

CHAPTER 4

Results

Thirteen hemodialysis patients voluntarily participated in this study. However, the data of two subjects were excluded from this study because of instrument malfunctions during data collection. Thus, data in this study were analyzed from eleven hemodialysis patients. Basically, these subjects were in hypertension condition, age, BMI, resting HR, resting SBP, resting DBP, Kt/V_{urea} , hemoglobin, hematocrit, TSH, and normalized protein equivalent of nitrogen (nPNA) appearance, as shown in Table 1. The results showed that there were normal values of BMI, resting HR, resting SBP, resting DBP, Kt/V_{urea} , hemoglobin, hematocrit, and TSH. Descriptive statistics analysis was used for reporting demographic data. A repeated measures ANOVA test was used to compare the differences in REE and hemodynamic parameters.

Table 1. Characteristics of the hemodialysis patients. Values are presented as means \pm SD.

Variables	Hemodialysis patients [n = 11; F = 4, M = 7]
Hypertension condition (n)	11
Age (yrs)	51.36 \pm 8.55
Body weight (kg)	56.22 \pm 7.50
Dry weight (kg)	54.05 \pm 7.06

Table 1. Characteristics of the hemodialysis patients. Values are presented as means \pm SD. (continued)

Variables	Hemodialysis patients [n = 11; F = 4, M = 7]
BMI (kg/m ²)	20.87 \pm 1.93
Period of hemodialysis (months)	96.32 \pm 48.68
Resting HR (bpm)	78.00 \pm 10.28
Resting SBP (mmHg)	141.00 \pm 9.15
Resting DBP (mmHg)	78.00 \pm 11.45
Kt/V _{urea}	2.25 \pm 0.95
Hemoglobin (g/dL)	10.79 \pm 0.81
Hematocrit (%)	32.80 \pm 3.12
TSH (uIU/ml)	2.01 \pm 0.77
nPNA (g/kg/day)	0.84 \pm 0.21

Denote: F = female; M = male; HT = hypertension; BMI = body mass index; HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; Kt/V_{urea} = fractional clearance of body water of urea; TSH = thyroid stimulating hormone; nPNA = normalized protein equivalent of nitrogen appearance.

Basal energy of metabolism

The VO₂, VCO₂ and RER alterations in the pre-, during and post-hemodialysis procedures of hemodialysis patients are shown in Table 2 and Figure 2-4. The percent change of VO₂, VCO₂ and RER alterations in the pre-, during and post-hemodialysis

procedures of hemodialysis patients are shown in Table 3. The REE alterations in the pre-, during and post-hemodialysis procedures of hemodialysis patients are shown in Table 4 and Figure 5. The percent change of REE alterations in the pre-, during and post-hemodialysis procedures of hemodialysis patients are shown in Table 5. Telemetry gas analysis (Oxycon, Sensor Medics, USA) was used to assess REE in pre-, during and post-hemodialysis procedures. The whole process requires approximately five hours, including pre-hemodialysis, in which data were presented for 30 min; during hemodialysis, in which data were collected for 4 hours and recorded every 30 min; and post-hemodialysis, in which data were collected for 30 min. After that, the average of every 30 min of data was analyzed as the results. The results showed that VO_2 at pre-hemodialysis showed significant differences from the post-hemodialysis (204.56 ± 38.94 and 244.92 ± 62.76 ml/min at pre- and post-hemodialysis, respectively; $p < 0.05$). RER at 30th, 60th, 150th, 180th, 210th, and 240th min during hemodialysis showed significant differences from post-hemodialysis (0.92 ± 0.08 , 0.93 ± 0.11 , 0.92 ± 0.04 , 0.90 ± 0.05 , 0.90 ± 0.06 , and 0.89 ± 0.05 and 0.81 ± 0.07 ml/min at 30th, 60th, 150th, 180th, 210th, and 240th min during and post-hemodialysis, respectively; $p < 0.05$).

Table 2. VO_2 , VCO_2 and RER alterations for pre-, during and post-hemodialysis procedures. Values are presented as means \pm SD.

Time		VO_2 (ml/min)	VCO_2 (ml/min)	RER
Pre-hemodialysis		204.56 ± 38.94	180.85 ± 32.89	0.89 ± 0.08
During hemodialysis	30 th min	209.36 ± 32.84^c	191.21 ± 24.18^b	0.92 ± 0.08^c
	60 th min	$222.14 \pm 44.77^{b,c}$	205.07 ± 40.58	0.93 ± 0.11^c

Table 2. VO₂, VCO₂ and RER alterations for pre-, during and post-hemodialysis procedures. Values are presented as means ± SD. (continued)

Time		VO ₂ (ml/min)	VCO ₂ (ml/min)	RER
During hemodialysis	90 th min	220.50 ± 36.01	202.43 ± 29.46	0.93 ± 0.08
	120 th min	234.57 ± 57.40 ^a	216.43 ± 41.85	0.94 ± 0.11
	150 th min	205.50 ± 54.30	187.21 ± 42.10	0.92 ± 0.04 ^c
	180 th min	217.64 ± 49.27	194.21 ± 42.15	0.90 ± 0.05 ^c
	210 th min	215.29 ± 50.92	191.00 ± 40.89	0.90 ± 0.06 ^c
	240 th min	219.36 ± 48.41	193.57 ± 44.58	0.89 ± 0.05 ^c
Post-hemodialysis		244.92 ± 62.76 ^a	199.53 ± 56.50	0.81 ± 0.07

Denote: VO₂ = oxygen consumption; VCO₂ = carbondioxide product; RER = respiratory exchange ratio

^a significant different from pre-hemodialysis at p < 0.05.

