Effects of shift work on psychophysical health of pregnant women

— Urinary Norepinephrine level and STAI-A-State score —

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Abstract

It has been suggested that shift work, night work in particular, affects one's psychophysical health. However, the effects of night work on the health of pregnant women are not psychophysically well elucidated. The effects of night work on the biological function and psychological response of pregnant women were studied. Three pregnant and six non-pregnant nurses that engaged in fast-rotating shift system cooperated for the study. The 24-hour urine samples were collected on the day shift, the night shift and the days off in two time frames, daytime (07:00 to 23:00) and nighttime (23:00 to 07:00). Urinary concentration of norepinephrine (NE) was measured by enzyme-linked immunosorbent assay (ELISA) and expressed as the physiological index. The STAI-A-State score was employed as the psychological index. The urinary NE level during the night work was the highest among the three work shifts. The urinary NE level of the pregnant subjects during the night work was more than twice higher than those of the non-pregnant. It was suggested that the physical burden due to the night work would be larger in the pregnant subjects than in the non-pregnant. The results of STAI-A-State suggested that the psychological stress at the night shift was remarkably increased both in the pregnant shift workers and in the non-pregnant ones. At the 32 weeks of gestation, both levels of the urinary NE and the A-State score of pregnant shift worker increased remarkably. The effects of shift work on urinary excretion rates of NE and A-State score of the pregnant subjects mentioned above, suggested that not only the night work but also the day work in the last trimester of the pregnant shift workers should be much more relieved.

Key words : shift work, pregnant women, norepinephrine, STAI-A-State

Introduction

It has been reported that shift work affects one's health. Shift work, particularly night work, disturbs the biological rhythms of workers, giving rise to adverse affects on their psychophysical health. Female shift workers can be more vulnerable than male workers to their reproductive function[1-3]. Since a number of adverse pregnancy outcomes, such as spontaneous abortion, premature delivery and low birth weight are found to be related to shift work[1-3], health care for the pregnant shift workers is an impor-

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tant social issue. However, the exact influence of shift work on the health of pregnant women has not necessarily been psychophysiologically well elucidated. Therefore, the effects of shift work, particularly night work, on the health of pregnant workers, with special reference to biological function and psychological response, need to be examined. The biological function of pregnant shift workers in the study was estimated by measuring urinary norepinephrine and the psychological response by STAI-A-State.

It is well known that norepinephrine (NE) is primarily secreted in response to physical exertion. Plasma NE concentration shows a tendency to be high during the daytime when one is in activity and low during the night when one is at rest. These characteristics of NE have lead investigators to use NE as an indicator of physical fatigue or stress[4-6].

Unlike serum level of NE that quickly fluctuates over time, urinary metabolite provide average assessment of the level of the hormone. Therefore, urinary excretion of NE was measured in the study. It is already known that the urinary concentrations of NE correlate well with their respective serum levels[7-9].

The State-Trait Anxiety Inventory (STAI) was developed by Spielberger and introduced to Japan by Toyama[10-12]. The State-Trait Anxiety Inventory is composed of two parts of scale, which is State-anxiety and Trait-anxiety. The validity and reliability of both these scales are satisfactory and the STAI-A-State scale, combination of them is appropriate indicator to assess the psychological influence[13].

Here assessed was the psychophysical effect of shift work including night work on the health of pregnant women, with special reference to biological functions and psychological aspects, which have not been studied in detail.

Materials and methods

Subjects

Three pregnant and six non-pregnant nurses took part in the study as the subjects (Table 1). The pregnant nurses were between 32 and 39 years of age (average 34.3). They had heights within normal range (average 158.7cm) and had normal body weights before gestation (average 55.2kg). All were multiparas, and were eventless throughout their gestations. In fact, almost one month after completion of their cooperation to this study, all pregnant subjects had a normal full term delivery. Non-pregnant subjects were all healthy, single, and manifested regular monthly cycles. They ranged in age from 22 to 38 years (average 29.7), and had body heights and weights within normal range (average 156.8cm, 50.8kg). None of the nine subjects smoked, drank and were on any medication. All nine subjects were engaged in the same pattern of shift rotation system in the same hospital, and then there was no much difference in their work conditions. In order to decrease the masking effects on hormonal secretions, the nine examinees were requested to avoid excessive exercise, drinking, staying up late at night, and to keep their usual daily life style during the sampling period. Documented informed consents were obtained from all participants.

