

1)

(continuous ambulatory peritoneal dialysis, CAPD)  
 , CAPD  
 가(subjective  
 global assessment, SGA)

CAPD  
 2 CAPD  
 6 (urea kinetic study) 106  
 . 1994 12 1 1996 11 30 2  
 (total CO2 content, tCO2) ( :  
 <22mM/L, : 22- 26mM/L, : 26mM/L)  
 가 2

1) 106 1.2 : 1 , 46.9 ± 12.2 , CAPD  
 28.3 ± 21.8 2 23.9 ± 2.1mM/L ,  
 59.0 ± 8.9kg, % Bwt/IBW 104.1 ± 11.5%, % LBM/Bwt 75.5 ± 11.1%, SGA  
 65.4%

2) 2 , ,  
 6.6 ± 0.7g/dL, 4.0 ± 0.4g/dL, 55.6 ± 13.6mg/dL 12.3 ± 3.5mg/dL .  
 NPCR 0.96 ± 0.16g/kg/day, weekly Kt/Vurea 2.02 ± 0.37, SCCr 63.7 ± 18.4L/week/1.73m2  
 RRF 1.0 ± 1.3ml/min , 1 (Dpro and  
 Dalb) 6.2 ± 1.9g/day 4.2 ± 1.3g/day .

3) , 15 (14.2%),  
 75 (70.8%), 16 (15.1%) . % Bwt/IBW 113.1 ± 15.3%,  
 103.5 ± 11.5%, 98.7 ± 8.0%  
 (P < 0.05), 51.0 ± 10.8 (47.0 ± 12.4 ) (42.6 ± 11.4 )  
 (P < 0.05). , , , % LBM/Bwt SGA

가 .  
 4) 20.6 ± 1.2mM/L, 23.9 ± 1.1mM/L, 27.3 ±

0.8mM/L 가 ( $P < 0.05$ ),  $3.75 \pm$   
 $0.4g/dL$ ,  $4.04 \pm 0.3g/dL$  ( $P < 0.05$ ),  
 $46.1 \pm 7.2mg/dL$   $61.1 \pm 14.3mg/dL$   $56.5 \pm 13.7mg/dL$   
 ( $P < 0.05$ ).  
 가 .  
 5) NPCR( $1.02 \pm 0.21g/kg/day$  vs.  $0.88 \pm 0.14g/kg/day$ ) (ultrafiltra-  
 tion)( $1.4 \pm 0.4L/day$  vs.  $1.0 \pm 0.3L/day$ ) ( $P < 0.05$ ),  
 Kt/Vurea, SCCr, RRF, Dpro Dalb 가 .  
 6) 2  
 , ( $-0.17 \pm 0.61gm/dL$  vs.  $-0.11 \pm 0.57gm/dL$ ,  $-0.07 \pm 0.61gm/dL$ ). 2  
 , % Bwt/IBW, % LBM/Bwt, , NPCR RRF  
 가 .  
 7)  
 NPCR( $r = -0.33$ ,  $P < 0.001$ ), % Bwt/IBW( $r = -0.32$ ,  $P < 0.001$ ), ( $r =$   
 $-0.29$ ,  $P < 0.005$ ) ( $r = -0.24$ ,  $P < 0.05$ ) ,  
 , % LBM/Bwt Kt/Vurea 가 .  
 8) NPCR(  $r = -0.3491$ ,  $P < 0.001$ ), % Bwt/IBW(  $r = -0.046$ ,  $P <$   
 $0.001$ ) (  $r = -0.0012$ ,  $P < 0.005$ )

CAPD  
 가 가 ,  


---

 가 , (bicarbonate)  
 ,  
 bicarbonate  
 가 8). Reich  
 bicarbonate  
 , Stein 10)  $40mM/L$  (lactate)  
 2).  
 가  $35mM/L$  1  
 3), midarm circumference 가  
 가  
 ,  
 branched chain keto-acid dehydrogenase  
 4). branched chain amino-  
 acid(BCAA) 가  
 5), 11, 12).  
 , (catecholamines)  
 6). May  
 7) 13), Arnett Dempster 14) pH가