^b significant different from previous value at p < 0.05.

^c significant different from post-hemodialysis at p < 0.05.

Table 3. Percent change of VO₂, VCO₂ and RER alterations for pre-, during and post-hemodialysis procedures.

Time		VO ₂ (%)	VCO ₂ (%)	RER (%)
Pre-hemodialysis		100	100	100
During hemodialysis	30 th min	102.34	105.73	103.37
	60 th min	108.59	113.39	104.49
	90 th min	107.79	111.93	104.49
	120 th min	114.67	119.67	105.62

Table 3. Percent change of VO₂, VCO₂ and RER alterations for pre-, during and post-hemodialysis procedures. (continued)

Time		VO ₂ (%)	VCO ₂ (%)	RER (%)
During hemodialysis	150 th min	99.97	103.52	103.37
	180 th min	106.39	107.39	101.12
	210 th min	105.25	105.61	101.12
	240 th min	107.24	107.03	100
Post-hemodialysis		119.73	110.33	91.01

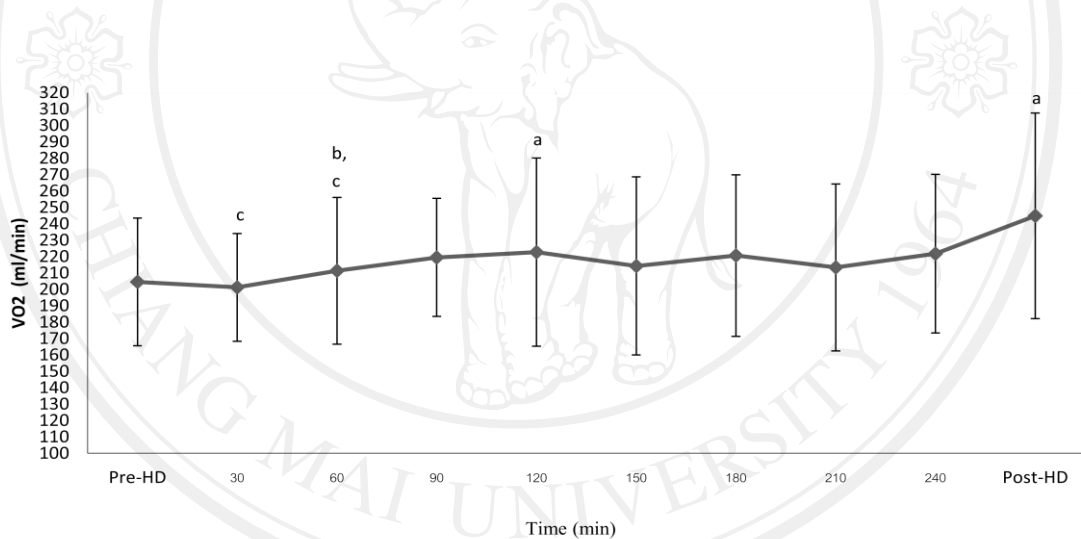


Figure 2 Oxygen consumption (VO₂). VO₂ data were used an average 30 min of pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as mean ± SD. ^a significant different from pre-hemodialysis at $p < 0.05$, ^b significant different from previous value at $p < 0.05$, ^c significant different from post-hemodialysis at $p < 0.05$.

