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PDF issue: 2026-11-02

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(Citation)
Bulletin of allied medical sciences Kobe : BAMS (Kobe),3:45-51

(Issue Date)
1987-12-10

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(URL)
https://hdl.handle.net/20.500.14094/80070276

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Mechanism of Hemodynamic Changes Induced by Micturition in Human Subjects

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and Yasuyuki Ueba[1]

It is well known that various cardiovascular disorders are developed by hemodynamic changes related to micturition. However, it is still obscure what mechanism plays an important role in the setting of this hemodynamic changes. As we reported before on experimental rats, a rise in vesical pressure activated sympathetic nerve activity in different magnitude by each organ and this reflex was mediated through the spinal pathway. However, it is not clear yet whether this mechanism developes in human subjects as well.

Patients with spinal transection and healthy young males were subjected. When vesical pressure was loaded to a patient with spinal transection at C_1 level, hypertension was developed and accompanied by bradycardia due to baroreflex. However, in a patient with spinal transection below L_1 level, the rise in vesical pressure did not affect these parameters. These results clearly showed that hemodynamic changes induced by micturition was mediated through spinal reflex.

For the purpose of measuring peripheral circulation, the amplitudes of photoelectric pletysmograms of ear, finger and toe were recorded simultaneously. The amplitudes of the finger and toe decreased during micturition, while the amplitude of the ear increased. After micturition, each response was inverted. These results suggested the development of difference in sympathetic nerve activity among each part of the body.

Thus, the same mechanisms, as was observed in rats, must be present and play a role to induce pathologic hemodynamic changes related to micturition.

Key Words
Micturition,
Hemodynamics,
Sympathetic Nerve Activity,
Spinal Reflex.

INTRODUCTION

It has been reported that various cardiovascular disorders are developed by hemodynamic changes related to micturition(1 — 5). In this mechanism, the autonomic nervous system must play important roles. As we reported before on experimental rats(2), non-uniform responses of sympathetic nerve activity to a rise in vesical pressure were observed. Because the cervical sympathetic nerve activity was less activated than either renal and hypogastric sympathetic nerves, increase of blood flow in the carotid artery was observed during vesical load. In that report, we concluded that this mechanism had to play an important role to result in the redistribution

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of blood flow to important organs. However, it is not clear yet whether this mechanism is occurred in human subjects.

In this report, in order to verify the mechanism in human subjects, we attempted to clarify the pathway of vesico-sympathetic-hemodynamic reflex and redistribution of peripheral circulation.

Firstly, to clarify the reflex pathway, responses of blood pressure and heart rate to a rise in vesical pressure were examined in patients with spinal transection at various levels.

Secondly, in order to investigate blood redistribution, peripheral circulation in different parts of the body was measured by photoelectric pletysmography by a chance of spontaneous micturition.

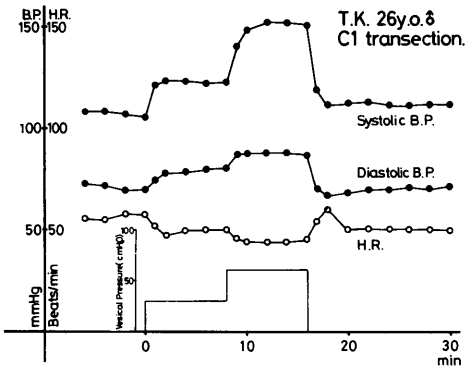


Figure 1. HEMODYNAMIC CHANGES IN A PATIENT WITH SPINAL TRANSECTION AT C_1.
A result from a patient with spinal transection which was caused by necrotic vertebral artery embolism. The lesion was at the level of C_1-C_2. As vesical pressure was loaded to 70cmH_2O, systolic and diastolic BP(blood pressure) were elevated while HR(heart rate) was decreased.

