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Chapter 12

HYPERKALEMIA AND HYPERDOPAMINEMIA ALONG WITH PSYCHOLOGICAL MODIFICATION INDUCED BY OBSESSIVE EATING OF BANANAS IN AN ANOREXIA NERVOSA ADOLESCENT

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ABSTRACT

Bananas are known as a dopamine-rich and potassium-rich food, however no previous data regarding biochemical or psychological alteration induced by excess intake of bananas has been reported. We encountered a female adolescent patient with anorexia nervosa, who was obsessed by an extremely restricted eating habit. As a result of ingesting nothing but a maximum of 20 bananas and less than 500 ml of mineral water per day for more than two years, she exhibited biochemical and metabolic disorders such as hyperkalemia, hyperdopaminemia, and pseudoaldosteronism. The patient also showed a drastic change in her psychological state, represented by decreased anxiety and increase in inner-impulse. Based on the biochemical changes seen in the patient, the accumulation of free dopamine due to obsessive banana ingestion was the most likely cause of her

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altered psychological state. When the patient resumed eating other food items after 26 months of obsessive and restricted banana ingestion, the abnormalities in her blood values and her psychological state were corrected to that of the pre-obsessive eating period. We conclude that in this case, an obsessive and restricted eating habit of banana ingestion modulated her biological and psychological homeostasis.

INTRODUCTION

Eating disorders, which are subcategorized in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) as anorexia nervosa, bulimia nervosa, and eating disorder not otherwise specified, are characterized by unusual eating habits caused by an intense fear of becoming fat (American Psychiatric Association, 1994). Although the precise etiology of eating disorders is unclear, abnormalities of biogenic amine neurotransmitters such as serotonin (5-hydroxytryptamine, 5-HT) and dopamine are found in some patients (Brewerton and Jimerson, 1996; Kaye et al 1999; Wolfe et al 2000), suggesting the relevance of these factors to eating habits. Since an abnormal eating habit is the essential phenotype of eating disorders (Behrman et al 2000), the occurrence of obsessive eating habits in patients with eating disorders is not surprising (Kaye, 2008).

Anorexia nervosa is characterized by self-imposed weight loss and amenorrhea. A distorted psychopathologic attitude toward eating and body weight is pathognomonic of anorexia nervosa. (Behrman et al 2000). DSM-IV (American Psychiatric Association, 1994) classifies anorexia nervosa into a restricting type and binge-eating/purging type based on the presence of binge-eating/purging (rapid consumption of large amounts of food, followed by induced vomiting or misuse of laxatives). In DSM-IV, bulimia nervosa is distinguished from anorexia nervosa based on the clinical manifestations, although the psychological background including excessive concern about body shape and weight is common to both. In contrast to the emaciation generally observed in anorexia nervosa patients, bulimia nervosa patients hardly manifest noticeable under- or overweight. The DSM-IV criteria define bulimia nervosa as follows: the binge-eating/purging episodes are observed at intervals of less than 2 hours, and the patient has a minimum average of two episodes per week for at least 3 months.

Anorexia nervosa and bulimia nervosa patients share particular eating habits including binge eating, restricted food selection, and obsessive eating. Dysfunction of serotonergic or dopaminergic neuronal systems is the most likely pathophysiologic process in these disorders (Bosanac et al 2005). The serotonergic neuronal system originates from the midbrain raphe nucleus, and its projection regulates diverse physiologic functions, including sleep, appetite, pain, motor function, cognition, sexual activity, and emotions such as mood and anxiety. Decreased activity of the serotonergic neuronal system is often observed in patients with eating disorders (Fumeron et al 2001; Sorbi et al 1998). On the other hand, the dopaminergic neuronal system has a role in cognition, locomotor activity, exploration, motivation, feeding, and sexual behavior. Activation of the dopaminergic neuronal system in restricting anorexia nervosa patients has been suspected based on their clinical manifestations and the increase of dopamine metabolites observed in their cerebrospinal fluid (Devesa et al 1988; Kaye et al 1999). However, no conclusive evidence is available to date.

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It is conceivable that the frequent co-morbidity of anorexia nervosa / bulimia nervosa with other psychiatric disorders is quite relevant to abnormalities of serotonergic / dopaminergic systems. For instance, it is fairly common to observe food- and weight-related obsessive-compulsive symptoms during the course of anorexia nervosa. Patients with anorexia nervosa often are obsessed with calculating calories, searching for low-calorie food, or performing obviously excessive amounts of exercise. All of these features can be interpreted as phenotypes of obsessive-compulsive disorder or obsessive-compulsive personality disorder. Recent neurobiological, genetic, and psychological investigations have accumulated evidence of an overlapping spectrum between anorexia nervosa, bulimia nervosa, and binge eating disorder (originally classified in the eating disorders-NOS in DSM-IV) and obsessive-compulsive disorder or obsessive-compulsive personality disorder (Lazaro et al 2005; Serpell et al 2002).