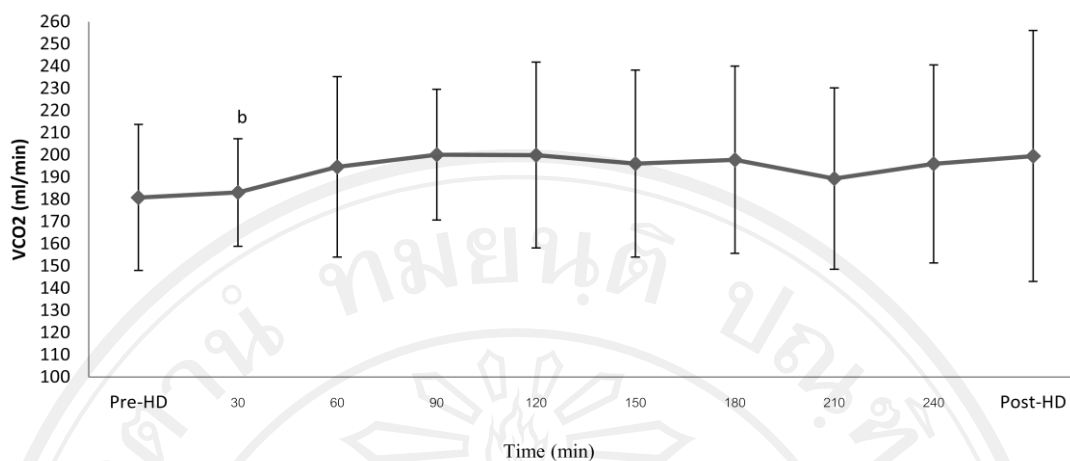


Figure 3 Carbondioxide product (VCO₂). VCO₂ data were used an average 30 min of pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as mean ± SD. ^a significant different from pre-hemodialysis at $p < 0.05$, ^b significant different from previous value at $p < 0.05$, ^c significant different from post-hemodialysis at $p < 0.05$.

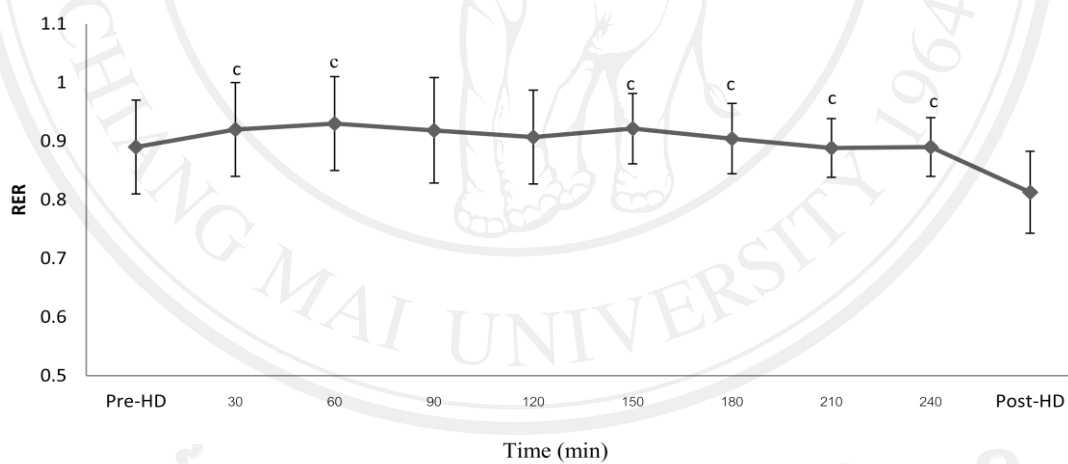
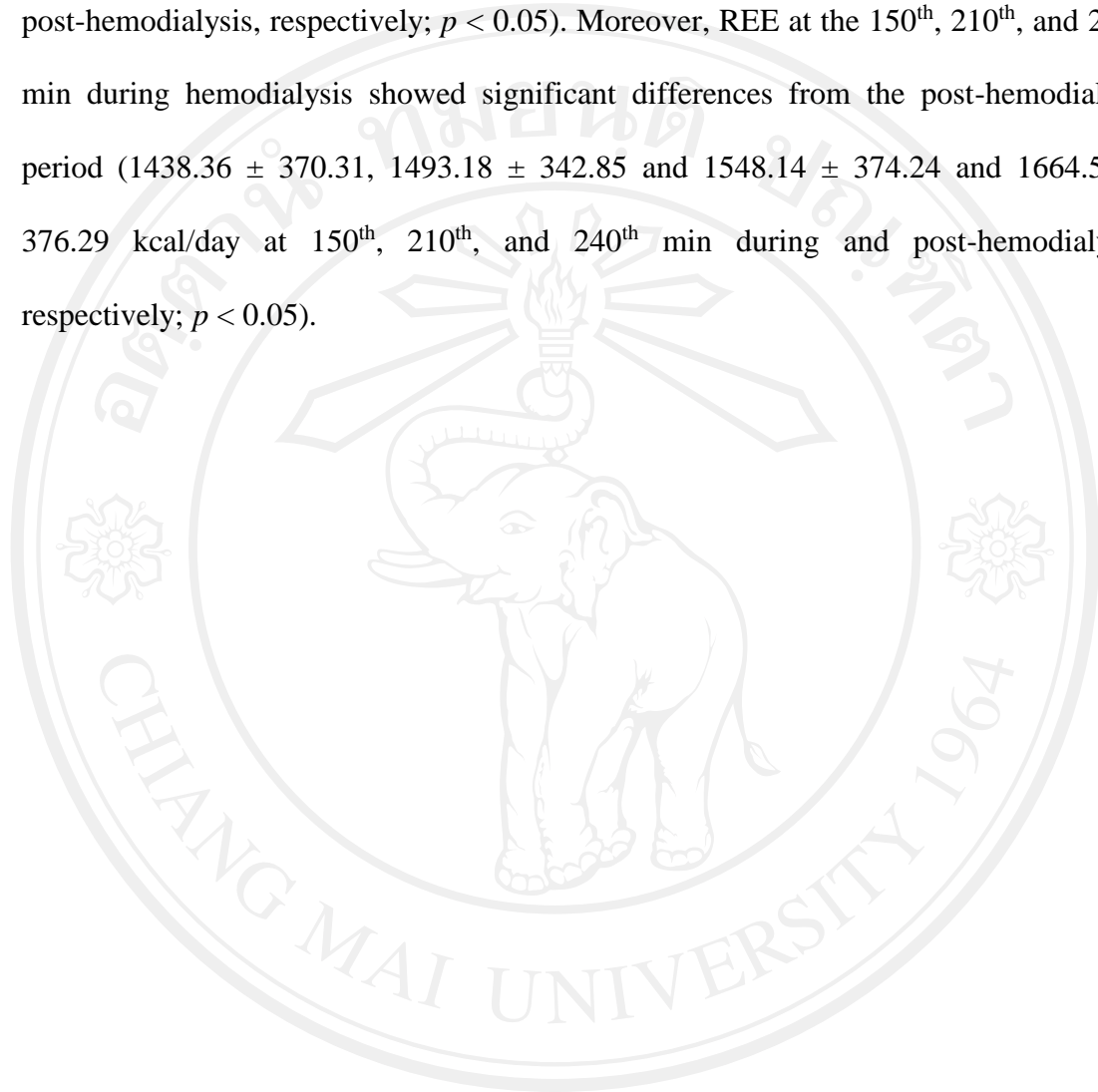