Table 1. Characteristics of the subjects

	Pregnant (n=3)	Non-pregnant (n=6)
Age (yr)	34.3 (32-39)	29.7 (22-38)
Height (cm)	158.7 (150.0-164.0)	156.8 (148.0-165.0)
Weight (kg)	55.0 (49.0-62.0) (before gestation)	50.8 (42.0-60.0)
Number of childlen	1-2	0

Data are presented as mean (range) or range.

Shift system

All nine nurses were on a randomly-ordered fast-rotating shift system based on a backward rotation system, which was a 7 day-cycle composed of daytime, evening and night shift. Two days off were set for every five-work day. The working times for day, evening and night shift were 08:00-16:00, 16:00-00:00 and 00:00-08:00, respectively.

Urine collection and measurement of norepinephrine

Taking into account the secretory profiles of hormones during a day, the 24-hour urine samples were collected divided into two time frames, daytime (from 07:00 to before 23:00) and nighttime (from 23:00 to before 07:00). We collected urine samples on the day shift, the night shift and the days off (Table 2). On the days off and on the day shift, the daytime urine samples were collected first, followed by the nighttime samples. On the night shift, the nighttime urine samples were collected first and followed by the daytime samples. Ten ml of urine, for analysis of NE, was stored at -80℃ with the additive of 100μl of 6 N hydrochloric acid[7,14]. All urine samples were collected from December 1998 to November 1999.

Table 2. Time frames for urine sampling

	Daytime urine (07:00−23:00)	Nighttime urine (23:00−07:00)
Days off[1)]	Rest	Rest
Day shift[1)]	Work (08:00−16:00)	Rest
Night shift[2)]	Rest	Work (00:00−08:00)

1) The daytime urine samples were collected first and followed by the nighttime.
2) The nighttime urine samples were collected first and followed by the daytime.

All pregnant subjects were examined four times: 20-23 weeks of gestation (designated hereafter as G 1), 26-28 weeks (G 2), 32 weeks (G 3) and 36 weeks (G 4) (Table 3). They were exempted from night duty after 32 weeks and took maternity leave after 36 weeks of gestation. Therefore, their urine samples were collected and examined on the days off and on the day shift for the G 3 and only on the days off for the G 4. In order to avoid the effects of menstrual cycle on NE secretion, urine samples from the non-pregnant subjects were collected once per each work shift exclusively at their follicular phase.

Table 3. Shift schedule and urine sampling for pregnant subjects with gestational stages and for non-pregnant ones

	pregnant n=3				non-pregnant n=3
	G 1	G 2	G 3	G 4	follicular
days off	○	○	○	○	○
day shift	○	○	○	×	○
night shift	○	○	×	×	○

○ : sampling, × : no sampling,
G 1 : 20-23wk, G 2 : 26-28wk, G 3 : 32wk, G 4 : 36wk.

Urinary concentration (ng/ml) of free NE was measured in duplicates by enzyme-linked immunosorbent assay (ELISA, IBL,

Hamburg, Germany). For comparison of hormone levels among the three shifts the results were standardized as an excretion rates per hour (μg/h). The correction of these levels by urinary creatinine concentration gave the same values as the standardized ones. Thus, the results were presented as the excretion rates.

Inquiry survey of STAI-A-State

A psychophysical response of hospital nurse during each work shift was measured using STAI-A-State scale. The STAI-A-State asks to subjects how they feel about them selves at the exact moment. The Self-Evaluation Questionnaire of STAI-A-State is composed of twenty items. The questionnaires ask a four-stage reply. On this scale, the larger the score, the higher the anxiety. The total score of the STAI-A-State ranges actually from 20 to 80 points[12]. The questionnaire for estimation of STAI-A-State was carried out to subjects at daytime both on the days off and the day shift, and ones at midnight on the night shift. The A-State score was compared each other among the work shifts. And it was also compared between pregnant nurses and non-pregnant ones. In addition, sleep or nap times during each shift were recorded by each examinee (Table 4).

Table 4. Hours of sleep/nap on work shift

		pregnant (n=3)	non-pregnant (n=6)
Days off	sleep	6.3±0.48	6.9±0.08
Day shift	sleep	6.0±0.48	7.2±0.28
Night shift	nap	1.0±0.39	1.0±0.63

Data are presented as mean ± SE.

