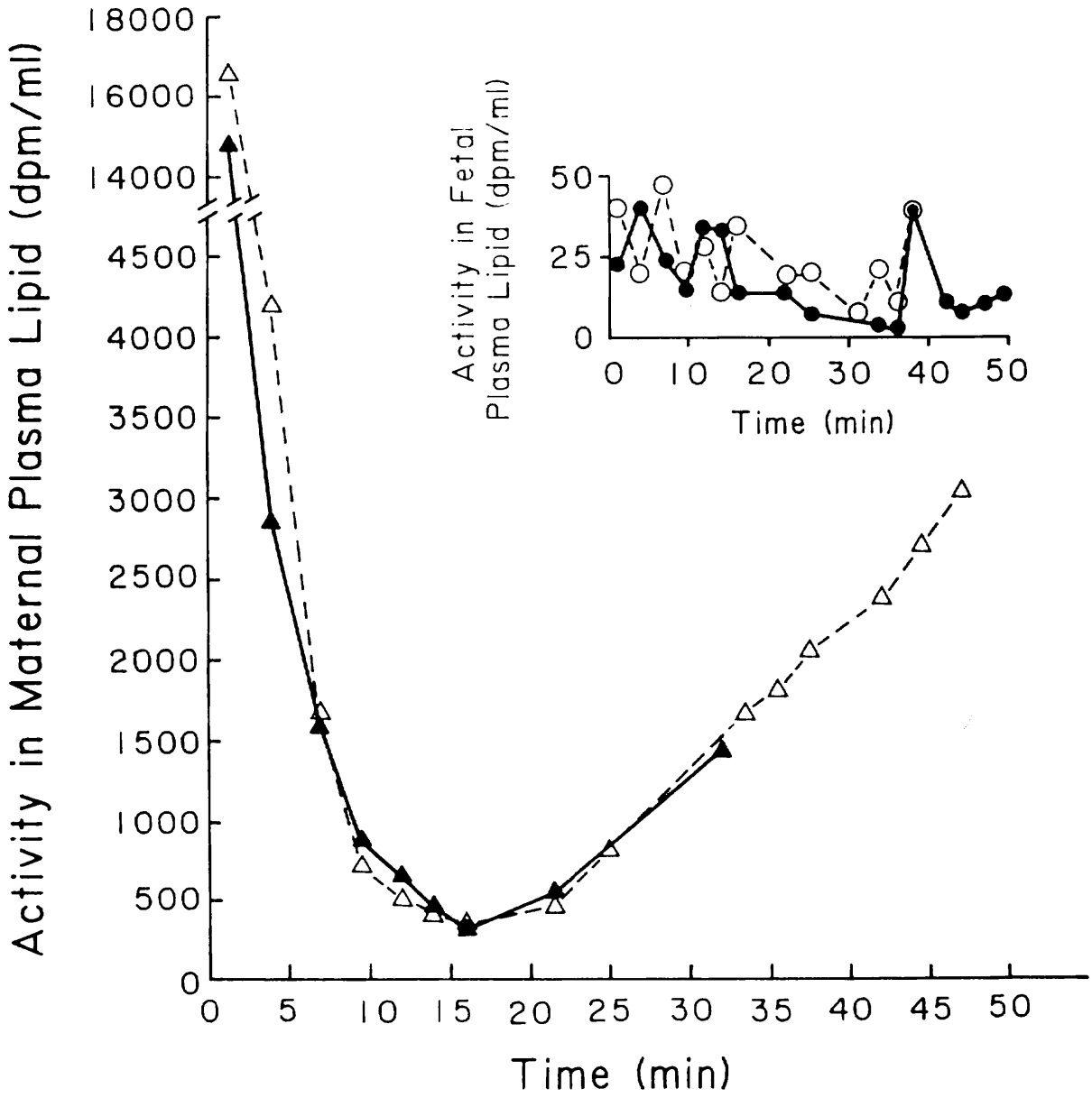

Figure 5. Radioactivity in maternal and fetal plasma lipid following maternal injection of 100 μCi of [^{3}H] palmitic acid (Exp. 2). Solid circle (●) represents FV; open circle (○) represents FA; solid triangle (▲) represents UV and open triangle (△) represents UA.