Figure 4 Respiratory exchange ratio (RER). RER data were used an average 30 min of pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as mean ± SD. ^a significant different from pre-hemodialysis at $p < 0.05$, ^b significant different from previous value at $p < 0.05$, ^c significant different from post-hemodialysis at $p < 0.05$.

The results showed that REE at pre-hemodialysis differences from the post-hemodialysis periods (1463.40 ± 353.34 and 1664.54 ± 376.29 kcal/day at pre- and post-hemodialysis, respectively; $p < 0.05$). Moreover, REE at the 150th, 210th, and 240th min during hemodialysis showed significant differences from the post-hemodialysis period (1438.36 ± 370.31 , 1493.18 ± 342.85 and 1548.14 ± 374.24 and 1664.54 ± 376.29 kcal/day at 150th, 210th, and 240th min during and post-hemodialysis, respectively; $p < 0.05$).



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Table 4. REE alterations for pre-, during and post-hemodialysis procedures. Values are presented as means \pm SD.

Time		REE (kcal/day)
Pre-hemodialysis		1463.40 \pm 353.34
During hemodialysis	30 th min	1557.00 \pm 276.72
	60 th min	1555.09 \pm 355.50
	90 th min	1532.00 \pm 341.36
	120 th min	1596.32 \pm 393.97
	150 th min	1438.36 \pm 370.31 ^c
	180 th min	1492.18 \pm 313.52
	210 th min	1493.18 \pm 342.85 ^c
	240 th min	1548.14 \pm 374.24 ^c
Post-hemodialysis		1664.54 \pm 376.29 ^a

Denote: kcal/day = kilocalories per day.

^a significantly different from pre-hemodialysis at $p < 0.05$.

^b significantly different from previous value at $p < 0.05$.

^c significantly different from post-hemodialysis at $p < 0.05$.

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Table 5. The percent change of REE alterations in the pre-, during and post-hemodialysis procedures.

Time	REE (%)	
Pre-hemodialysis	100	
During hemodialysis	30 th min	106.39
	60 th min	106.27
	90 th min	104.69
	120 th min	109.08
	150 th min	98.29
	180 th min	101.97
	210 th min	102.03
	240 th min	105.79
Post-hemodialysis	113.74	