Prevalence rates for obsessive-compulsive disorder or obsessive-compulsive features in eating disorders are relatively high, ranging between 25–69% in anorexia nervosa, and 3–40% in bulimia nervosa (Lawson et al 2007). Abnormal eating habits such as restriction and binge eating themselves can be explained by compulsive behavior to achieve affect regulation (e.g., reducing anxiety). Therefore, there is a keen debate about the pertinence of separating eating disorders and obsessive-compulsive disorder as different diagnostic categories, because they are presently assigned to separate categories in DSM-IV (Grilo, 2004; Wu, 2008). Moreover, mood disorders, anxiety disorders, and personality disorders are more commonly present with bulimia nervosa than anorexia nervosa, suggesting that the etiologies of anorexia nervosa and bulimia nervosa are quite similar but not identical (Carlos et al 2009; Kaye, 2008). However, it is noteworthy that such disorders, which are possibly co-morbid with anorexia nervosa / bulimia nervosa, are also known to be caused, at least partially, by serotonergic neuronal dysregulation.

Obsessive eating in patients with bulimia nervosa / binge eating disorder is more likely to involve an obsession with the cycle of overeating and purging rather than with the food itself. This behavior can be understood to be similar to an addiction to drugs or other substances. Usually the patients experience regret and anguish after the binge eating episode, followed by inadequate compensatory behavior such as vomiting, laxative abuse, diuretic abuse, or over-exercise, but are unable to escape from the addiction by themselves. Anxiety, depression, and low self-esteem frequently coexist in these patients, often becoming their dominant thought and subsequently increasing the likelihood of co-morbidities like mood disorder and anxiety disorder (Carlos et al 2009). In contrast to patients with bulimia nervosa / binge eating disorder, those with restricting anorexia nervosa present obsessive eating habits less frequently (Emily et al 2008). They develop malnutrition, hormonal imbalances, and a variety of electrocardiographic abnormalities due to reduced total calorie intake and dehydration, which are the most lethal manifestations, and thus are important in the treatment of the patients.

Recently, we encountered a remarkable and uncommon case of an adolescent with restricting anorexia nervosa who presented with obsessive and restricted banana ingestion for more than 2 years (Tazoe et al 2007). As a result, the patient developed extreme hyperkalemia, hyperdopaminemia, pseudoaldosteronism, and dysthymia, which could not be explained by the pathology of restricting anorexia nervosa alone. Moreover, the patient had presented with obvious aggression and inner-impulse paralleling an increase in whole blood dopamine, suggesting that the brain dopamine concentration was also affected by the

obsessive and restricted banana ingestion. Since bananas are known to be rich sources of both dopamine and potassium (Kanazawa and Sakakibara, 2000; Kasuga A, 2008), the clinical condition of this patient was thought to be dramatically altered by the massive ingestion of bananas.

CASE

At the age of 15, the female patient visited a pediatric clinic for emaciation, amenorrhea, and appetite loss, which had been noted by her school teacher. The patient had been on a strict diet intentionally for the past half year, and had lost 6.2 kg of weight (decreasing from 46.9 to 40.7 kg; BMI (body mass index) = 15.7). She was born at term, her psychomotor development was normal, and had no past history of Attention Deficit / Hyperactivity Disorder or other behavioral problems. Her pulse rate and blood pressure were within the normal range, and the electrocardiogram and cardiac ultrasound showed no abnormality. Although no abnormality was found in the regular blood analysis data, obvious hormonal imbalances were noted as follows:

GH (Growth hormone) 1.47 ng/ml (↓), IGF-1 (Insulin-like growth factor-1, somatomedin-C) 88 ng/ml (→), ACTH (Adrenocorticotropic hormone) 14 pg/ml (→), Free T4 0.81 ng/dl (↓), Free T3 1.65 pg/ml (↓), TSH (Thyroid stimulating hormone) 1.740 μU/l (→), and estradiol <10 pg/ml (↓). Minor elements such as Cu, Zn, vitamins B_1 and B_2, lactate, and pyruvate were all within normal ranges. She had pigmentation of the skin and was obviously hyperactive.

OBSESSIVE BANANA INGESTION DIRECTLY AFFECTS THE BLOOD DOPAMINE CONCENTRATION AND ELECTROLYTES

Figure 1 shows the course of illness observed in the patient. She was hospitalized two times over a 60-month observation period, and the lowest body weight reported was 27.0 kg (BMI = 10.3). An increase in extraordinarily obsessive behavior began to be observed during her first hospitalization period (from the 8th month of the observed period). She denied ingesting any food item other than bananas (5–20 pieces a day) and hard mineral water (up to 500 ml a day), and was obsessed by the need to engage in excessive daily exercise. Following this obsessive eating behavior, blood analysis showed a gradual increase of serum potassium and whole blood dopamine. The second hospitalization period was required when her body weight dropped as low as 27.0 kg at the 16th month of the observation period. Intravenous hyperalimentation along with cognitive-behavioral therapy was performed during each hospitalization period.

After the 24th month of the observation period, the patient's whole blood dopamine concentration jumped to 180 ng/ml. At the same time, her serum potassium was as high as 6.1 mEq/l, although no abnormality was observed in electrocardiogram and blood pressure examination. Later, in the 38th month of the observed period, her dopamine concentration increased to as high as 210 ng/ml. At the 40th month of the observation period, her weight decreased again to 32 kg. Her serum potassium level was 5.7 mEq/l, aldosterone was 708.8

ng/dl, and renin was 130 pg/ml, all of which are relatively higher than the normal range in the Japanese population. Although the patient kept normal blood pressure throughout the course of the illness, the increases in renin and aldosterone suggested that she fell into a state of pseudoaldosteronism during this period. Serum catecholamine analysis showed an extreme increase of free dopamine (0.47 ng/ml, normal range < 0.03); however, no increase in epinephrine (<0.01 ng/ml) or norepinephrine (0.39 ng/ml) was observed.

