

## Transvaginal Hydrolaparoscopy by Flexible Fiberscope — A Study of Preliminary Cases —

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**Summary:** Transvaginal hydrolaparoscopy (THL) has become a first-line procedure in infertile women, and THL by flexible fiberscope (THLF) is a less traumatic and a more suitable outpatient procedure than diagnostic laparoscopy. We performed THLF on infertile women based on four indications; (i) tubal obstruction and/or peritubal adhesion as suggested by hysterosalpingography (HSG); (ii) serum antibody against Chlamydia (*C*) positive for *trachomatis*; (iii) diagnosis of early stage endometriosis; and (iv) unexplained infertility. Seven women with a chief complaint of infertility were the subjects of the present study. Two of the 7 cases had a history of gynecological surgery. Six of 7 cases had a history of *C. trachomatis* infection. Four cases had abnormal findings of fallopian tubal patency in hysterosalpingography. Parafallopean tubal atresia and tubal obstruction were observed in 4 cases by THLF. In one case the bilateral ovaries were extremely small and atrophic. None of the cases had serious complications after THLF. After the THLF, six women were able to have a baby by assisted reproductive technology (ART) within two years.

As THL was developed using a solid scope, indications for THL have been limited, and have excluded cases with retroverted uterus or peritoneal surgical history. In the present study, THL using a fiberscope was carried out in infertile women with retroverted uterus, and in women with a history of peritoneal cavity surgery to examine the feasibility of extending the indications for THL. Findings on the THLF were given precedence in deciding further treatment strategies. We believe that THLF can be useful in helping patients with these indications to successfully achieve early pregnancy. This study is the first trial of THLF.

**Key words** transvaginal hydrolaparoscopy, tubal infertility, endometriosis, assisted reproductive technology, laparoscopy

### INTRODUCTION

Since transvaginal hydrolaparoscopy (THL) was introduced as a first-line procedure for early stage exploration of the adnexal structures in infertile women, it has been shown that THL is a less traumatic and a more suitable outpatient procedure than diagnostic laparoscopy [1-3]. Transvaginal access and the systemic use of hydro flotation are potential advantages of THL for the exploration of tubo-ovarian structures

in infertility [1-6]. Moreover, inspection under fluid in THL improves the visualization of distal tubal disease [1-8]. The risks of a general anesthetic are avoided, and there is less chance of trauma to major vessels [8,9]. THL was developed for use with a solid scope, so the indications for THL have been limited, excluding cases with retroverted uterus or peritoneal surgical history. We have been performing THL by flexible fiberscope (THLF) as a diagnostic laparoscopy on infertile women based on any of the following four

indications; (i) tubal obstruction and/or peritubal adhesion as suggested by hysterosalpingography (HSG); (ii) serum antibody against Chlamydia (*C*) positive for *trachomatis*; (iii) diagnosis of early stage endometriosis; and (iv) unexplained infertility.

The present study of THLF in infertile women included three patients with retroverted uterus and history of peritoneal cavity surgery to examine the feasibility of extending the indications for THL to include these characteristics. THLF findings were given precedence in deciding further treatment strategies. We believe that THLF is useful helping such patients to successfully achieve early pregnancy. This study is the first study of THLF.

#### MATERIALS AND METHODS

The THL procedure followed that of Gordts et al. [1-3]. Women with a retroverted uterus have been excluded from THL because Darai et al. [4,7] suggested it should be considered as a relative contra-indication for THL. Briefly, THLF was performed under spinal anesthesia in the lithotomy position. After disinfection, a Hy-cath (Sumitomo Bakelite Co. Ltd, Tokyo, Japan) was inserted into the uterine cavity for the use of chromotubation. The uterine cervix was lifted by means of a tenaculum placed on the posterior lip.

Tubo-ovarian structures and tubal passage were investigated using a flexible fiberscope (Mochida Co, Tokyo, Japan). Approximately 500 ml of saline was instilled into the pouch of Douglas through a Hy-cath.

A 5.5-mm fiberscope was inserted by a stab incision in the posterior fornix, then the fiberscope was used with a flow channel attached to a 3 CCD digital video camera. The saline irrigation was continued throughout the procedure to keep the bowel and tubo-ovarian structures afloat. The posterior of the uterus and the tubo-ovarian structures were carefully observed, and tubal passage was confirmed using indigocarmine.