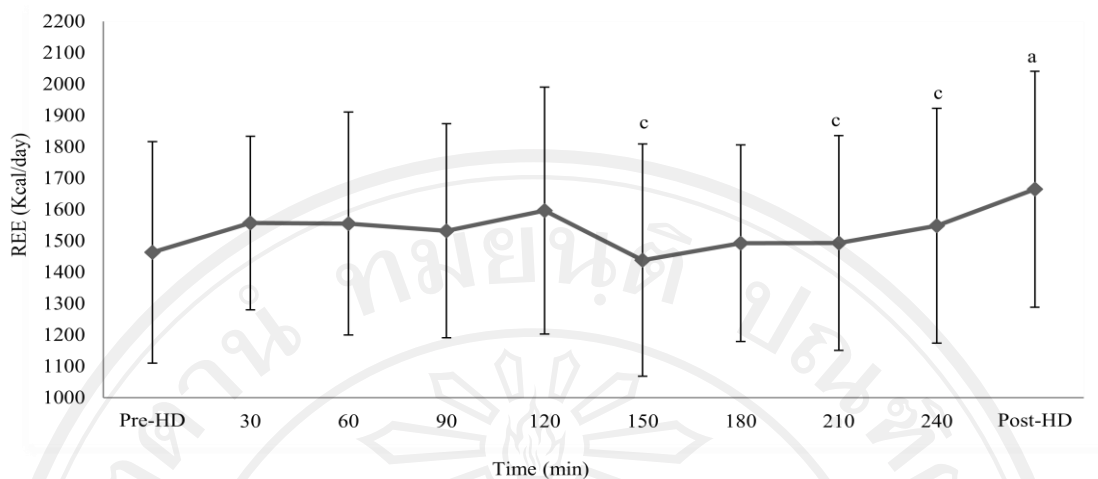


Figure 5 Resting energy expenditure (REE). REE data were used an average 30 min of pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as mean \pm SD. a significant different from pre-hemodialysis at $p < 0.05$, b significant different from previous value at $p < 0.05$, c significant different from post-hemodialysis at $p < 0.05$.

Hemodynamics

The hemodynamics alterations in the pre-, during, and post-hemodialysis procedures of hemodialysis patients are shown in Table 4 and Figure 6-13. PhysioFlow® Hemodynamics Redefined (Manatec, France) was used to assess hemodynamics alterations in the pre-, during, and post-hemodialysis procedures. The whole process requires approximately five hours, including pre-hemodialysis, in which data were collected for 30 min; during hemodialysis, in which data were collected for 4 hours and recorded every 30 min; and post-hemodialysis, in which data were collected for 30 min. After that, an average of every 30 min of data was analyzed as the results. There were

significant differences in SV, HR, CO, EDV, EF, TPR, SBP, and DBP among pre-, during, and post-hemodialysis periods.

Table 6. Hemodynamics alteration at pre-, during and post-hemodialysis procedures.

Values are presented as means \pm SD.

Time		SV (ml)	CO (L/min)	EDV (ml)	EF (%)	TPR (mmHg/L/ min)
Pre-hemodialysis		89.92 \pm 20.22	7.02 \pm 2.03	171.76 \pm 38.26	53.25 \pm 12.31	1206.50 \pm 327.69
During hemodialysis	30 th min	88.03 \pm 23.15	6.59 \pm 2.20	169.39 \pm 40.20	52.40 \pm 12.20 ^c	1322.89 \pm 405.90 ^a
	60 th min	90.88 \pm 27.55	6.85 \pm 2.52	174.84 \pm 51.02	52.21 \pm 11.74 ^c	1312.52 \pm 434.05
	90 th min	92.50 \pm 23.28 ^c	6.90 \pm 2.19 ^c	182.49 \pm 45.08	51.85 \pm 12.88	1258.93 \pm 364.93
	120 th min	89.89 \pm 22.89	6.54 \pm 2.00	177.06 \pm 37.90	51.36 \pm 12.88	1339.63 \pm 438.26 ^a
	150 th min	83.13 \pm 22.85 ^b	6.20 \pm 2.01 ^a	167.22 \pm 35.24 ^b	49.92 \pm 12.45 ^{a, b}	1412.46 \pm 457.56 ^a
	180 th min	86.06 \pm 19.32	6.17 \pm 2.01 ^a	171.71 \pm 37.11	49.15 \pm 12.50 ^a	1425.84 \pm 446.74 ^a
	210 th min	79.82 \pm 21.27 ^a	6.29 \pm 2.18	172.52 \pm 40.43	49.37 \pm 12.24 ^a	1397.67 \pm 382.23 ^a

Table 6. Hemodynamics alteration at pre-, during and post-hemodialysis procedures.

Values are presented as means \pm SD. (continued)

Time		SV (ml)	CO (L/min)	EDV (ml)	EF (%)	TPR (mmHg/L/ min)
During hemodialysis	240 th min	82.69 \pm	6.10 \pm	170.37 \pm	49.15 \pm	1375.73 \pm
		23.41	2.29 ^a	38.77	12.31 ^a	360.69 ^a
Post-hemodialysis		85.54 \pm	6.21 \pm	175.67 \pm	49.69 \pm	1360.98 \pm
		25.91	2.47	56.75	11.85 ^a	296.57 ^a

Acronyms: SV = stroke volume; CO = cardiac output; EDV = end-diastolic volume; EF = ejection fraction; TPR = total peripheral resistance.

^a significantly different from pre-hemodialysis at $p < 0.05$.

^b significantly different from previous value at $p < 0.05$.

^c significantly different from post-hemodialysis at $p < 0.05$.