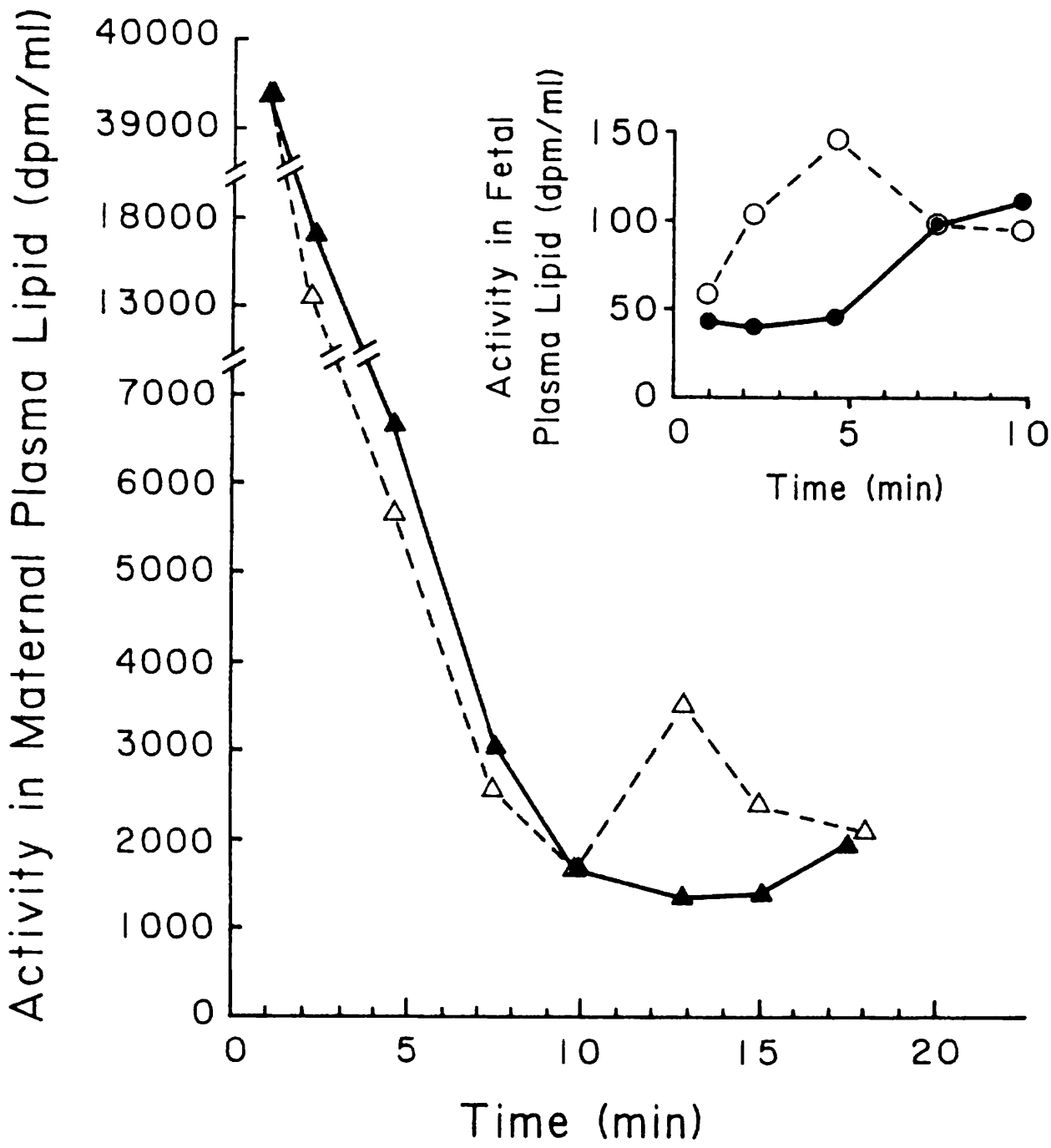

Figure 6. Radioactivity in maternal and fetal plasma lipid following maternal injection of 100 μCi of [^{3}H] palmitic acid (Exp. 3). Solid circle (●) represents FV; open circle (○) represents FA; solid triangle (▲) represents UV and open triangle (△) represents UA.