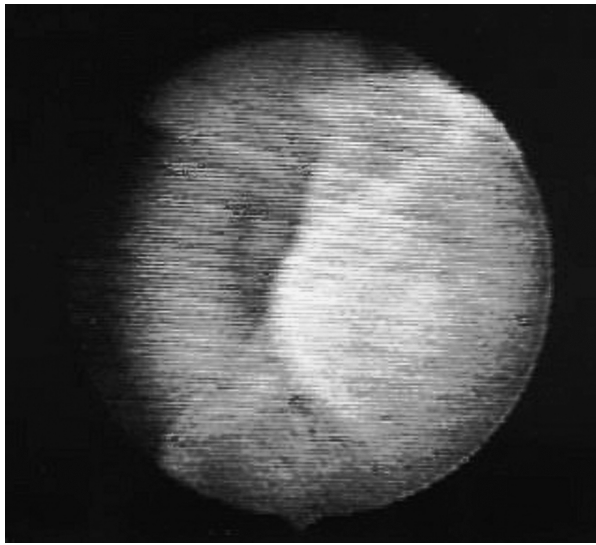
#### PATIENTS AND RESULTS

We have been performing diagnostic laparoscopy using THLF on infertile women based on any of the following four indications; (i) tubal obstruction and/or peritubal adhesion suggested by the HSG; (ii) positive serum antibody against *C. trachomatis*; (iii) diagnosis of early stage endometriosis; and (iv) unexplained infertility. Case reports are presented in Table 1. Seven women with a chief complaint of infertility were entered in this pilot study after informed consent. Two of 7 cases had a history of gynecological surgery. Six out of 7 cases had a history of *C. trachomatis* infection as diagnosed by serum antibody titres (IgG and IgA) against *C. trachomatis*. Four cases had abnormal findings of fallopian tubal patency in hysterosalpingography. Parafallopian tubal atresia and tubal obstruction were observed in 4 cases by THLF (Figs 1, 2, 3 and 4). In one case the bilateral ovaries were extremely small and atrophic. None of the cases had serious complications after THLF, and all were discharged the day after the procedure. After the THLF, six women were able

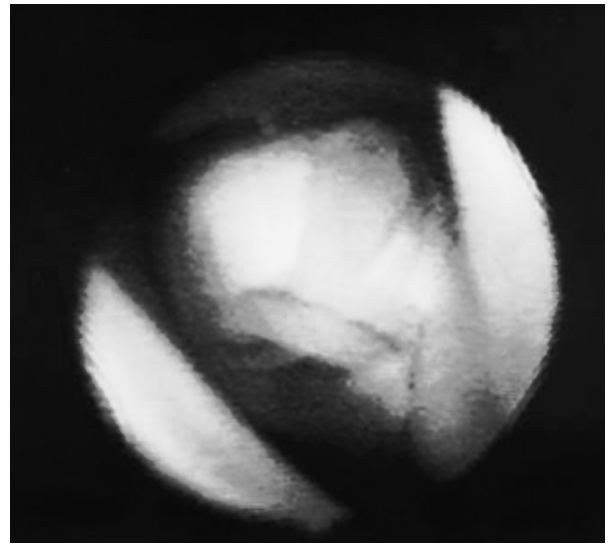
TABLE 1.  
*Patients and results*

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Age	37	28	29	32	34	36	30
PH/Uterine findings	Ectopic pregnancy		Retroverted uterus			Ovarian cystectomy	
Infertility term	4yr6mo	4yr10mo	3yr10mo	3yr2mo	2yr6mo	4yr1mo	5yr1mo
Chlamydia IgG/IgA	+/+	+/-	+/-	+/+	+/+	-/-	+/-
HSG	BTO	N.F.	BTO	BTO	PFA	N.F.	N.F.
THLF	PFA by Chlamydia and endometriosis	Abnormal tubal open	BTO by endometriosis	BTO by Chlamydia	N.F.	Atrophic ovary	PFA by Chlamydia and endometriosis
Post prognostic course	Baby by ART	Baby by ART	Baby by ART	Ectopic pregnancy. By OUT/Baby by ART	Baby by ART	Early menopause	Baby by ART