In response to treatment with cognitive-behavioral therapy, she began to ingest food items other than banana after 26 months of this restrictive eating pattern. Over the next 12 months, economic reasons prevented her from returning to the clinic; however, the most recent examination at the 56th month of the observation period showed distinct improvement in her blood values, including serum potassium of 5.6 mEq/l and whole blood dopamine of 56 ng/ml. In addition, her weight had increased to 36 kg. She seemed at that time to have "calmed down" and her skin was obviously depigmented.

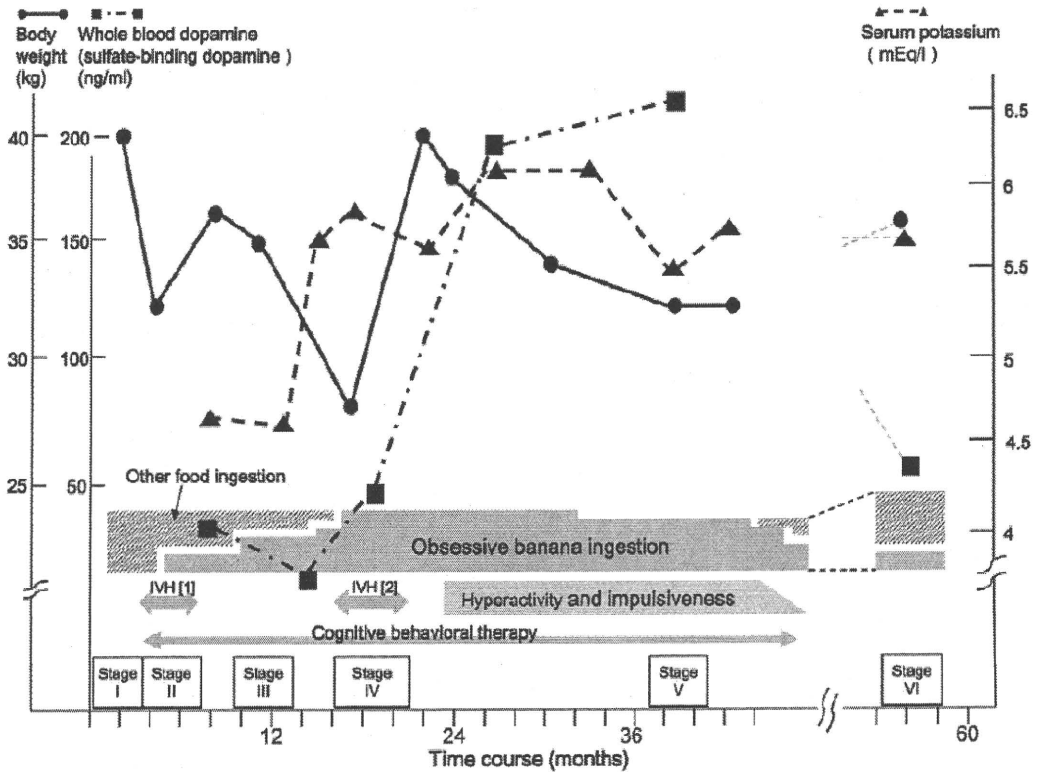


Figure 1. The course of illness in the patient with obsessive banana ingestion
The illness course of the patient is schematically presented. Changes in body weight, whole blood dopamine, serum potassium, and habit of food ingestion are shown. Two intravenous hyperalimentation treatments during hospitalization (IVH [1] and IVH [2]) and continuous cognitive-behavioral therapy were performed. The stages indicated in the figure correspond to the descriptions in the text.

Obsessive Banana Ingestion May have Modified the Psychobiological State in the Patient

The patient's psychological state had been continuously assessed by our team clinical psychologist (M.T.) regularly during the course of her illness, using three types of psychological tests: the tree drawing test (Koch, 1952; Kosaka, 2008), the Japanese version of the state-trait anxiety inventory (STAI) (Iwata et al 1998), and the Tokyo University egogram (TEG), which evaluates ego states (Oshima et al 1996).

The whole clinical course was classified to six stages according to the degree of emaciation, treatment, and blood analyses as follows (see also Figure 1).

Stage I. Prior to the first hospitalization: She did not cooperate with the psychological therapy or with oral ingestion of nutrient drinks. She walked more than 10 km daily, and exercised her abdominal muscles intensively to build her "ideal body." One drawing (Figure 2) was obtained during this stage.

Stage II. First admission: Within 6 months after the first visit, she had reduced her weight to 32.1 kg (BMI = 12.2). She underwent forced admission to the pediatric ward, where she was treated by intravenous hyperalimentation infusion, along with behavior restriction therapy. She gained 4 kg during the 30-day admission, and was discharged from the hospital afterward. Two drawings (Figures 3A and 3B) were obtained during this period.