Statistical analysis

Statistical analysis was performed by analysis of variance (ANOVA) for NE levels and t-test for STAI-A-State scores.

Results

1. Urinary excretion rates of NE

The effects of shift work on urinary excretion rates of free NE were compared between pregnant and non-pregnant women in relation to the 4 factors: shift, day/night, pregnancy and individual. Statistical analysis was performed by four-way analysis of variance. For this analysis, the data from the collection time frames of G1 through G2 for pregnant and non-pregnant subjects were used (Table 3). Data included measurements at all work shifts; the days off, the day shift and the night shift.

The day and the night urinary NE levels (μg/h) of the pregnant and the non-pregnant subjects on the three work shifts were presented in figure 1 (Fig. 1). The day levels of urinary NE were higher than the night levels for both the days off and the day shift. This was observed in both the pregnant and the non-pregnant subjects. On the night shift, however, the night levels of urinary NE were elevated, and slightly higher than the day levels both for the pregnant and the non-pregnant subjects. For the day levels of urinary NE in the non-pregnant subjects, the day shift showed the highest level and the night shift showed the lowest (1.86 μg/h and 1.25 μg/h, respectively). Whereas, for the pregnant subjects, the night shift showed the highest level, while the day shift showed the lowest (2.77μg/h and 2.40μg/h, respectively).

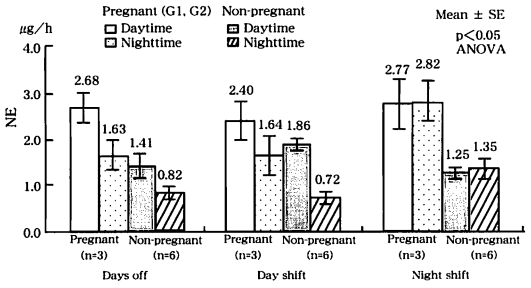

Fig 1. Urinary NE levels of pregnant and non-pregnant shift workers

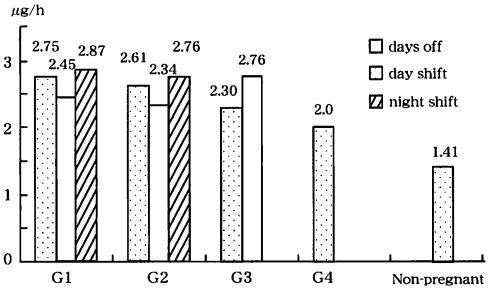

Fig 2. Urinary NE level on each gestational stage and on the days of non-pregnant

For the night levels of urinary NE, the night shift showed the highest for both the pregnant and the non-pregnant subjects (2.82 μg/h and 1.35μg/h, respectively). Both the day and the night urinary NE levels of the pregnant shift workers were higher than those of the non-pregnant workers on all the corresponding shifts. Particularly on the nightshift, the pregnant subjects' data were more than twice higher than those of the non-pregnant both for the daytime and the nighttime level (Fig. 1).

The result from the analysis of variance showed significant effects of all factors: shift, day/night, pregnancy and individual on the urinary NE level ($p<0.05$, $p<0.001$, $p<0.05$ and $p<0.001$, respectively).

The figure 2 shows the change of urinary NE level with the course of pregnancy, and also demonstrates the NE level of non-pregnant ones at the follicular phase (Fig. 2). The NE level was not changed in each shift in the course of pregnancy. The NE level at G 1 and G 2 was highest at the night-shift among the three shifts. The NE level at the days off has decreased with the progression of pregnancy. However, even the lowest level at G 4 was higher than that of non-pregnant subjects. Besides, the NE levels at the days off in G 1 and G 2 were higher than those at the day shift. The day shift level of NE at G 3 was remarkably higher than those at G 1 and G 2, however.

2. *STAI-A-State score*

The A-State score of each work shift, i.e. the days off, the dayshift and the night shift, was compared. The A-State score of G 1 and G 2 were compared with the non-pregnant subjects score on each work shift. The change of A-State score with the course of pregnancy was also analyzed.

The A-State score of non-pregnant subjects was the highest on the night shift (53.8), followed by the day shift (49.5) and the days off (31.2) (Fig. 3). There was significant difference of scores between the days off and the day shift, and between the days off and the night shift ($p<0.01$, respectively). Also, there was a significant difference of score between the day shift and the night shift ($p<0.05$).