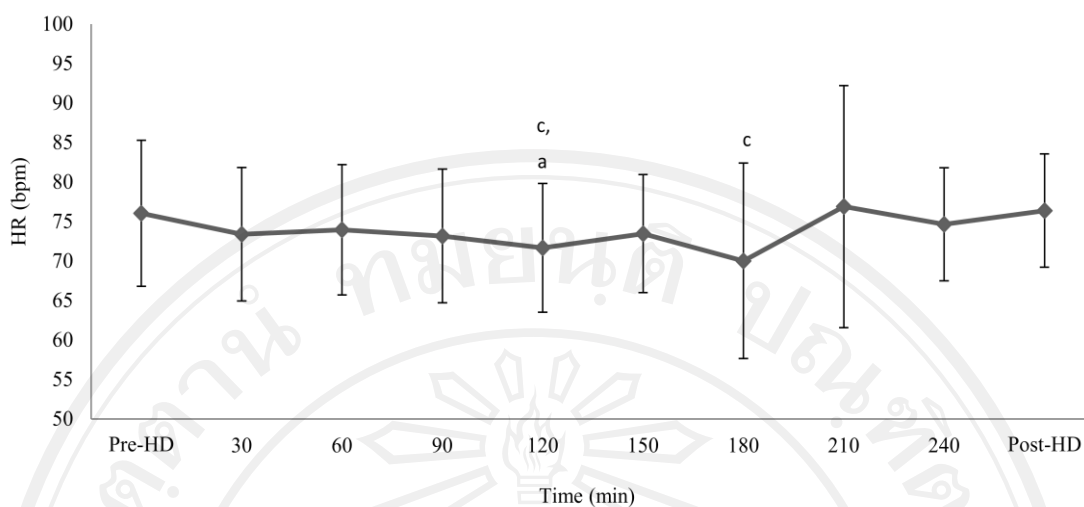


Figure 6 Heart rate (HR). HR data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.

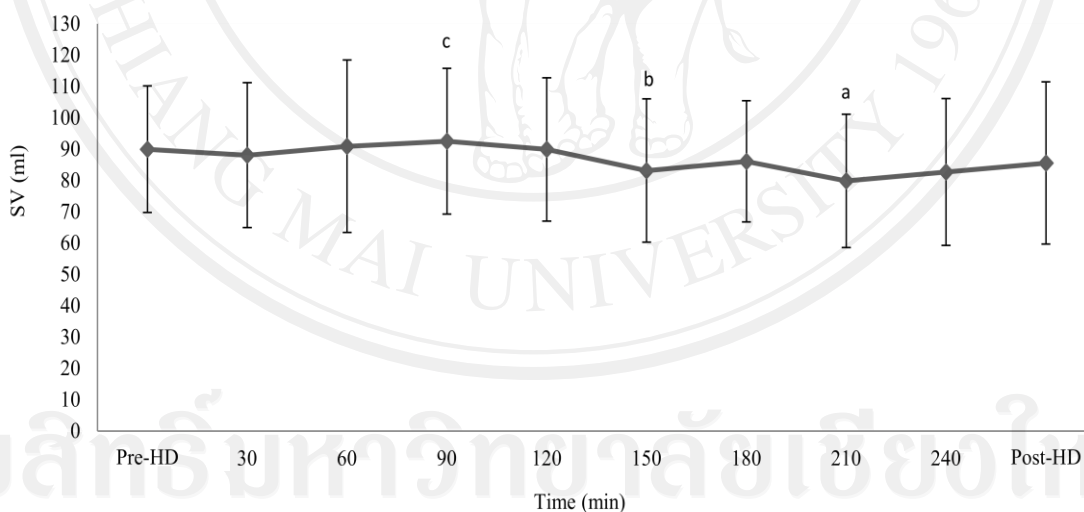


Figure 7 Stroke volume (SV). SV data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.

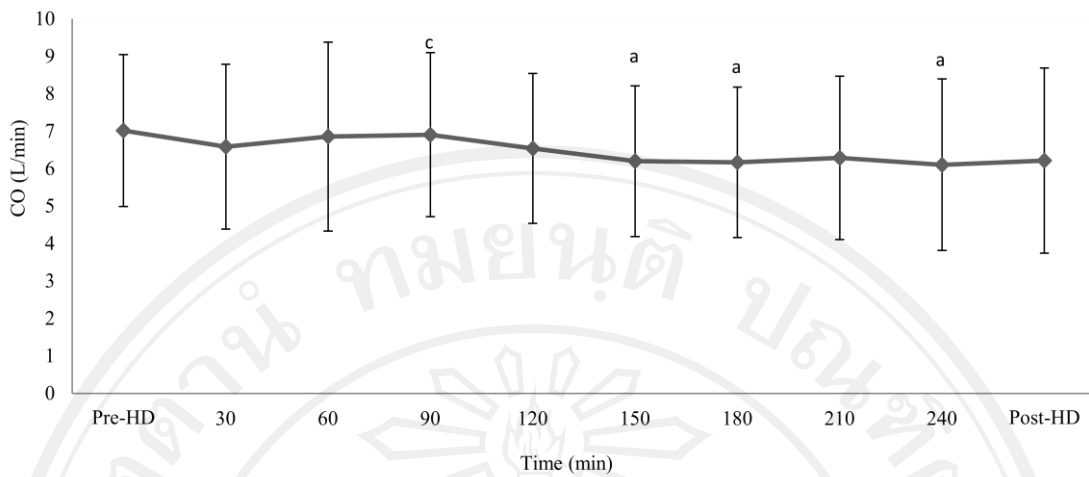


Figure 8 Cardiac output (CO). CO data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.