Stage III. Between the first and second hospitalizations: The patient was obsessed by the idea that all processed foodstuffs are contaminated by additives and pesticides. Eventually, she stopped eating except for a maximum of 20 pieces of banana and 500 ml of mineral water per day. She stuck to one type of banana (an organic product from Ecuador) and one brand of hard mineral water. During this period, two drawings (Figures 4A and 4B) were obtained from the patient.

Stage IV. Second hospitalization: Her weight dropped to 27.0 kg (BMI = 10.3) at this time, which again became an indication for intravenous hyperalimentation treatment and admission. This time she gained over 13 kg and was discharged. However, there was no change in her eating and exercise habit. Two drawings (Figures 5A and 5B) were obtained during this period.

Stage V. Increase in blood dopamine level due to excessive consumption of bananas: Against the counsel of physicians, psychologists, and her family members, the patient continued her strict avoidance of food items other than bananas and hard mineral water. Blood analysis revealed increased levels of serum potassium, whole blood dopamine, aldosterone, renin, and angiotensin, which suggested a state of pseudo-aldosteronism and hyperdopaminemia. At this stage, she also began to show obvious impulsiveness and irritability, which are not frequently observed in anorexia nervosa patients. One drawing (Figure 6) was obtained during this period.

Stage VI. Remission from the obsessive banana ingestion with recovery of all of the blood values: Her impulsiveness and irritability had almost disappeared and she was eating many kinds of food, although the amount was still small. One drawing (Figure 7) was obtained during this period.

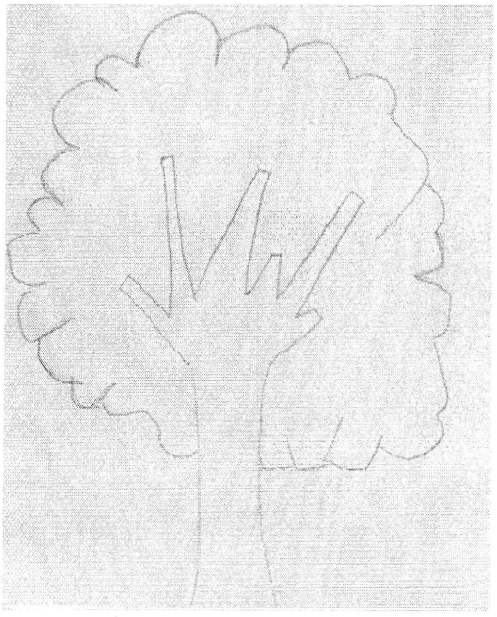
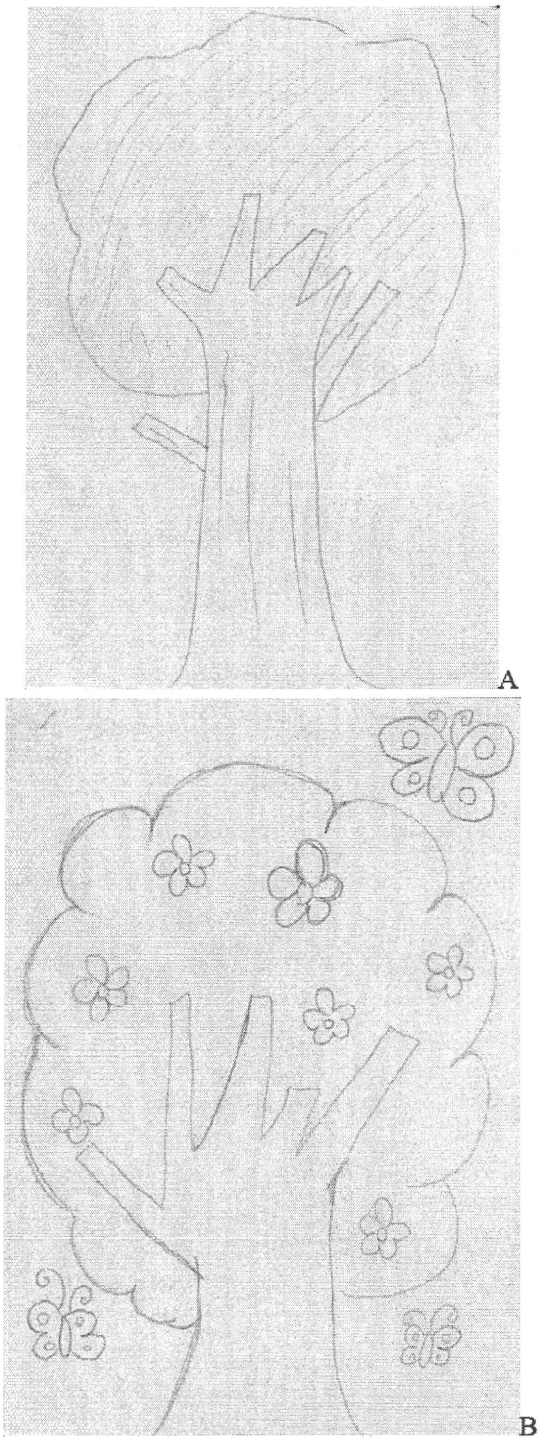


Figure 2. Tree drawing test drawing of the patient at Stage I
Tree drawing test drawing of the patient at Stage I is shown. Note that the branches are cut off in the middle. This feature is consistently observed in the rest of her drawings. The rigid crown shape and the solid and strong lines are also characteristic.