The A-State score of pregnant subjects showed the highest on the night shift (50.7) followed by the day shift (38.3) and the days off (28.7). This rank order of the A-State score of pregnant subjects was as same pattern as that of non-pregnant subjects. The A-State score of pregnant subjects demonstrated

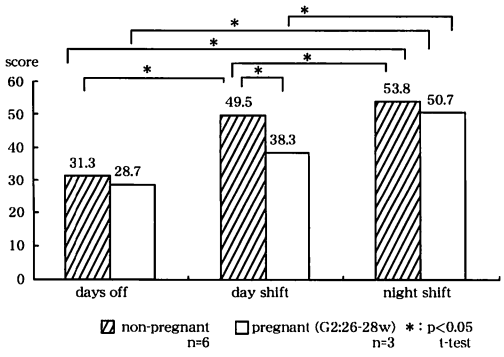

Fig 3. A-State score of each work shift

the significant differences between the days off and the night shift, and between the day shift and the night shift ($p<0.05$, respectively).

The A-State scores of non-pregnant subjects were higher than that of the pregnant ones on all work shifts. There was a significant difference between the pregnant subject's score of the day shift and the non-pregnant subject's ones (Fig. 3). From G 1 to G 2, there was no significant change of the A-State score on each corresponding work shift, i.e. the days off, the day shift and the night shift (Fig. 4). However, the A-State score of the days off (32.7) at G 3 indicated significantly higher level than that of G 1 ($p<0.05$). As for the A-State score of the day shift, the score of G 3 was the highest (54.3). There was significant differences in the A-State score between G 3 and G 1, and between G 3 and G 2 ($p<0.05$, respectively).

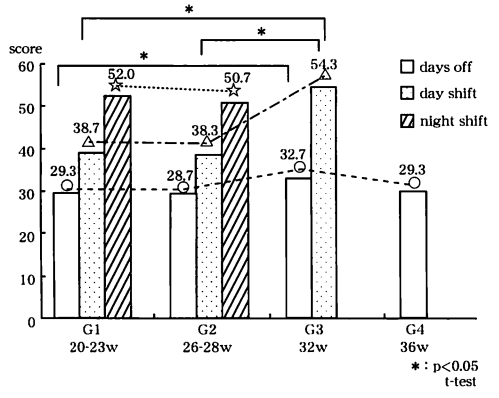

Fig 4. A-State score on each gestational stage

Discussion

Among all pregnant individuals who cooperated in this study, only three took uneventful course up to delivery and remained as available subjects for the analysis. Others were excluded from the analysis because of adverse outcome such as threatened abortion or premature delivery. Urine samples of three pregnant subjects were collected from G 1 to G 4, and urinary NE was measured. Thus, the effects of shift work on urinary excretion rates of NE with gestational age were studied. The data of the pregnant subjects were also compared with those of the non-pregnant ones.

Hospital nurses engaged in shift work tend to have irregular menstruation[15]. Among all non-pregnant nurses who agreed to cooperate with this study, only six had regular menstrual cycles and could participate in as subjects. All non-pregnant subjects were examined once per each work shift during the follicular phase of their monthly cycle. It took a long period to complete all sampling, as we had to wait for the appropriate timing when the three work shifts match with their follicular phase.

Twenty-four hour urine was collected divided into two timeframes, sixteen hours during daytime and eight hours at night, and the results were satisfactory.

NE

Urinary NE levels both on the days off and the day shift revealed evident difference between daytime and nighttime, i.e., high in the daytime and low in the nighttime. This was observed in both the pregnant and the non-pregnant subjects. These results do not contradict to the physiological profile of normal NE secretion[4-6]. Urinary NE levels on the night work, however, have significantly increased in both the pregnant and the non-pregnant subjects, and the evident day/night differences mentioned above have disappeared. Thus, the urinary NE excretion rates of nighttime were significantly affected by the work shifts in both the pregnant and the non-pregnant subjects. Night work generally raises the NE level to flatten the physiological rhythm of NE secretion[4-6]. The results of our analysis of variance indicated that this applies not only to non-pregnant but also to pregnant subjects. The enhanced NE levels during night work suggested the increase in physical burden to both the non-pregnant and the pregnant individuals.