(osteoclast) 가 가 가(subjective global assess-  
, Lefebvre 15) ment; SGA) .  
가 가 2.  
, 2  
(mean venous total  
CO2 content; tCO2) ( ; mean tCO2  
<22mM/L, ; 22mM/L mean tCO2<26mM/L,  
; mean tCO2 26mM/L)  
nitrogen balance) (positive ;  
CAPD - (per-  
cent of body weight over ideal body weight  
% Bwt/IBW) , creatinine kinetics  
16-19), Kopple 20) (percent of lean body  
mass over body weight; %LBM/Bwt)  
, Dumler 21) 가  
가  
CAPD 가 81  
가 SGA  
(subjective global assessment, SGA) 가 24  
. 24 가  
CAPD ,  
- 가 , 24 24  
, %LBM/  
Bwt, SGA, weekly Kt/Vurea,  
가 (NPCR), (SCCr),  
, CAPD (RRF), 24  
(Dpro Dalb) 22)  
Watson  
normogram23)  
(PCR) Randerson 24)  
1. (Table 1).  
1996 12 1 2  
2 CAPD , ,  
40mM/L lactate , % Bwt/IBW, % LBM/Bwt, SGA, ,  
106 , , NPCR, Kt/Vurea,  
, 6 SCCr, RRF, Dpro Dalb 2  
(urea kinetic study) , 1

**Table 1. Calculation of RRF, Kt/Vurea, NPCR and SCCr**

1.  $RRF(\text{ml}/\text{min}) = \{(\text{Ucr}/\text{Scr} + \text{Uurea}/\text{Surea}) \times \text{Uvol}\} / 1440 \times 2$
2.  $\text{Weekly Kt}/\text{Vurea} = \{[\text{Dun} + \text{Uun}]/\text{V}\} \times 7$   
 $\text{Dun} = \text{Dvol} \times \text{Durea}/\text{BUN}$   
 $\text{Uun} = \text{Uvol} \times \text{Uurea}/\text{BUN}$   
 $\text{V} : \text{Total body water}$
3.  $\text{NPCR}(\text{g}/\text{kg}/\text{day}) = \text{PCR}/\text{standard weight}$   
 $\text{PCR} = 10.76(\text{Gun} + 1.46)$   
 $\text{Gun} = (\text{Dvol} \times \text{Durea} + \text{Uvol} \times \text{Uurea}) / 1440$   
 $\text{Standard weight} = \text{V}/0.58$
4.  $\text{SCCr}(\text{L}/\text{week}/1.73\text{m}^2) = \{(\text{Dvol} \times \text{Dcr})/\text{Scr} + (\text{Uvol} \times \text{Ucr})/\text{Scr}\} \times 7 \times 1.73/\text{BSA}$

*Ucr* : urine creatinine concentration  
*Scr* : serum creatinine concentration  
*Uurea* : urine urea nitrogen concentration  
*Surea* : serum urea nitrogen concentration  
*Durea* : dialysate urea nitrogen concentration  
*Uvol* : urine volume/day  
*Dvol* : drained dialysate volume/day  
*Gun* : urea generation rate  
*BSA* : body surface area

% Bwt/IBW, % LBM/Bwt, ,  
 , NPCR, Kt/Vurea, SCCr, RRF, Dpro  
 Dalb ,

3.

SPSS , Chi-square  
 oneway ANOVA(analysis of variance) , 15  
 , paired student (14.2%), 75 (70.8%), 16  
 t- test (15.1 %)  
 가 . P 0.05

1.

106 가 57 , 가 49  
 ( 1.2 : 1) , 19 73  
 46.9 ± 12.2 , CAPD 18.3 ± 21.8  
 , 23.9 ±  
 2.1mM/L , 59.0 ± 8.9kg, % Bwt/  
 IBW 104.1 ± 11.5%, % LBM/Bwt 75.5 ± 11.1%,

**Table 2. Characteristics of Patients**

Age(years)	46.9 ± 12.2*
Sex(M : F)	1.2 : 1
mean tCO <sub>2</sub> (mM/L)	23.9 ± 2.1
Body weight(kg)	59.0 ± 8.9
% IBW(%)	104.1 ± 11.5
% LBM/Bwt(%)	75.5 ± 11.1
SGA(normal:malnourished)	53 : 28
Duration between initiation of CAPD and baseline(0 month) data collection	(No. of patients)
<3 month	13
3- 6 month	31
6- 12 month	20
12- 24 month	14
>24 month	28

\*: Mean ± S.D.