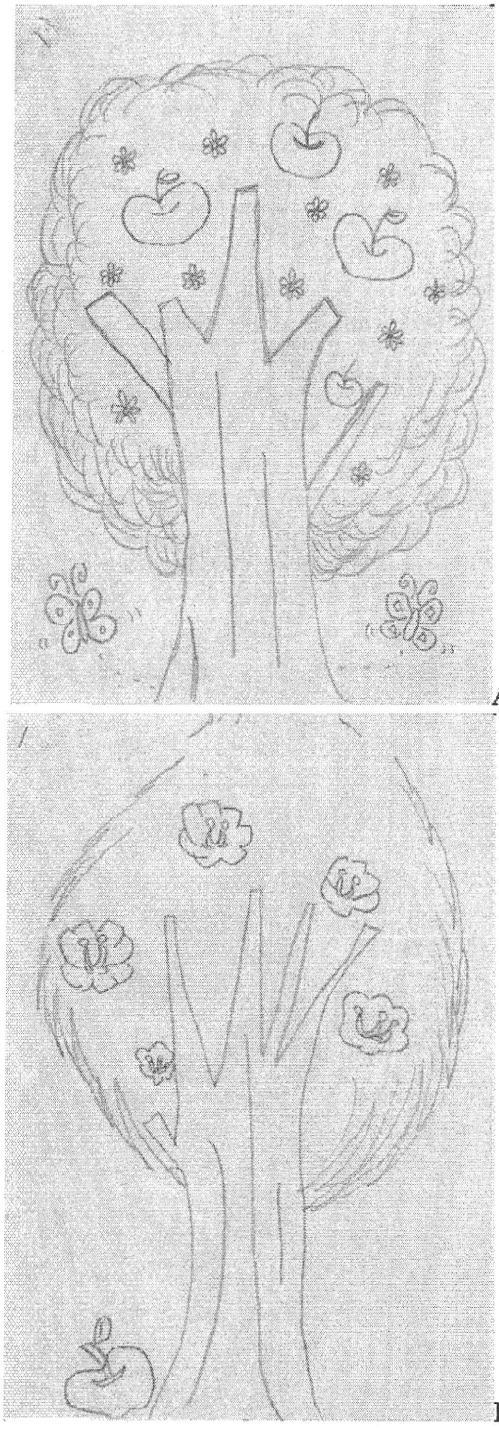
The Tree Drawing Test

Figure 2 shows the patient's drawing at Stage I. The form of her drawing was interpreted as defensive to stimuli from the outer world (outlining of the crown is rigidly shut) and emotionally shut off from relationships with others (the branches are all cut off in the middle), which are both considered to represent a pathologically low energy state. The lines of drawing were consistently solid and high in strength during all stages, which was thought to represent the inherent individuality of her obsessive tendency.

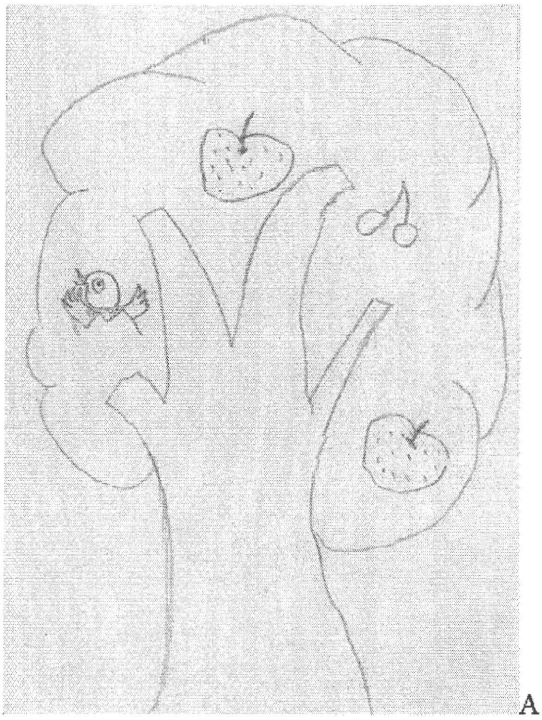
Figures 3A and 3B were both obtained during Stage II, the first hospitalization period. On admission (Figure 3A), the crown was drawn with discontinuous lines in the tree drawing test, suggesting her susceptibility to the outer world. The branches were still the same, having the cut-off-in-the-middle shape, suggesting her emotionally shut-off state. In addition, the crown was shaded, which was thought to represent her depressive state. The size of the crown was reduced and a branch grew beneath the crown, which was considered representative of her psychological regression. On discharge after approximately a month of hospitalization, her drawing (Figure 3B) still showed signs of defensiveness and emotional shutting off. However, the crown was enlarged and was no longer painted, and no branches were seen beneath the crown. These observations suggested that her psychological regression had ended. Instead, the drawing showed flowers and butterflies with a trunk of wide width, which was thought to represent her self-display and magnified self. The lines of the drawing are solid and very strong, similar to those of previous drawings.