It is reported that urinary and plasma NE levels are not different between pregnant and non-pregnant individuals[16,17]. However, our results from analysis of variance implied that urinary NE levels of the pregnant subjects were significantly higher than those of the non-pregnant subjects. In particular, the urinary NE level during night work of the pregnant subjects displayed twice as high as that of the non-pregnant individuals. These findings indicate that the physical burden by the night work would be larger in the pregnant subjects than in the non-pregnant. Besides, the urinary NE level during daytime immediately after night work was more than two times higher in the pregnant subjects than in the non-pregnant subjects. In the non-pregnant subjects, the daytime NE level immediately after the night work was the lowest among the daytime levels of the three shifts, while it was highest in the pregnant subjects. These findings suggest that pregnant shift workers would take insufficient rest after night work, presumably carrying fatigue from the night work over the next day[18,19].

The urinary NE level of the days off from G 1 , working period, to G 4 , non-working period, have consistently declined (Fig. 3). The NE levels in serum or in urine during pregnancy are on controversy; increased[20], decreased[21] or not changed[16]. None of these reports, however, referred to the relationship between NE level and workload of pregnant shift workers. The decrease in the urinary NE level of the days off with advancing pregnancy in the study might reflect relieve of workload by such as exemption from the night work and taking the maternity leave. However, urinary NE levels of the pregnant subjects were higher than that of the non-pregnant subjects even at G 4 when the work load was completely exempted. All of the pregnant participants on the study took care of their children during the sampling period. The enhanced urinary NE level might reflect not only the workload but also the household duties and child-rearing burden[5,19].

In spite of higher NE level of the pregnant subjects than that of the non-pregnant, the formers stayed healthy and gave birth to newborns uneventfully. It might be said, therefore, that the shift work including

night work, indeed was not as much as to affect maternal and fetal health, but it surely affected the urinary NE excretion rates.

A-STATE score

The change of A-State score during the each work shift of the pregnant subjects and the non-pregnant ones were analyzed. Also, the A-State score of G 1 and G 2 were compared with those of the non-pregnant subjects on each three work shift. The A-State scores of the non-pregnant subjects has increased in order from the days off (31.2), the day shift (49.6) and the night-shift (53.8). It represented that the nurse's state anxiety was evidently intensified during the night-shift. On the other hand, the A-State scores of the pregnant subjects were almost the same as those of the non-pregnant, and demonstrated the maximal value at the night-shift. The A-State score of the pregnant subjects during the nigh shift was significantly higher than those at the days off and the day shift, suggesting the pregnant subjects at night shift has strong sense of state anxiety. The comparison of non-pregnant and pregnant subjects indicated that the former had higher mark in either shift. The A-State score at the day shift gave significant difference between non-pregnant and pregnant groups. These results implied that non-pregnant group has more uneasiness than the pregnant one. When the A-State score was viewed from G 1 to G 2, no significant change was noted in the days off, the day shift and the night shift. The score at the days off was significantly elevated in G3 (32.7) than in G 1 (29.3) ($p<0.05$). In addition, the score at the day shift was higher in G 3 (54.3) than those at G 1 (38.7) and G 2 (38.3) ($p<0.05$, respectively). The score of the day shift in G 3 was highest in all scores. In other words, it was higher than that at night shift. These results suggested that the pregnant subjects, despite of exemption from night work has substantial state anxiety even during the day shift. In effect, the urinary NE excretion on the day shift was markedly enhanced on G 3, which however, displayed no statistical significance between those at G 1 and G 2. These results disclosed that the daytime job at G 3 is a large burden for pregnant nurses not only physically but also psychologically.

It is reported that, elevated NE level produces uterine contraction[22,23] rendering deleterious effects on the health of the mother and fetus. These reports as well as our results here suggest that some policy to relieve the workload of the pregnant shift workers should be taken.

Future tasks

Since the study described here is an experimental study with combination of field visits, the control for masking effects on hormone secretion might not be adequate. The increase in the number of subjects and more control of such masking effects would be necessary for future study.

Conclusions

The effects of shift work including night work on the urinary excretion rates of NE and A-State score of pregnant subjects and non-pregnant ones were summarized as follows;

1. The urinary NE level of the pregnant subjects during night work was remarkably higher than that of the non-pregnant subjects. Therefore, it was suggested that the physical burden due to the night work in pregnant subjects was larger than that in non-pregnant subjects.

2. The A-State score of pregnant subjects during the night shift was significantly higher than those at the days off and the day shift. It was suggested that the pregnant subjects at night shift has strong sense of state anxiety.