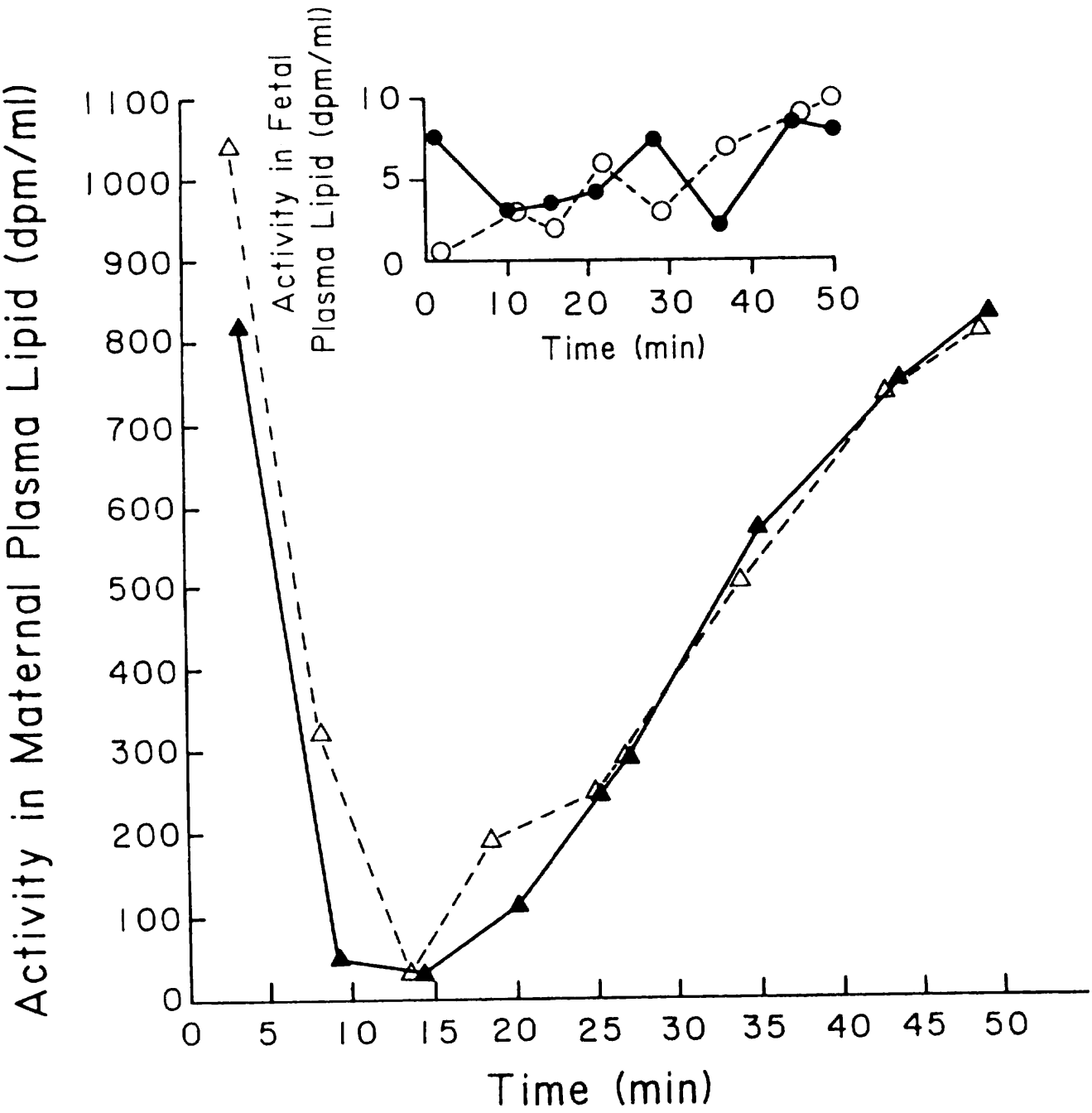

Figure 7. Radioactivity in maternal and fetal plasma lipid following maternal injection of 250 μCi of [^{14}C] octanoic acid (Exp. 4). Solid circle (●) represents FV; open circle (o) represents FA; solid triangle (▲) represents UV and open triangle (Δ) represents UA.