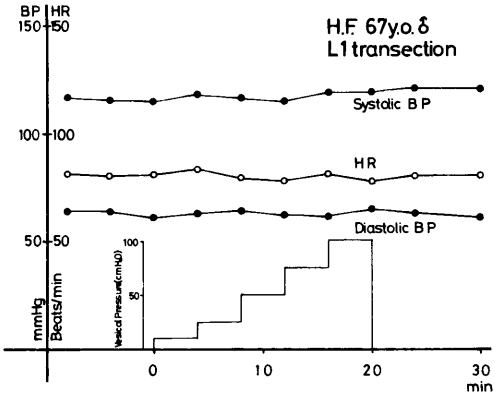


Figure 2. HEMODYNAMIC CHANGES IN A PATIENT WITH SPINAL TRANSECTION BELOW L_1.
A result from a patient with spinal transection which was caused by traffic accident. The lesion was below L_1. Although vesical pressure was increased gradually up to 100 cmH_2O, either BP or HR did not show significant changes.

These investigations must contribute to clarify the mechanism of hemodynamic changes related to micturition.

METHOD

To clarify the hemodynamic changes and its reflex loop, subjects were divided into two groups. Statistical analysis was performed by Student's test and data were shown as mean ± S.E.M. The statistical significant level was determined at 5% level.

1) DETERMINATION OF THE REFLEX LOOP

To determine the reflex loop of vesico-sympathetic-hemodynamic changes, two patients with spinal transection at different level were subjected. The

levels of transection were L_1 and C_1 which were confirmed by neurological signs. Vesical pressure was loaded by a reservoir with warmed (37°C) saline through a transurethral catheter as we reported before(1). Arterial blood pressure and heart rate were measured by sphygomomanometer every minutes throughout the study.

2) CHANGES IN PERIPHERAL CIRCULATION INDUCED BY SPONTANEOUS MICTURITION

Seven healthy male students of our school were subjected to void at standing position to investigate effects of spontaneous micturition on peripheral circulation and sympathetic nerve activity. Changes in peripheral circulation were measured by a method of photoelectric pletysmography at occasions of spontaneous micturition from three different parts of body, i.e., ear, finger and toe as well as arterial blood pressure and heart rate. The amplitudes of five consecutive pulses of pletysmogram were averaged for statistical analysis. These were recorded simultaneously. Moreover, in five out of seven students, blood samples were obtained to measure plasma catecholamine level. The concentration of catecholamine was assayed by THI method using a chromatography.

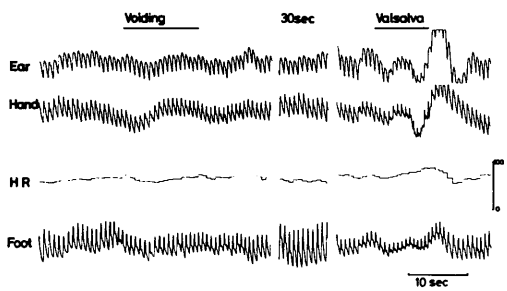


Figure 3. RECORDING OF PHOTOELECTRIC PLETYSMOGRAMS IN EAR, FINGER (HAND) AND TOE (FOOT) DURING MICTURITION (VOIDING).

The pulses in ear were increased during micturition while pulses in hand and foot were decreased. Thirty seconds after the micturition, the responses were inverted. During Valsalva maneuver, each amplitude decreased in the same manner.

RESULTS

1) RESULTS OF PATIENTS WITH SPINAL TRANSECTION

Figure 1 illustrates the results in a man with spinal transection at C_1 level. As vesical pressure was loaded up to 70 cmH_2O, blood pressure was markedly elevated and accompanied by bradycardia. When vesical pressure was reduced to the original level, these parameters also returned to the control values.

Figure 2 shows the results in a man with spinal transection below L_1 level. In contrast to a man with spinal transection at C_1 level, arterial blood pressure and heart rate did not show significant changes despite a gradual elevation in vesical pressure up to 100 cm H_2O.