SGA 65% .  
 6.6 ± 0.7g/dL, 4.0 ± 0.4g/dL, 55.6  
 ± 13.6mg/dL 12.3 ± 3.5mg/dL .  
 NPCR 0.96 ± 0.16g/kg/day, weekly Kt/  
 Vurea 2.02 ± 0.37, SCCr 63.7 ± 18.4L/week/1.73m<sup>2</sup>  
 RRF 0.99 ± 1.32ml/min , 1  
 6.2 ± 1.9g/day  
 4.2 ± 1.3g/day (Table 2).

2.

15  
 16  
 20.6 ± 1.2mM/L, 23.9 ± 1.1mM/L,  
 27.3 ± 0.8mM/L 가  
 51.0 ± 10.8 , 47.0 ± 12.4  
 , 42.6 ± 11.4 ,  
 (P<0.05). % Bwt/IBW  
 113.1 ± 15.3%, 103.5 ± 11.5%,  
 98.7 ± 8.0%  
 , , % LBM/  
 Bwt, SGA 가  
 (Table 3).

3. day,  $P < 0.05$ ) ( $1.4 \pm 0.4\text{L/day}$  vs.  $1.0 \pm 0.3\text{L/day}$ ,  $P < 0.05$ )  
 $3.8 \pm 0.4\text{g/dL}$ , Kt/Vurea, SCCr, RRF, Dpro  
 $4.0 \pm 0.3\text{g/dL}$  ( $P < 0.05$ ), Dalb 가 (Table 5).  
 $46.1 \pm 7.2\text{mg/dL}$   
 $61.1 \pm 14.3\text{mg/dL}$   $56.5 \pm 13.7\text{mg/dL}$  5.

가 (Table 4).

4. , ( $-0.17 \pm 0.61\text{gm/dL}$  vs.  $1.02 \pm 0.21\text{g/kg/day}$  vs.  $0.88 \pm 0.14\text{g/kg/}$   $-0.11 \pm 0.57\text{gm/dL}$ ,  $-0.07 \pm 0.61\text{gm/dL}$ ). 2 ,

**Table 3. Clinical Characteristics of the 3 Groups Classified According to Mean tCO<sub>2</sub> Level**

	Group (tCO <sub>2</sub> < 22)	Group (22 < tCO <sub>2</sub> < 26)	Group (tCO <sub>2</sub> > 26)
Patients(%)	15(14.2)	75(70.8)	16(15.1)
Age(years)	51.0 ± 10.8*	47.0 ± 12.4	42.6 ± 11.4
Sex(M : F)	0.9 : 1	1.3 : 1	1 : 1
Duration on CAPD(months)	29.0 ± 25.2	27.3 ± 20.2	31.9 ± 26.3
Bwt/IBW(%)	113.1 ± 15.3	103.5 ± 11.5 †	98.7 ± 8.0 †
LBM/Bwt(%)	71.0 ± 11.2	76.7 ± 11.5	74.0 ± 8.9
Malnourished patients by SGA(%)	7/20(35.0)	16/50(32.0)	5/11(45.5)

\*: Mean ± S.D., †:  $P < 0.05$  vs. Group

**Table 4. Biochemical Data of the 3 Groups Classified According to Mean tCO<sub>2</sub> Level(Mean ± S.D.)**

	Group (tCO <sub>2</sub> < 22)	Group (22 < tCO <sub>2</sub> < 26)	Group (tCO <sub>2</sub> > 26)
Mean tCO <sub>2</sub> (mM/L)	20.6 ± 1.2	23.9 ± 1.1*	27.3 ± 0.8*†
BUN(mg/dL)	61.1 ± 14.3	56.5 ± 13.7	46.1 ± 7.2*†
Creatinine(mg/dL)	12.0 ± 3.21	2.7 ± 3.7	11.1 ± 1.7
Total protein(g/dL)	6.7 ± 0.8	6.6 ± 0.7	6.2 ± 0.6
Albumin(g/dL)	4.0 ± 0.3	4.0 ± 0.4	3.8 ± 0.4*