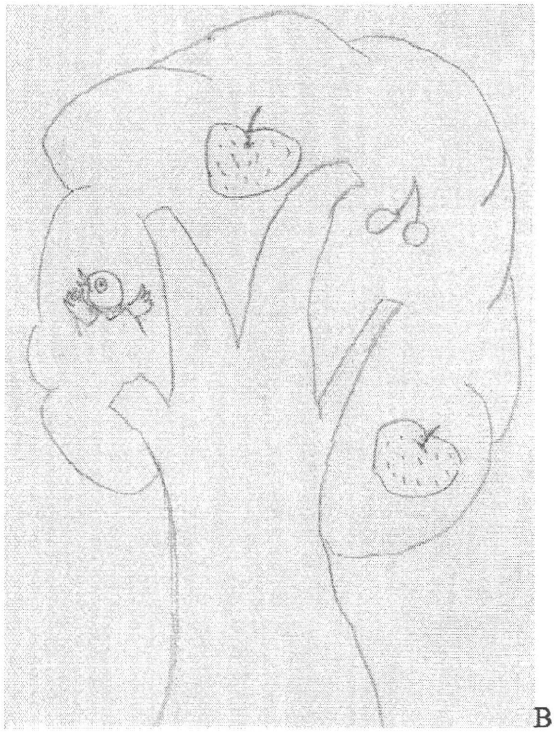
Figures 3A and 3B. Tree drawing test drawings of the patient at Stage II.
Tree drawing test drawings at Stage I, on admission (Figure 3A) and on discharge (Figure 3B) following the patient's first hospitalization period are shown. Note that the defective crown size and form seen on admission have improved by discharge.



Figures 4A and 4B. Tree drawing test drawings of the patient at Stage III.
Tree drawing test drawings earlier (Figure 4A) and later (Figure 4B) in Stage III are shown. The patient was obsessed banana ingestion, and her condition gradually deteriorated during this period. Note that the outline of the crown was drawn differently, and later, the crown protruded from the paper.



A



B

Figures 5A and 5B. Tree drawing test drawings of the patient at Stage IV.
Tree drawing test drawings at Stage IV on admission (Figure 5A) and on discharge (Figure 5B) following the second hospitalization period are shown. Note that on admission, the form of the drawing seems collapsed and the crown has a discontinuous outline, showing loss of energy.

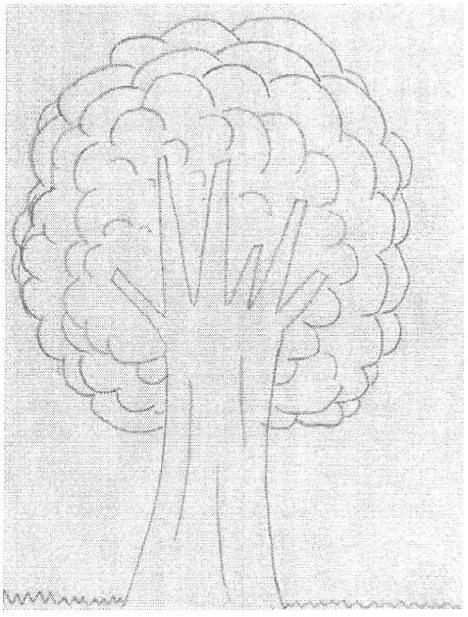


Figure 6. Tree drawing test drawing of the patient at Stage V.
Tree drawing test drawing at Stage V is shown.
Note the formation of the crown with lines rising one by one from the inner side of the tree, as if showing the patient's effort to resist her bursting inner-impulse.

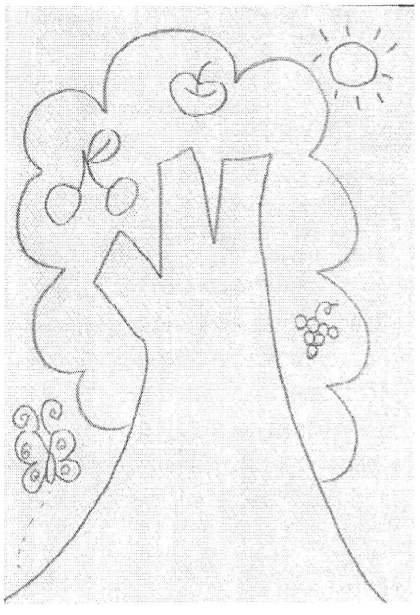


Figure 7. Tree drawing test drawing of the patient at Stage VI.
Tree drawing test drawing at Stage VI is shown. After remission of the obsessive banana ingestion, the bizarre observations seen in the Tree drawing test drawing at Stage V have completely disappeared and the drawing now resembles figures 3B and 5B, from the earlier post-treatment periods.

During Stage III, the period when the patient's obsessive banana ingestion began and continued, the tree drawing test was performed twice and an obvious change in the crown form was observed. The outline of the crown was drawn fluffy with repeated lines in the earlier drawing of Stage III (Figure 4A), which was deformed into more sharp-pointed and discontinuous form in the later drawing (Figure 4B). These observations were interpreted to mean that as her susceptibility to outer stimuli grew and she needed to pile up the lines to be more defensive. Later on, she became irresistibly hypersensitive and more aggressive. This time, the crown protruded out from the paper, representing her acting-out state.

During Stage IV, the second period of hospitalization that occurred when her critical emaciation had progressed as a result of her obsessive banana ingestion, the tree drawing test was performed twice (Figures 5A and 5B). In Figure 5A, the tree drawing test was performed upon admission. The patient's drawing showed a wide trunk, branches beneath the crown (regression), and a discontinuous outline of the crown. It seemed she no longer had the energy to shut the crown through repeated drawing; the single discontinuous line can easily let the outer stimuli invade into her inner-self. On discharge after the second hospitalization period, the form of the tree drawing test (Figure 5B) showed slight improvement, with a wide trunk and fruits that represent self-display and magnified self.