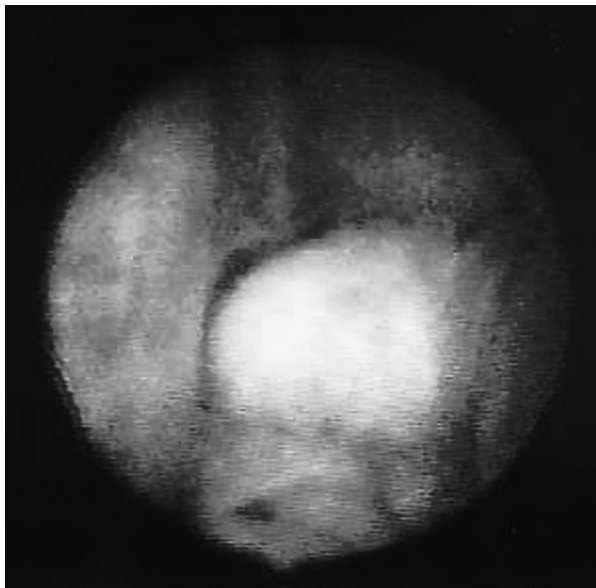
BTO: Bilateral tubal obstruction, PFA:Perifallopian tubal atresia, ART: Assisted reproductive technology, OUT: Oocyte intrauterine transfer, N.F.: Normal finding,



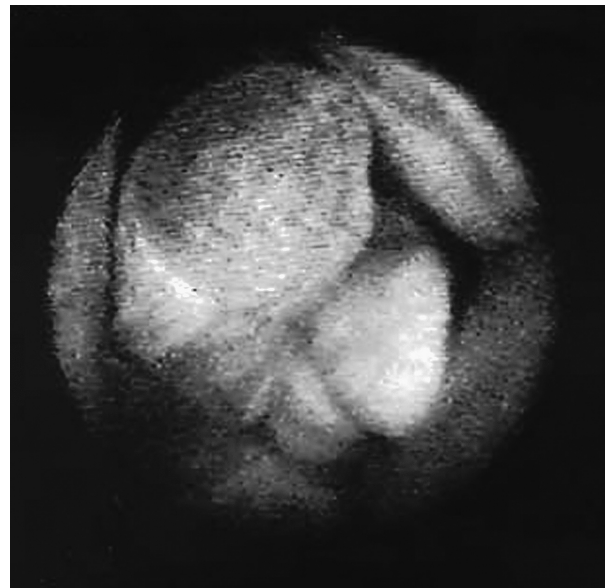
*Fig. 1.* Lace-like adhesion of perfallopian tube in Case 1.



*Fig. 2.* Floating and distended fimbriae partially adhering the ovary in Case 3.



*Fig. 3.* Peritubal adhesion with sigmoid colon of the left fallopian tube. in Case 4.



*Fig. 4.* The balloon-like swelling was observed in the right side fallopian tube in Case 4.

to have a baby by assisted reproductive technology (ART) within two years.

### DISCUSSION

In 1998, Gordts et al. [1-3] introduced the concept of transvaginal hydrolaparoscopy to explore the pelvic cavity through a vaginal incision using a saline solution medium. Several reviews have validated the concept of THL in comparison to the gold standard: laparoscopy [10]. In a literature review of 187 patients from

six studies including one prospective double-blind trial, a high concordance was found between THL and laparoscopy ranging from 77.8% to 100% [7,8]. In a review of 1516 THL, the rate of failure was 5.4% and these were linked to retroverted uterus and the presence of adhesions [3]. Another review of 1205 THL revealed that complete exploration of the pelvis, including analysis of both sides with visualization of ovaries and tubes, was achieved in 88.3% of the cases [11-13]. In a review of 4232 procedures from 10 studies, bowel injuries occurred in 0.61%. In a multicenter

TABLE 2.  
Comparisons between THLF and Laparoscopy

	THLF	Laparoscope
① Dermatologic incision	No	Multiple smalls
② Anesthesia	Local	General
③ Invasion	Small	Large for only observation
④ Admission	No	A few days
⑤ Operative procedures	Difficult	Possible
⑥ Observation	Clear in fluid	Clear

study, the incidence of bowel perforation was 0.65% and decreased to 0.25%, after an initial learning experience of 50 THL; 92% of these bowel injuries were managed expectantly without consequences [7-9]. In addition to diagnostic THL, the relevance of operative THL has been validated mainly for ovarian drilling for polycystic ovary syndrome. Despite the advantages of THL in terms of cost, reliability as compared to laparoscopy in detecting pelvic abnormalities, and its superiority in detecting subtle lesions, as well as the feasibility of performing it under local anesthesia thereby contributing to the couple's participation, adoption of THL remains relatively low, underlining the need to promote this minimally invasive procedure [1-8].