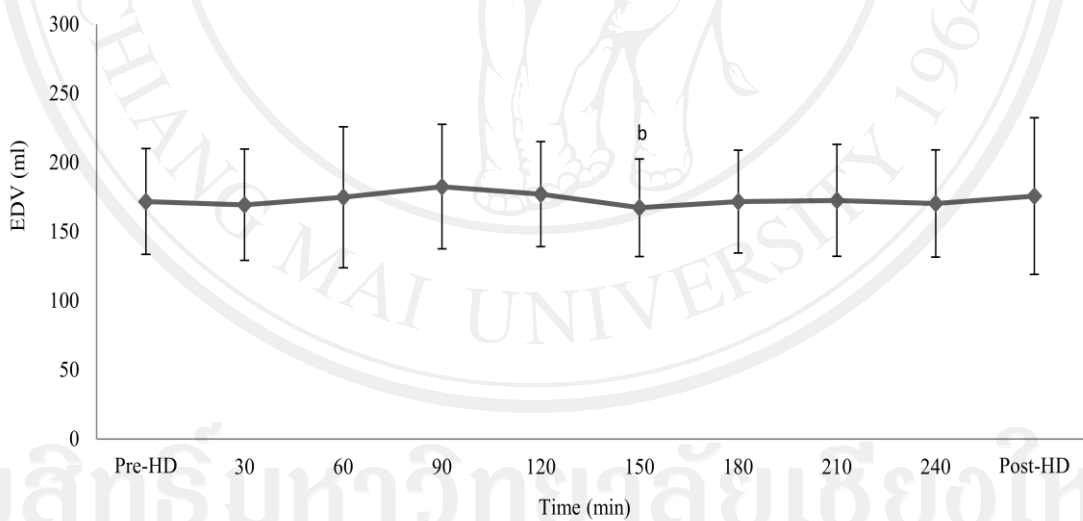


Figure 9 End-diastolic volume (EDV). EDV data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.

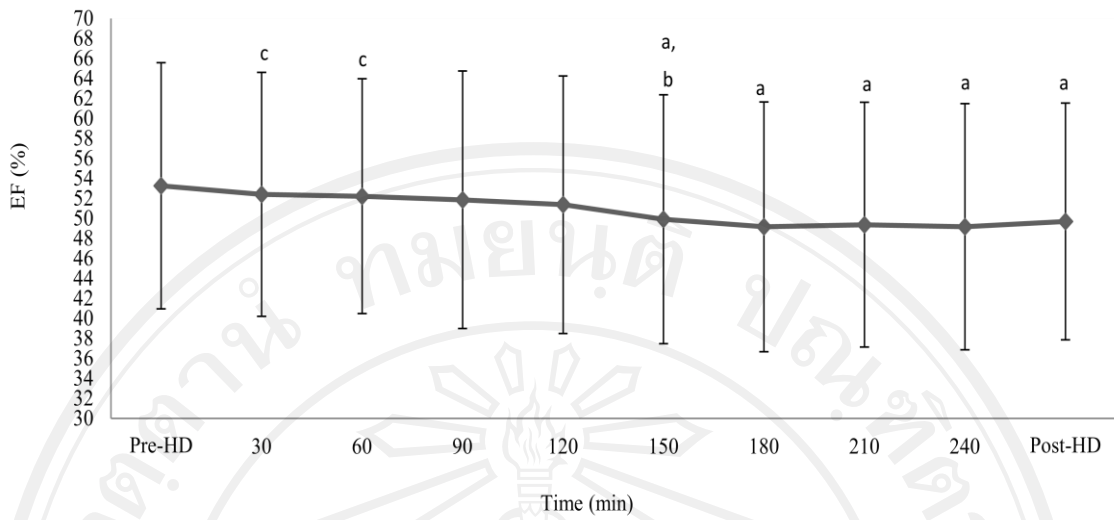


Figure 10 Ejection fraction (EF). EF data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.