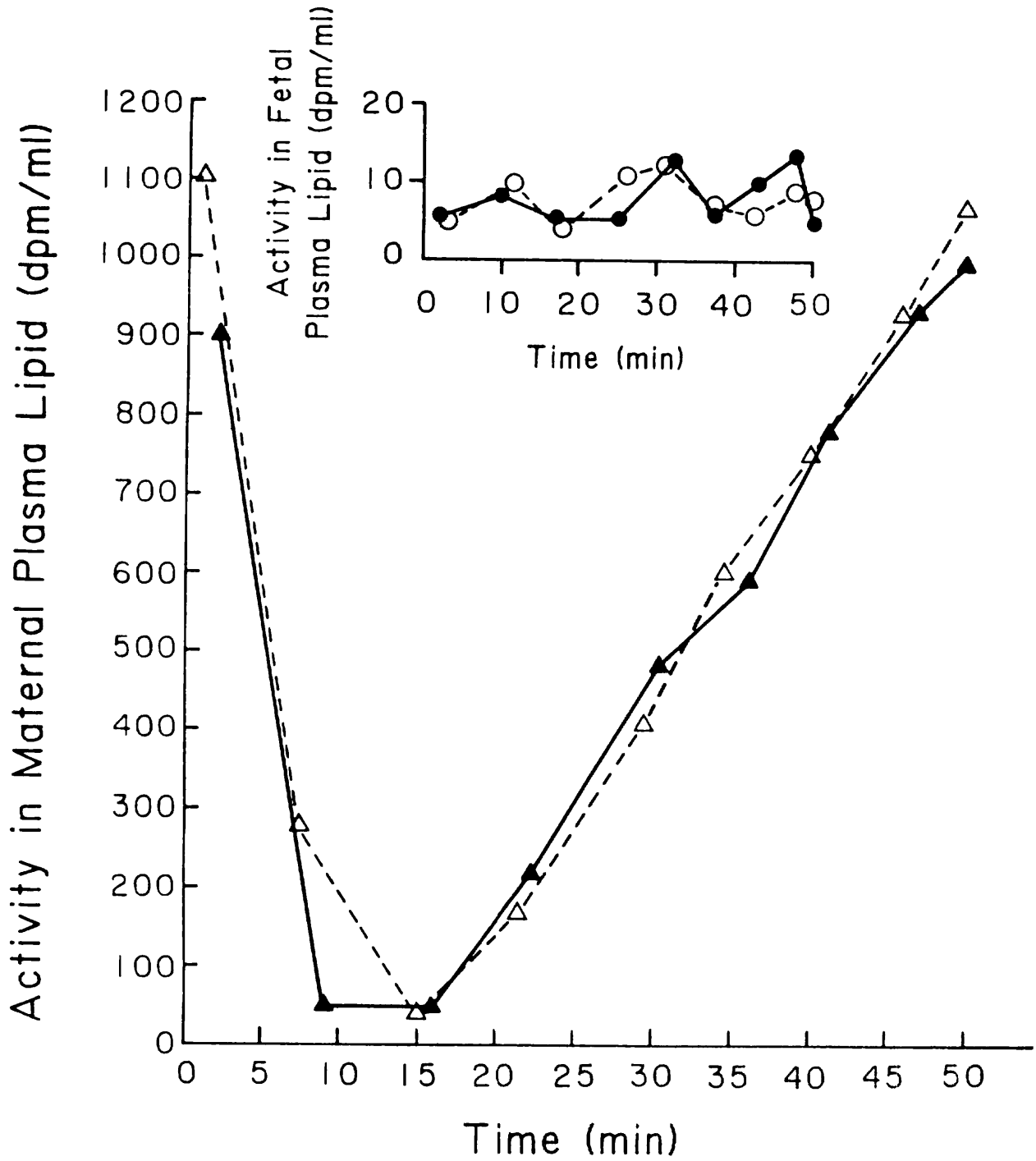

Figure 8. Radioactivity in maternal and fetal plasma lipid following maternal injection of 250 μCi of [^{14}C] octanoic acid (Exp. 5). Solid circle (●) represents FV; open circle (o) represents FA; solid triangle (▲) represents UV and open triangle (Δ) represents UA.