2) RESULTS OF SPONTANEOUS MICTURITION

Figure 3 depicts typical tracings of photoelectric pletysmogram of three different parts during spontaneous standing micturition. During micturition (voiding) amplitudes of pulses in finger and toe were reduced although the amplitude of pulses in ear was increased. However, 30 seconds after micturition, responses were inverted to

show an increase of the amplitude in hand and foot in spite of the reduction in ear.

In order to compare Valsalva effect, Valsalva maneuver was performed at the end of each study. The grade of maneuver was ordered as much as done during micturition. During the maneuver each amplitude of pulses became smaller in the same manner as shown in the figure.

Figure 4 summarizes the changes in amplitude of pulses in ear (E), finger

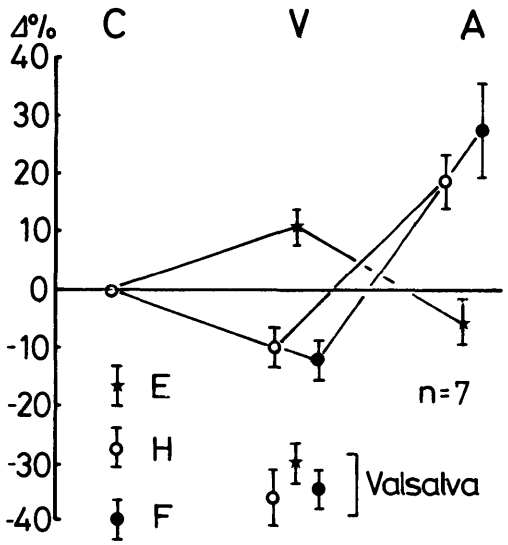


Figure 4. SUMMARIZED RESULTS OF PLETYSMOGRAMS IN MALE SUBJECTS.

The figure shows relative percent changes in the amplitude of pletysmograms in ear (E), hand (H) and foot (F). During micturition (V), in finger and toe, amplitudes were decreased while the amplitude in ear was increased. However, 30 seconds after micturition, the response was inverted. The values during Valsalva maneuver are also shown.

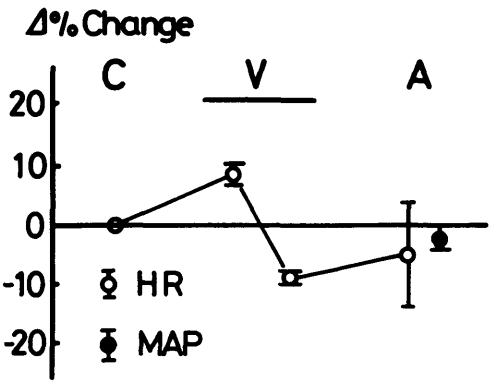


Figure 5. SUMMARIZED RESULTS OF HEART RATE (HR) AND MAP (MEAN ARTERIAL PRESSURE) IN 7 MALE SUBJECTS.

These values are shown in relative percent changes from the control value (C). HR was increased at the start of micturition (V) which was followed by bradycardia. Thirty seconds after micturition HR and MAP were still below the control value.

(H) and toe (F). Values of each parameter before micturition were described as 100% and expressed in terms of relative percent changes. During micturition the amplitude in ear increased to + 11% whereas the amplitude in hand and foot decrease to − 9% and − 12%, respectively. Thirty seconds after the end of micturition, these changes were inverted and the amplitude in ear, finger and toe were − 6%, + 16% and + 24% from the control level, respectively.

The changes during Valsalva maneuver were also shown in comparison with the results during micturition. All these kinds of pulses were decreased by almost same degree. This suggested that specific results of pulse amplitude during micturition were characteristic

changes.

Figure 5 depicts the summarized data of heart rate (HR) and mean arterial pressure (MAP) shown as relative percent changes from the control value in 7 subjects. At the start of micturition, HR increased to + 8% which was followed by a decrease to −9% from the control value. Thirty seconds after micturition, HR and MAP were still lower than control by 6% and 3%, respectively.

Figure 6 shows the absolute values of MAP, HR and plasma catecholamine concentration (p CA) before (B) and after (A) micturition in 5 subiects. Plasma catecholamine decreased from 474ng/1 to 428 ng/1 in mean value as well as HR and MAP in all subjects.