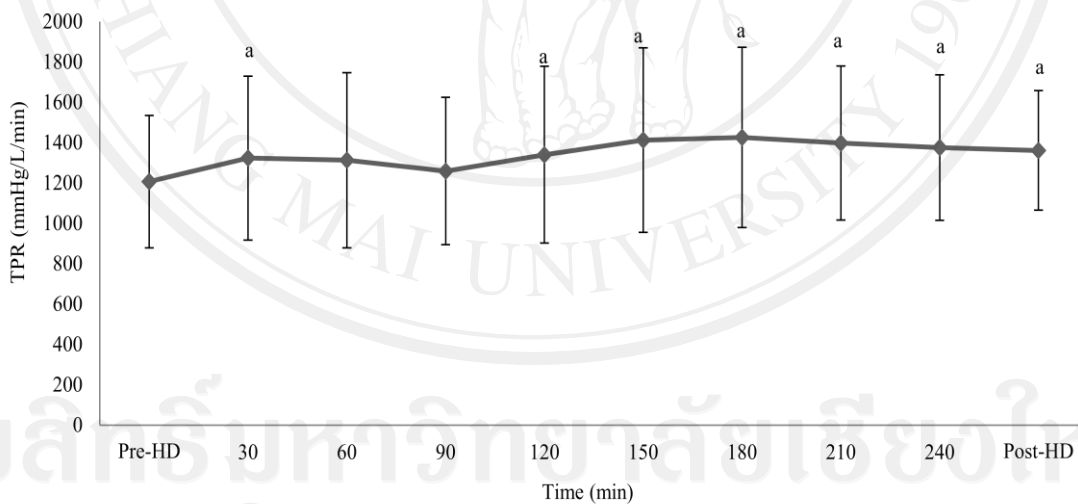


Figure 11 Total peripheral resistance (TPR). TPR data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.

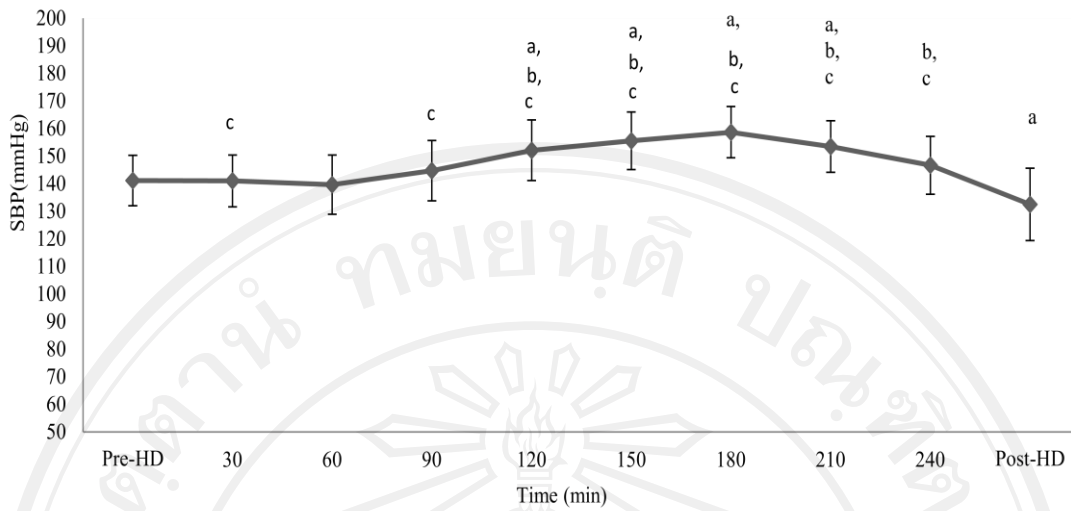


Figure 12 Systolic blood pressure (SBP). SBP data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.

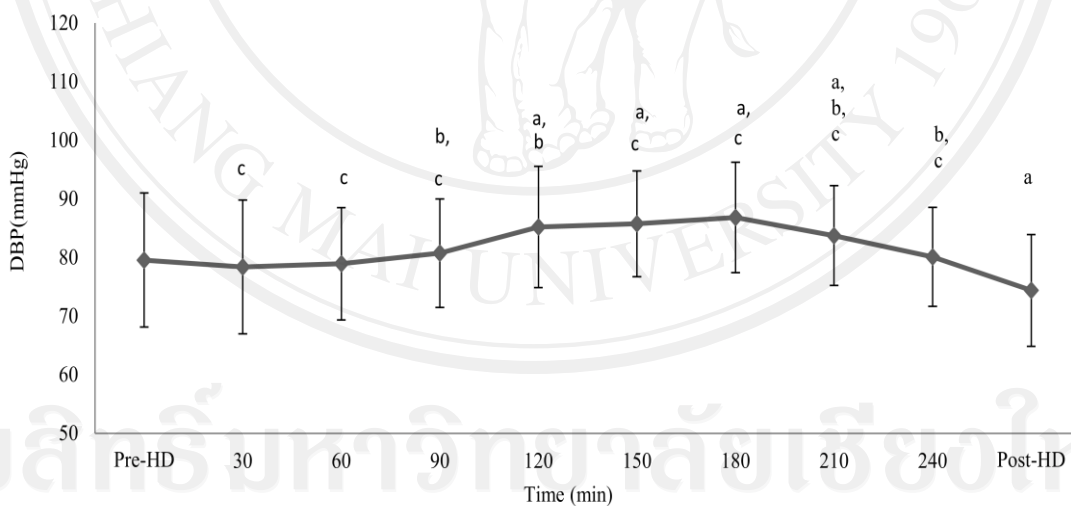


Figure 13 Diastolic blood pressure (DBP). DBP data were averaged every 30 min in pre- and post-hemodialysis periods, as well as for each 30 min of hemodialysis. All data are presented as means \pm SD. ^a significantly different from pre-hemodialysis at $p < 0.05$, ^b significantly different from previous value at $p < 0.05$, ^c significantly different from post-hemodialysis at $p < 0.05$.