3. At the 32 weeks of gestation, both levels of the urinary NE and the A-State score of pregnant shift worker increased remarkably.

4. The effects of shift work on urinary excretion rates of NE and A-State score of the pregnant subjects mentioned above, suggested that not only the night work but also the day work in the last trimester of the pregnant shift workers should be much more relieved.

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References

1) Scott AJ., et al.: Shiftwork: Effects on sleep and health with recommendations for medical surveillance and screening. Occup Med: State of the Art reviews 5 : 273-299, 1990.

2) Costa G. The problem: shiftwork. Chronobiol Int. 14 (2) : 89-98, 1997.

3) Nurminen T. Shift work and reproductive health. Scand J Work Environ Health. suppl 3 : 28-34, 1998.

4) Fujiwara S., et al.: The acute effects of experimental short-term evening and night shifts on human circadian rhythm; the oral temperature, heart rate, serum cortisol and urinary catecholamines levels. Int Arch Occup Environ Health. 63: 409-418, 1992.

5) James GD. et al.: The association between daily blood pressure and catecholamine variability in normotensive working women. Psychosom. Med 55 (1): 55-60, 1993.

6) Sluiter JK., et al.: Work stress and recovery measured by urinary catecholamines and cortisol excretion in long distance coach drivers. Occup Environ Med. 55 (6) : 407-413, 1998.

7) Bojkowski CJ., et al.: Melatonin secretion in humans assessed by measuring its metabolite, 6-sulfatoxymelatonin. Clin Chem. 33 (8) : 1343-1348, 1987.

8) Akerstedt T., et al.: Comparison of urinary and plasma catecholamine responses to mental stress. Act Physiol Scand. 117 (1) : 19-26, 1983.

9) Wolfrum R. Comparison of total urinary oestrogens and total serum oestriol in pregnancy. Clin Chim Acta. 86 (3) : 357-367, 1978.

10) SPIEL BERGER C. D., ed. Anxiety and Behaviour. Academic Press. New York. 1966.

11) SPIEL BERGER C. D., STAI Manual. Consulting Psychologists Press. California. 1970.

12) TOYAMA N., et al.: Proceeding of the 40th Annual Meeting of the Japanese Society for Psychology, 891-892. A study on state-trait anxiety inventory. 1976.

13) Iwamoto M., et al.: A study of the state-trait anxiety inventory (STAI) and its application to noise stress Japanese Journal of Hygiene. 43 : 1116-1123, 1989.

14) Oishi S., et al.: Catecholamine. Japanese Journal of Clinical Medicine. 53 : 507-510, 1995. in Japanese.

15) Miyauchi F., et al.: Effects of night shift on plasma concentrations of melatonin, LH, FSH and prolactin, and menstrual irregularity. Jpn J Ind Health. 34 (6) : 545-550, 1992. in Japanese with English abstract.

16) Zuspan FP. Urinary excretion of epinephrine and norepinephrine during pregnancy. J Clin Endocrinol Metab. 30 (3) : 357-360, 1970.

17) Vaha-Eskeli KK., et al.: Effects of short- term thermal stress on plasma catecholamine concentrations and plasma renin activity in pregnant and nonpregnant women. Am J Obstet Gynecol. 167 (3) : 785-789, 1992.

18) Miyaue H. Evaluation of 12-hour time shift work from the excretory rhythm of urinary catecholamines. J Kyoto Pref. Univ. Med. 107 (9) : 1005-1016, 1998. in Japanese with English abstract.

19) Lundberg U., et al.: Stress and workload of men and women in high-ranking positions. J Occup Health Psychol. 4 (2) : 142-151. 1999.

20) Takeda M. Urinary adrenaline and noradrenaline in the field of obstetrics and gynecology. Igaku Kenkyu. 39 : 366-391, 1969. in Japanese with English abstract.
21) Natrajan PG., et al.: Plasma noradrenaline and adrenaline levels in normal pregnancy and in pregnancy-induced hypertension. Br J Obstet Gynaecol. 89 (12) 1041-1045, 1982.
22) Roy AC., et al.: Pharmacology of parturition. Ann Acad Med Singapore. 20 (1) : 71-77, 1991.
23) Pennefather JN., et al.: Supersensitivity to the stimulant action of noradrenaline on human myometrium near term. Reprod Fertil Dev. 5 (1) : 39-48, 1993.