All data represent mean value of the 2-year follow-up

\*:  $P < 0.05$  vs. Group, †:  $P < 0.05$  vs. Group

**Table 5. Urea Kinetic Data and Dialysate(D) Protein and Albumin Loss of the 3 Groups Classified According to Mean tCO<sub>2</sub> Level(Mean ± S.D.)**

	Group (tCO <sub>2</sub> < 22)	Group (22 < tCO <sub>2</sub> < 26)	Group III(tCO <sub>2</sub> > 26)
NPCR(g/kg/day)	1.02 ± 0.21	0.97 ± 0.15	0.88 ± 0.14*
Kt/Vurea	1.99 ± 0.37	2.03 ± 0.39	2.03 ± 0.23
SCCr(L/wk/1.73m <sup>2</sup> )	64.4 ± 23.6	63.1 ± 17.6	65.9 ± 17.7
RRF(ml/min/1.73m <sup>2</sup> )	1.14 ± 1.74	1.00 ± 1.23	0.76 ± 1.31
D protein loss(g/day)	6.3 ± 2.5	6.0 ± 1.8	6.4 ± 1.8
D albumin loss(g/day)	4.5 ± 1.5	4.0 ± 1.2	4.5 ± 1.5
Ultrafiltration(L/day)	1.4 ± 0.4	1.1 ± 0.4	1.0 ± 0.3*

All data represent mean value of the 2-year follow-up

\*:  $P < 0.05$  vs. Group

% Bwt/IBW, % LBM/Bwt, NPCR, RRF,  $\uparrow$  NPCR( $r=-0.33, P<0.001$ )(Fig. 1), % Bwt/IBW( $r=-0.32, P<0.001$ ), (Fig. 2) ( $r=-0.29, P<0.005$ )(Fig. 2) ( $r=-0.24, P<0.05$ )(Fig. 3), % LBM/Bwt, Kt/Vurea,  $\uparrow$  (Table 7).

**Table 6. Changes(D) of Parameters after 2-Year Follow-Up Period(Mean  $\pm$  S.D.)**

	Group (tCO <sub>2</sub> <22)	Group (22<tCO <sub>2</sub> <26)	Group (tCO <sub>2</sub> >26)
Body weight(kg)	0.6 $\pm$ 4.5	0.3 $\pm$ 6.1	-0.3 $\pm$ 3.6
Bwt/IBW(%)	0.9 $\pm$ 8.1	1.0 $\pm$ 11.7	-0.3 $\pm$ 6.8
LBM/Bwt(%)	-3.9 $\pm$ 15.4	-1.1 $\pm$ 13.1	-2.2 $\pm$ 13.9
BUN(mg/dL)	-5.3 $\pm$ 18.1	0.8 $\pm$ 15.6	1.3 $\pm$ 7.31
Albumin(g/dL)	-0.17 $\pm$ 0.61	-0.11 $\pm$ 0.57	-0.07 $\pm$ 0.61
NPCR(g/kg/day)	-0.09 $\pm$ 0.28	-0.04 $\pm$ 0.23	0.01 $\pm$ 0.20
RRF(ml/min/1.73m <sup>2</sup> )	-1.13 $\pm$ 2.01	-1.00 $\pm$ 1.56	-0.98 $\pm$ 1.56

**Fig. 1.** Correlation between mean tCO<sub>2</sub> and NPCR.

**Fig. 3.** Correlation between mean tCO<sub>2</sub> and albumin.

**Table 7. Correlation between Mean tCO<sub>2</sub> Level vs. Other Parameters including Albumin**

Parameters	Correlation coefficient	P - value
NPCR	-0.33	<0.001
Bwt/IBW(%)	-0.32	<0.001
Ultrafiltration volume	-0.29	<0.005
Albumin	-0.24	<0.05
Creatinine	-0.13	NS*
LBM/Bwt(%)	-0.05	NS
Kt/Vurea	-0.01	NS

**Fig. 2.** Correlation between mean tCO<sub>2</sub> and ultrafiltration volume.

\*: Not significant

**Table 8. Independent Factors Affecting Mean tCO<sub>2</sub> Level- Stepwise Multiple Regression Analysis**

Parameters	*	S.E. †	P- value
NPCR	- 3.9491	1.1185	< 0.001
Bwt/IBW(%)	- 0.0463	0.0149	< 0.001
Ultrafiltration volume	- 0.0012	0.0005	< 0.005

\*: Regression coefficient, †: Standard error

7.