DISCUSSION

As we reported before(2), sympathetic nerve activity which controlled three different organs showed specific changes during vesical load in rats. We concluded that this mechanism was developed by spinal reflex and played an important role in symptoms related to micturition. In this report, we attempted to clarify whether this mechanism in animals works in human subjects as well.

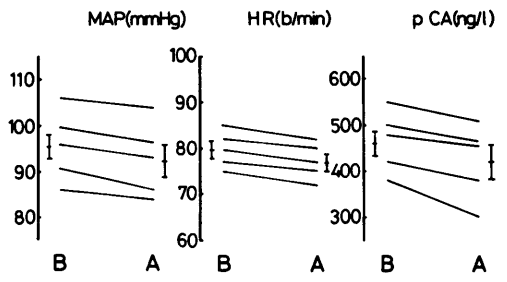


Figure 6. CHANGES IN HEMODYANAMICS AND PLASMA CATECHOLAMINE IN 5 MALE SUBJECTS.
The figure shows the difference between before (B) and after (A) micturition in absolute values of MAP, HR, and pCA(plasma catecholamine).

1) IMPORTANCE OF SPINAL REFLEX

As Wurster and colleague reported(6), the responses of heart rate and blood pressure were different in patient with spinal transection between above and below T_5. They noted that increased sympathetic activity resulted in increased cardiac contractility when the lesion was above T_5. In cases below T_5, increase in blood pressures was smaller due to failed augumentation in ventricular myocardial contractile force and also limited vasoconstriction.

According to our present results, in the patients with spinal transection, cardiovascular responses were different between higher and lower lesion. As seen in figure 1, in a patients with higher lesion, bradycardia was developed during vesical load while tachycardia was observed in healthy subjects. In this mechanism, hypertension was developed by dysfunction of baroreflex which, in normal subject, suppressed sympathetic nerve activity during hypertension(7). However, the vagal nerve can control the heart in this case because this nerve distributed directly from the brain. Thus, the vagal nerve, which was activated by the hypertension, induced bradycardia during vesical load in the patient with higher lesion.

In the patient with lower lesion as shown in figure 2, no significant changes in blood pressure and heart rate were observed because reflex area

was destroyed. This result indicated the importance of spinal pathway in the vesico-sympathetic hemodynamic reflex.

Thus, the spinal sympathetic pathway is important to control of heart rate and blood pressure during vesical load.

2) DIFFERENCES AMONG THREE TRACINGS OF PLETYSMOGRAM

When three kinds of tracings of pletysmogram recorded simultaneously during spontaneous micturition at standing position, the amplitude in the ear was quite different from the results of finger and toe. As it was reported that photoelectric pletysmogram was an indicator of local blood flow and affected by sympathetic nerve activity, the changes in amplitude coincided with the grade of vasoconstriction(8). Thus, these differences among each amplitude indicate development of redistribution of blood flow.

As we reported on experimental rats(2), cervical sympathetic nerve activity, which controls the blood flow to the brain, was increased during vesical load. However, because more significant increase in other nerves such as renal and hypogastric sympathetic nerves induced much more vasoconstriction, the blood flow of the carotid artery was increased during vesical load by relatively low vasoconstriction.

The increased amplitude of pletysmograms in the ear suggested the same mechanisms as observed in rats. This may result in the flushing during vesical load.

The changes of each pletysmogram were inverted after micturition. The increase in the amplitude in the ear was followed by a decrease. In this phase, heart rate, blood pressure and plasma catecholamine were reduced as well. These results suggest that poor blood flow distribution to the head developed after micturition. This may result in micturition syncope in a patient with poor baroreflex function such as the orthostatic hypotension.

CONCLUSION

Thus, local blood circulation was changed in specific manner by each part of the body during and after micturition. This hemodynamic changes were controlled by autonomic nervous system mediated through spinal reflex. This mechanism must result in development of disorders related to micturition.

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