*C. trachomatis* is the main agent of PID. The problem is that the majority of cases with *C. trachomatis* infection are asymptomatic and are often referred to as 'silent PID'. Some patients become aware of *C. trachomatis* infection after experiencing infertility or an ectopic pregnancy. The association between *C. trachomatis* antibody in the sera of infertile women and tubal subfertility has been well documented [8-14]. *C. trachomatis* antibody can be determined at low cost and presents no burden to the patient. The discriminative capacity of *C. trachomatis* antibody in the diagnosis of various tubal pathologies was analyzed and it was found to be comparable to that of HSG in the diagnosis of tubal occlusion. It was also suggested that *C. trachomatis* antibody testing does not seem to be useful in predicting the prognosis of fertility, as it provides no information on the severity of tubal disease.

In current practice, HSG is widely used to assess tubal patency and uterine anomalies [2]. HSG has been a routine examination in many infertility centers as it is less costly and less invasive than laparoscopy. However, laparoscopy is superior in detecting peritoneal adhesions and endometriosis as compared with HSG [2,7,8]. In the present study, THLF was used for evaluating tubo-ovarian pathology in infertile women.

THLF is less traumatic than standard laparoscopy. Transvaginal access and the systemic use of hydro floatation are potential advantages of THLF for the exploration of tubo-ovarian structures in infertility [3,7,8]. The advantages of THLF include accurate and atraumatic inspection of adnexal structures without manipulation, with the opportunity to perform dye hydrotubation and salpingoscopy. Furthermore, THLF was performed in three cases with retroverted uterus and peritoneal surgical history in spite of contraindication for solid scope THL. THLF was very useful in extending the indications for THL. The risks of a general anesthetic are avoided, and there is less chance of trauma to major vessels (Table 2). There was no complication by THLF in the presented cases.

Six of the 7 patients became pregnant by ART, and discrepancies between HSG and THLF were observed in 3 of the 6 patients. The HSG revealed normal findings in 2 of the 3 women, whereas THLF showed the presence of severe fimbrial adhesions; therefore ART was recommended. Three cases with abnormal findings of both HSG and THLF were also recommended for treatment by ART. Findings on THLF were given precedence in deciding further treatment strategies. We believe that THLF is useful helping these types of patients to successfully achieve early pregnancy. This study is the first trial of THLF.

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# Assessment of Physical and Mental Health in Male University Students with Varying Sleep Habits

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**Summary:** Healthy sleep habits entail not only sleeping for a sufficient period (quantity) but also regularity of the sleep cycle and getting sound sleep (quality). University students often have erratic schedules that cause irregular sleep patterns even though sleep durations remain relatively constant. This study compared the physical and mental health of 90 male university students with different sleep habits. We created sleep habit scales using the Tokyo Metropolitan Institute for Neuroscience life habits inventory (TMIN-LHI; Miyashita, 1994) by performing a factor analysis and classifying sleeping habits based on regularity, quality, and quantity. Four types of sleep habits were identified by cluster analysis; good sleep was characterized by regular and high quality sleep but of relatively short sleep duration; long sleep was regular and relatively long but of low quality; short sleep was of high quality but short and irregular, while poor sleep was irregular, of low quality, and relatively long. The good sleep group had a significantly lower average waist circumference, and lower systolic and diastolic blood pressure. The long and poor sleep groups, which both had low quality sleep, scored lower than the national standard on the mental component summary (MCS) calculated from the Social Functioning-36 (SF-36) short-form health survey. Furthermore, the average MCS score of the poor sleep group was significantly lower than that of any other sleep habit group. Subjects with poor sleep also scored lowest on the Self-rating Depression Scale (SDS). In addition, the short and poor sleep groups were prone to glucose or lipid metabolism disorders. Maintaining good physical and mental health without sound sleep and a regular sleep cycle is difficult, even if sleeping hours are kept constant. Therefore, we included the assessment of regularity and quality in addition to hours of sleep in order to develop appropriate sleep guidelines for improved physical and mental health.