Generally speaking, to this point, her psychological energy had been decreasing in tandem with the stage progression. However, at Stage V, when her obsessive eating was at a maximum and her blood dopamine concentration was elevated as high as 180 ng/ml, her drawing showed drastic changes. Figure 6 shows her drawing at this stage. The form of the crown was completely changed, with lines rising one by one from the inner area of the tree, as if showing the effort of the patient's resistance to her bursting inner-impulse. For the first time, a horizon appeared in her drawing as a notched line, representing a decrease in her anxiety and an apparent stabilization (in her subjective sense, although she was not healthy). The lines were drawn smoothly with no disconnection, showing her full of energy without anxiety or depression. These changes were totally inexplicable and unexpected based on her physical state, which was characterized by body weight as low as 30 kg, indicating that she was critically ill with anorexia nervosa.

At Stage VI, the bizarre observations seen in the drawing at Stage V had completely disappeared, namely, the drawing showed the pattern that had originally been observed in the patient (Figure 7). The form of the crown was smooth, with a continuous outline with no rigidness, indicating that her defensiveness and susceptibility to the outer stimuli were decreased in her current psychiatric state. The extremely wide trunk (especially at the bottom) and fruits/butterfly showed that her self-display and magnified self-tendency still exist, suggesting that she was not completely healthy but was seemingly back to her original psychiatric state as a result of stopping banana ingestion and the consequent decrease in her blood dopamine concentration.

The STAI

The STAIs were performed at Stages III, IV, and V. The STAI-state anxiety score was 55, 68, and 46, and the STAI-trait anxiety score was 47, 58, and 49, respectively, at each stage. At Stage V, the patient's anxiety levels, which had been rising along with her illness

condition suddenly decreased, apparently showing that the patient "did not feel" anxious anymore during this period. These finding were similar to the results of the tree drawing test.

The Ego State

The patient's ego states were examined at Stage I and Stage V. At Stage I, low energy was observed in the egogram, and low CP (Critical Parent) and FC (Free Child) were observed along with high AC (Adopted Child). These results were interpreted to indicate low ego state, low self-assertion, and emotional repression with high law-abiding tendency. This observation was consistent with her tree drawing test and the diagnosis of restricting anorexia nervosa. In contrast, at Stage V, high energy was observed in the egogram. Her ego state showed a result that was the complete inverse of that in Stage I, with high-rising CP and FC, and an obvious decrease in AC. At this stage, the patient "feels" high ego energy, high self-assertion, and emotional elevation with low law-abiding tendency, and is seemingly full of vigor. Again, this observation did not contradict the results of the tree drawing test and STAI at this stage, suggesting transitory and unexpected psychological alteration had occurred at Stage V.

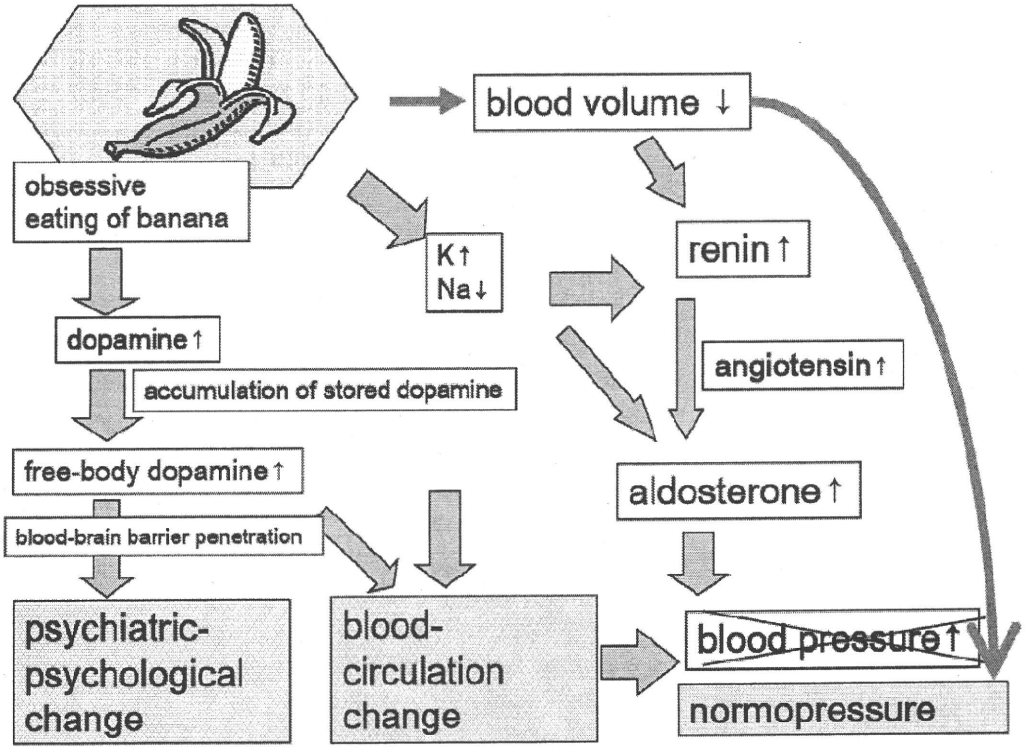


Figure 8. The summarized feature of the case with obsessive eating of banana is shown. The increase of blood potassium and dopamine induced by unusual consumption of banana was considered to be responsible for the pseudoaldosteronism and the psychiatric-psychological change in the patient.