NPCR( = -0.3491,  $P < 0.001$ ), %Bwt/IBW( = -0.046,  $P < 0.001$ )

( = -0.0012,  $P < 0.005$ )

(Table 8).

가

ammonium

,

가

가 25).

가

3),

bicarbonate

가

가

4).

gluco-

가

corticoid

25),

branched

chain keto- acid dehydrogenase

14 15).

CAPD

(lactate)

branched chain amino- acid(BCAA)

가

11, 12).

Hara 12)

bicarbonate

가

가

31),

BCAA

bicarbonate

가

가

CAPD

34% 가 7, 26),

May 7)

가 가 , bicarbonate

. Williams 27)

가가

Reaich 9)

4

bicarbo-

nate

. Stein 10) 40mM/L

35mM/L

1

midarm circumference

가

Gotch 28)

(insulin- like growth factor- I, IGF- I),

(triiodothyronine,

T3)

가

20%

6).

13),

29).

가 calcium carbonate

30),

가

가 가

bicarbonate  
 , Dumler 2)  
 (metabolic acid) - 가 22mEq/L ,  
 30, 33). Feriani3) 가  
 1 35mM 가 20mEq/L .  
 34), bicarbonate 23.9 ± 2.1mM/L  
 bicarbonate 35). , ,  
 bicarbonate , 1 200cc bicar- 가 , % Bwt/IBW  
 bonate (0- 2.2mM/day) .  
 bicarbonate bicarbonate  
 bicarbonate 가 , Dumler 2)  
 36). 가  
 CAPD . Acchiardo 4)  
 bicarbonate NPCR  
 bicarbonate가 ,  
 bicarbonate 36). 가가  
 CAPD  
 가 bicarbonate 가 , CAPD  
 bicarbonate , 가가  
 carbonate 가 bi- NPCR  
 bonate 가 bicar- 가  
 17). 가 NPCR  
 CAPD가 가 가  
 가 32, 37, 38). control Chauveau 4)  
 , prealbumin,  
 body mass index, NPCR 가  
 39, 40), CAPD , 가  
 - , 가 ,  
 가  
 bicarbonate 가  
 39, 40), CAPD .  
 bicarbonate 3). 가(SGA) , SGA  
 가  
 가  
 43-45).



SGA

가 52).  
 46 Bergström 53)  
 47). Fenton 48) SGA Kt/Vurea bicarbonate  
 가 , 가 (R=0.272, P=  
 SGA 가 bicarbonate  
 0.2087), 가  
 <22mEq/L 22mEq/L  
 SGA , 22mEq/L

CAPD

가  
 weekly Kt/Vurea가 2.02  
 ±0.37  
 NPCR, %  
 가 2  
 Bwt/IBW,  
 가 . Dumler Galen 2)

Galen2)

24 가 ±0.2g/dL  
 NPCR (R=0.564, P=0.0001)  
 (R=0.373, P=0.0007), bicarbonate  
 가 2  
 Dumler (R=- 0.172, P=0.13).  
 NPCR, % Bwt/IBW  
 NPCR (R=0.259, P=0.007)  
 가  
 NPCR  
 bicarbonate % Bwt/IBW

가 8), 49) turnover 가  
 bicarbonate , CAPD  
 515)

23.9 ± 2.1mM/L(18.0- 28.6mM/L) CAPD

Graham bicarbonate  
 19.3mM/L 가  
 38) 가

= Abstract =

### Impact of Metabolic Acidosis on Serum Albumin and Other Nutritional Parameters in CAPD Patients

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Metabolic acidosis(MA) is associated with increased proteolysis, increased osteoclast activity and blunted cardiac muscle response, but the effect of MA on various clinical parameters in CAPD patients is not well known. To evaluate the effects of MA on serum albumin level and other nutritional parameters in CAPD patients, we studied 106 CAPD patients retrospectively who have had monthly biochemical measurement and urea kinetic studies every 6 months for more than 2 years. The patients were divided into three groups according to their mean total  $\text{CO}_2$ (tCO<sub>2</sub>) level of the 2-year follow-up(Group 1; mean tCO<sub>2</sub> < 22mM/L, Group 2; 22mM/L < mean tCO<sub>2</sub> < 26mM/L, and Group 3; mean tCO<sub>2</sub> > 26mM/L), and the clinical, biochemical, and urea kinetic data were compared among the three groups.