**Key words** university students, sleep habits, sleep hygiene, regularity of sleep, quality of sleep, sleep duration

## INTRODUCTION

Metabolic syndrome and depression are now attracting considerable research attention. These disorders are closely related to various aspects of lifestyle, such as diet [1], exercise [2], and mental stress [3]. The Japanese population has a tendency to neglect sleep

because of a national work ethic based on diligence [4]. In addition, working overtime is considered a virtue in Japan, and 24-h work operations are commonplace. Twenty-four hour stores are a regular feature and many young people work in late shifts. For them, work time and free time are more important than sleep duration [5].

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Abbreviations: ANOVA, analysis of variance; ASDA, American Sleep Disorders Association; BMI, body mass index; FBS, fasting blood sugar; HDL-C, high-density cholesterol; HMW-adiponectin, high molecular weight adiponectin; HOMA-IR, homeostasis model of assessment-insulin resistance; HSD, honestly significant difference; LDL-C, low-density cholesterol; ME, Morningness-Eveningness; MCS, mental component summary; n.s., not significant; PCS, physical component summary; QOL, quality of life; SD, standard deviation; SDS, Self-rating Depression Scale; SF-36, Social Functioning-36; TMIN-LHI, Tokyo Metropolitan Institute for Neuroscience life habits inventory.

However, irregular and insufficient sleep can cause daytime drowsiness and a lack of concentration, reduced quality of life, and a decline in performance. For example, Belenky [6] has indicated that once chronic sleep insufficiency affects performance, complete recovery is difficult even if adequate sleep was secured for three consecutive nights. When chronic sleep insufficiency gradually accumulates in an individual, performance is drastically reduced even if sleepiness is not felt. Lack of sleep and insomnia also cause mental disorders. Kaneita's study [7] on 24,686 Japanese adults ascertained that sleep duration of less than six h and more than eight h was associated with symptoms of depression. Sleep deficiency can affect physical health as well. Gangwish [8] found that subjects who slept less than four hours were 73% more obese than those who slept more than seven h. Tochikubo [9] reported a high blood pressure throughout the day in subjects who had only 3-4 h of sleep the previous night. Knutson [10] demonstrated that one week of sleep insufficiency caused impaired glucose tolerance because of a decline in insulin sensitivity levels. Therefore, adequate sleep is important not only for performing normal daytime activities efficiently, but also for good physical and mental health.

University students often have erratic schedules that cause irregular sleep patterns. Kang [11] suggested that students with an irregular bedtime schedule might experience poor sleep quality. In addition, Buboltz [12] investigated that poor sleep habits might become a self-perpetuating cycle that students are unaware of and might be unable to alter. Chang [13] conducted a follow-up study on 1053 male university graduates for 34 years. Of these, 103 developed depression, and the risk of depression in those who had insomnia during their university days was twice as high as that in subjects who did not. Therefore, it has been suggested that poor sleep habits at a young age could have an effect on sleep habits in middle age in the same individual, and that sleep habits are not short-term but rather long-term factors.

When evaluating sleep, we tend to emphasize the number of hours (i.e., the quantity of sleep). However, maintaining a regular and sound sleep cycle are also important factors. Hayashi [14] stated that sleep habits could be measured in three dimensions (i.e., regularity, quality and quantity). In an earlier study, Takeuchi [15] identified these three factors of sleep from the Tokyo Metropolitan Institute for Neuroscience life habits inventory (TMIN-LHI) and classified sleep habits on the basis of these factors. Takeuchi's analysis takes into account not only the quantity of sleep but

also examines other perspectives, by which the issue can be more comprehensively understood. Minimizing hidden perspectives in this way provided a better understanding of the sleep habits of university students. However, no physical or mental data were investigated in that study, so the relationship between health condition and sleep habits was ambiguous. University students often have physical and mental problems besides sleep disorders [16]. In this study, we used Takeuchi's method to compare the physical and mental condition of university students in order to clarify the effects of certain factors that cause differences in sleep habits. In addition, because sleep habits differ between sexes [17], we restricted our study to males in order to obtain a more exact analysis. Therefore, we investigated sleep habits (sleep hygiene) in male university students for the purpose of demonstrating the association between sleep habits and physical and mental health.