DISCUSSION

The patient followed an unusual course of restricting anorexia nervosa, which was considered to be related to her long period of obsessive and restricted banana ingestion. The summary points of the case is shown in Figure 8. Bananas are known to be a dopamine-rich food. Approximately 0.72 mg of dopamine is contained within 100 g (approximate weight of the edible portion of one banana) of ripe banana fruit, and 100 g of unripe banana fruit contains as much as 10 mg of dopamine. Moreover, 100 g of ripe banana skin and thread contain 235 mg of dopamine and 100 g of unripe banana skin and thread contain approximately 1940 mg of dopamine (Kanazawa and Sakakibara, 2000). Dopamine is absorbed in a sulfate conjugated form from the digestive tract, and normally the free dopamine level is not affected by the dose of ingested dopamine (Davidson et al 1981; Dunne et al 1983).

The patient showed some level of hyperdopaminemia from the beginning of her illness course, which is consistent with previous reports of dopaminergic neuronal hyperactivity in anorexia nervosa (Devesa et al 1988; Kaye et al 1999). However, the dramatic increase in her whole blood dopamine concentration, which was observed immediately after she began excessive ingestion of bananas, cannot be explained simply based on the pathogenesis of anorexia nervosa. Rather, considering the fact that the patient preferred unripe bananas to ripe ones and often ate the skin and thread of the banana as well, her daily ingestion of dopamine must have increased significantly. That increase may eventually have led to an increase in free dopamine (0.47 ng/ml, compared with the normal range in the Japanese population of <0.03 ng/ml), without a corresponding increase in epinephrine or norepinephrine, most likely because banana contains particularly large amounts of dopamine, but relatively smaller amounts of epinephrine and norepinephrine. We suspect that in the case of this patient, sulfate-binding dopamine became oversaturated by daily ingestion of large amounts of banana, which led to the resulting increase in free dopamine.

In addition to hyperdopaminemia, the patient demonstrated hyperkalemia and pseudoaldosteronism. Bananas are also known to be rich in potassium, containing 330–400 mg of potassium in 100 g of the edible portion of the fruit (Kasuga A, 2008). Hyperkalemia, along with hyperdopaminemia, is considered to be the leading cause of pseudoaldosteronism. An obvious increase in blood renin and angiotensin was observed, but her blood pressure remained normal throughout the course of her illness, probably because of her absolute hypovolemia.

In the initial tree drawing test and egogram performed prior to the onset of obsessive eating, the patient showed low energy and ego states, with defensiveness, low self-assertion, and a strong protective tendency, which were all reasonably explained by the psychopathology of anorexia nervosa and essential obsessive personality of the patient (Mizuta et al 2002). However, in the tree drawing test, egogram, and STAI performed after two years of obsessive ingestion of only banana, the opposite results were observed; high energy and ego states, with an extreme internal impulsiveness and low anxiety and high self assertion. Given that this alteration in psychological state occurred with simultaneous hyperdopaminemia and disappeared along with remission of the obsessive banana ingestion, it is possible that the extreme increase in her blood dopamine level resulting from obsessive

banana ingestion was responsible for saturating binding proteins and increasing free dopamine, which affected her psychological state.

Her obvious aggression and inner-impulse, in accordance with the increase in whole blood dopamine, suggest that the brain dopamine concentration was also affected by the obsessive and restricted ingestion of banana. Dopamine is well known to have poor blood–brain barrier penetration because of physiological blockade caused by its high polarity. However, a recent study revealed that blood-brain barrier penetration of dopamine could be increased in a dose- and time-dependent manner by continuous arterial infusion of dopamine (Martel et al 1996). Thus, it seems reasonable to assume that blood-brain barrier penetration by dopamine was modified in the patient, who experienced hyper-free dopaminemia, as a result of lengthy and excessive ingestion of banana.

Nutrient imbalance resulting from deficiency of vitamins and minerals such as calcium, iron, zinc, phosphate, and magnesium may be observed in eating disorders, and this imbalance may cause skin disease, endocrinological disorder, or osteopenia (Seidenfeld et al 2004). Zinc is an important brain nutrient, acting as a neuromodulator/neurotransmitter mainly in the cortex in relation to glutaminergic neurons (Harrison and Gibbons, 1994; Takeda et al 2000). Deficiency of zinc may be related to cognitive disorder or depression (Meunier et al 2005). However, no clear link to eating disorders has yet been proven, and no sign of zinc deficiency was observed in the present case.

The case of our patient is noteworthy as an extreme example of how ingested banana directly affects the biochemical and psychic state. The patient showed strong and irrational obsessive behavior with banana and exercise compared to patients with regular anorexia nervosa. Since abnormal eating habits are common in patients with anorexia nervosa, it is necessary to identify detailed eating habits of anorexia nervosa patients to avoid the cumulative effects of a particular food on their physical and psychic state.

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