1) The mean age of the subjects was  $46.9 \pm 12.2$  years with a sex ratio of 1.2:1, the mean CAPD duration  $28.3 \pm 21.8$  months, mean body weight(Bwt)  $59.0 \pm 8.9$ kg, %Bwt/IBW  $104.1 \pm 11.5\%$ , %LBM/Bwt  $75.5 \pm 11.1\%$  and well-nourished patients by subjective global assessment(SGA) were 65%.

2) The mean BUN, creatinine, total protein and albumin of all patients were  $55.6 \pm 13.6$ mg/dL,  $12.3 \pm 3.5$ mg/dL,  $6.6 \pm 0.7$ g/dL and  $4.0 \pm 0.4$ g/dL, respectively. In urea kinetic study, the mean NPCR, weekly Kt/Vurea, SCCr and RRF were  $0.96 \pm 0.16$ g/kg/day,  $2.02 \pm 0.37$ ,  $63.7 \pm 18.4$ L/week/1.73m<sup>2</sup> and  $0.99 \pm 1.32$ ml/min, respectively.

3) The mean age was significantly higher in group 1 ( $51.0 \pm 10.8$ ) than those of group 2 ( $47.0 \pm 12.4$ ) and 3 ( $42.6 \pm 11.4$ )( $P < 0.05$ ). %Bwt/IBW of group 1 ( $114.4 \pm 15.8\%$ ) was also significantly higher than those of group 2 ( $104.6 \pm 12.6\%$ ) and 3 ( $103.5 \pm 13.7\%$ )( $P < 0.05$ ), but there were no significant differences in sex ratio, CAPD duration, %LBM/Bwt, and SGA among the three groups.

4) The mean tCO<sub>2</sub> in group 1, group 2, and group 3 were  $20.6 \pm 1.2$ mM/L,  $23.9 \pm 1.1$ mM/L, and  $27.3 \pm 0.8$ mM/L, respectively. Compared to group 1, group 2 had significantly higher BUN( $61.1 \pm 14.3$  vs.  $46.1 \pm 7.2$ mg/dL,  $P < 0.05$ ) and serum albumin( $4.04 \pm 0.31$  vs.  $3.75 \pm 0.39$ g/dL,  $P < 0.05$ ), in spite of comparable dialysis dose and albumin loss into dialysate.

5) NPCR( $1.02 \pm 0.21$ g/kg/day vs.  $0.88 \pm 0.14$ g/kg/day,  $P < 0.05$ ) and ultrafiltration volume( $1.4 \pm 0.4$  vs.  $1.0 \pm 0.3$ ,  $P < 0.05$ ) were significantly higher in group 1 than those of group 2. But there were no significant differences in Kt/Vurea, SCCr, RRF, and 24-hour dialysate loss of protein/albumin among the three groups.

6) No differences were observed among the three groups in the changes of body weight, %Bwt/IBW, %LBM/Bwt, BUN, albumin, NPCR, and RRF from the baseline values after the 2-year follow-up.

7) There were significant inverse correlations between the mean tCO<sub>2</sub> level and NPCR( $r = -0.33$ ,  $P < 0.001$ ), %Bwt/IBW( $r = -0.32$ ,  $P < 0.001$ ), RRF( $r = -0.29$ ,  $P < 0.005$ ), and serum albumin level( $r = -0.24$ ,  $P < 0.05$ ). But, creatinine, %LBM/Bwt, and Kt/Vurea did not show any correlation with the mean tCO<sub>2</sub> level.

8) Using stepwise multiple regression analysis, NPCR( $\beta = -0.3491$ ,  $P < 0.001$ ), %Bwt/IBW( $\beta = -0.046$ ,  $P < 0.001$ ), and ultrafiltration volume( $\beta = -0.0012$ ,  $P < 0.005$ ) were independent factors affecting the mean tCO<sub>2</sub> level.

In conclusion, low total CO<sub>2</sub> level in long-term CAPD patients may reflect increased protein intake and mild to moderate degree of metabolic acidosis may not affect the nutritional status of well-dialyzed CAPD patients.

**Key Words :** CAPD, Metabolic acidosis, Serum albumin, Normalized protein catabolic rate

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