## MATERIALS AND METHODS

### *Study subjects and duration*

The subjects of this study were male students of Kurume University (18-29 years; average age: mean  $\pm$  standard deviation (SD),  $19.4 \pm 1.8$  years). None of the subjects had any physical or mental disease and none were on regular medication. In addition, obesity can cause secondary sleep disturbances because of sleep apnea syndrome. Therefore, a body mass index (BMI) of 18.5 to 24.9 was set as an inclusion factor for this study. In total, 90 students were included in this study, which was carried out in June 2010. There were no aggravating circumstances such as examinations or long breaks before or after the testing day.

### *Questionnaires*

We used the TMIN-LHI, which is a detailed questionnaire comprising two sections. The first section includes 60 questions based on sleep habits and other lifestyle issues. The second section is a Morningness-Eveningness (ME) questionnaire created by Horne and Ostberg [18] and translated into Japanese by Ishihara [19]. It comprises 19 items. We calculated the ME score for our subjects on the basis of their grade slips.

### *Preparation of the sleep habits scale and classification of subjects*

#### **Selected Items**

From TMIN-LHI, 26 of 60 items from section 1 were excluded. These were nominal items or the items targeting certain people who offered a specific answer, and had large ceiling or floor effects. We eventually

conducted a factor analysis with 35 items (i.e., the remaining 34 items from section 1 and the ME score from section 2).

### Factor Analysis

We extracted factors by principal factor analysis and ran a promax rotation. Three factors were chosen on the basis of scree plot. The characteristic values were 6.120, 3.030 and 2.591 respectively, and the cumulative percentage was 33.5%.

Following analysis of the 35 items from the TMIN-LHI, which was done five times, 18 items were excluded. The remaining 17 items had factor loadings of  $\geq 0.35$ . The explanatory power was 53.4% and the accumulated contribution rate was 46.0%. The confidence coefficients ( $\alpha$ ) of the three factors were 0.878, 0.683, and 0.670 for the first, second and third factor, respectively.

The three factors focused on in this study are described in Table 1 along with their factor loadings. The first factor comprised 8 items: regular bedtime, regular wake-up time, irregular bedtime, irregular wake-up time, ME score, irregular sleep duration, breakfast habits, and exercise habits. This regularity factor along with its items was named the related Sleep Regularity scale. The second factor comprised 5 items: difficulty of sleep latency, time to fall asleep, mood on waking

up in the morning, depth of sleep and experience of insomnia. This quality factor along with its items was named the related Sleep Quality scale. The third factor comprised 5 items: regular sleep duration, ideal sleep duration, regular wake-up time, value attached to sleep and time spent in commuting. This quantity factor along with its items was named the related Sleep Quantity scale.

### Principal Component Analysis

Eight items from the first factor, five from the second factor and five from the third factor were subjected to principal component analysis, and each factor was given a standard score. We created a sleep habits scale by assuming the first score to be a scale score. The average score was initially fixed at 0. In the related Sleep Regularity scale, a positive score indicated mostly regular sleep habits and a negative score indicated mostly irregular sleep habits. In the related Sleep Quality scale, a positive score indicated a more sound sleep and a negative score indicated a very disturbed sleep. In the related Sleep Quantity scale, a positive score indicated longer sleep duration and more active procurement of sleep, and a negative score indicated shorter sleeping hours and more passive procurement of sleep.

### Classifying Subjects

The Ward method of cluster analysis was selected

TABLE 1.  
*Extracted factors and factor loadings*

	Items	Range	Factor Loadings
The First Factor $\alpha=0.878$	Q1: regular bedtime	early – late	0.868
	Q4: regular wake-up time	early – late	0.745
	Q2: irregular bedtime	small – large	0.713
	Q5: irregular wake-up time	small – large	0.689
	ME score	Eveningness – Morningness	-0.657
	Q8: irregular sleep duration	small – large	0.652
	Q37a: breakfast habits	always – never	0.616
	Q49: exercise habits	never – always	-0.596
The Second Factor $\alpha=0.683$	Q14: difficulty of sleep latency	easy – difficult	0.982
	Q13: time to fall asleep	short – long	0.529
	Q19: mood on waking up in the morning	pleasant – unpleasant	0.427
	Q20: depth of sleep	deep – light	0.417
	Q43: experience of insomnia	no – yes	0.408
The Third Factor $\alpha=0.670$	Q7: regular sleep duration	short – long	1.002
	Q11: ideal sleep duration	short – long	0.574
	Q4: regular wake-up time	early – late	0.397
	Q12: value attached to sleep	important – unimportant	-0.381
	Q45: time spent in commuting	short – long	-0.377



for classifying the subjects on the basis of principal component score for each factor. Four clusters were determined because they were the most balanced and the clearest following the dendrogram.

#### *Physical factors*

The subjects were instructed to measure their own height and weight. Waist circumference was measured at the umbilical region by members of the same study staff. The subjects also measured their own resting blood pressure and pulse with an automatic manometer (BP-203RV Type C, Nippon Colin, Tokyo, Japan) in a sitting position. If systolic blood pressure was  $\geq 130$  mmHg or diastolic blood pressure was  $\geq 85$  mmHg, subjects measured their blood pressure again. In the event that the second blood pressure measurement was unacceptable, the study staff measured it with a mercurial column manometer.

#### *Mental health*

We evaluated mental health using the Japanese version of the Social Functioning-36 (SF-36) [20-22] short-form health survey and Japanese version of the Self-rating Depression Scale (SDS) [23].

The Japanese version of the SF-36, which was developed by Fukuhara [20-22], is a general scale used to measure quality of life over a one-month period. All items are scaled, and the higher the scores, the better the quality of life. Physical component summary (PCS) and mental component summary (MCS) were derived from the SF-36: physical functioning, role physical, bodily pain, general health perceptions, vitality, social functioning, role emotional, and mental health. PCS score and MCS score can be compared to national standard values directly (50=national standard score). Furthermore, we can evaluate physical quality of life (QOL) from PCS and mental QOL from MCS in a comprehensive manner.

Zung [24,25] developed SDS as simple test to assess depression, and Fukuda translated it into Japanese [23]. It comprises 20 items, all graded according to four ranks of 1-4 points each. We used an integrated scoring system as follows:  $\leq 39$  points indicated normal mental health, 40-49 points indicated slight depression, and  $\geq 50$  points indicated moderate depression.

#### *Blood tests*

Blood samples were taken and fasting blood sugar (FBS), immunoreactive insulin levels, high-density cholesterol (HDL-C), low-density cholesterol (LDL-C), leptin, des-acyl ghrelin, and high molecular weight

adiponectin (HMW-adiponectin) were measured. In addition, the homeostasis model of assessment-insulin resistance (HOMA-IR) was calculated from FBS and immunoreactive insulin values;  $HOMA-IR = (\text{immunoreactive insulin} \times FBS) / 405$  [26].

#### *Statistical analysis and software*

The mean and SD values of each item were expressed as mean  $\pm$  SD. Shapiro-Wilk test was used as the normality test. If the item showed a normal distribution, one-way analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) tests were used as parametric tests. In the event that the item did not have a normal distribution, the Kruskal-Wallis H test and Scheffe test were used as nonparametric tests. We used SPSS15.0J Base System SC Kit software and set the significance level at  $p < 0.05$ .

#### *Ethical concerns*

Prior to enrollment, subjects were informed about the purpose and method of this study, following which they asked to sign written informed consent forms. If the subjects were minors, we obtained their parents' approval. We ensured that no one of the subjects would be pressured or harmed because of nonparticipation. Personal data were strictly monitored to maintain confidentiality and to protect the privacy of subjects. This study was approved by the Kurume University Mii Campus Ethical Review Board.

## RESULTS

#### *Characteristics of each type of sleep habits*

Figure 1 illustrates the four categories of sleep habits with the mean and SD of each scale score. The first type was the most regular and sound sleep, but there was a slight tendency towards shorter sleep duration. It was termed the "good sleep" type. The second type was somewhat regular and characterized by insomnia and longer sleeping period. It was called "long sleep" type. The third type was somewhat irregular but sound sleep and was characterized by the shortest sleep duration among all subjects. It was called "short sleep" type. The fourth type was the most irregular and was characterized by extreme insomnia and long sleep duration. It was referred to as the "poor sleep" type.

The upper section of Table 2 lists the averages for regular sleep duration, ideal sleep duration, regular bedtime, regular wake-up time, irregular sleep duration, irregular bedtime, irregular wake-up time and time to fall asleep for the four sleep habits groups. Regular sleep duration averaged  $6.7 \pm 1.2$  h. There were sig-

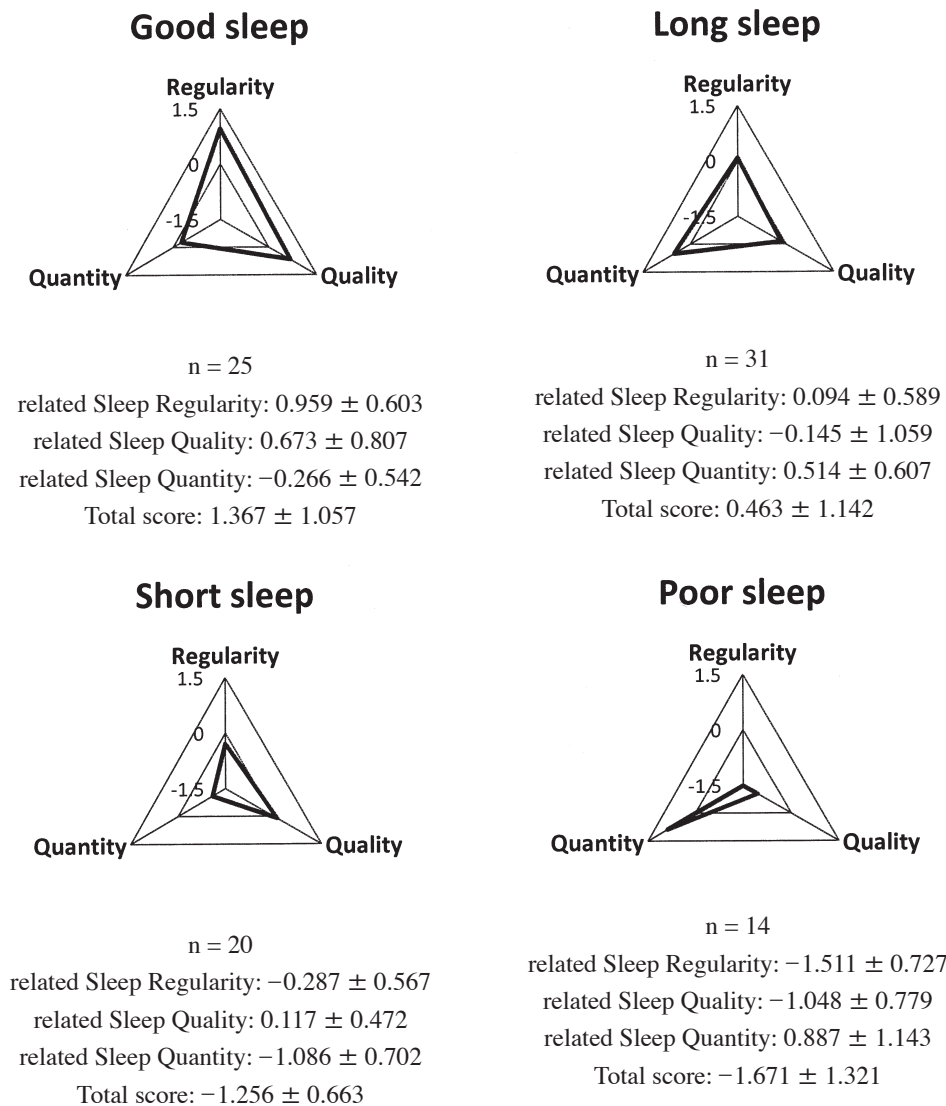


Fig. 1. Four types of sleep habits and corresponding scale scores (means  $\pm$  SD).

Good sleep was the most regular and sound sleep, but there was a slight tendency towards shorter sleep duration. Long sleep was somewhat regular and characterized by insomnia and longer sleeping period. Short sleep was somewhat irregular but sound sleep and was characterized by the shortest sleep duration. Poor sleep was the most irregular and was characterized by extreme insomnia and long sleep duration.

nificant differences in regular sleep duration (multiple comparison; short sleep vs. good sleep, long sleep and poor sleep:  $p < 0.001$ ), ideal sleep duration (short sleep vs. long sleep:  $p < 0.05$  and poor sleep:  $p < 0.01$ ), regular bedtime (good sleep vs. long sleep:  $p < 0.01$ , short sleep and poor sleep:  $p < 0.001$ , long sleep vs. poor sleep:  $p < 0.001$ , short sleep vs. poor sleep:  $p < 0.05$ ), regular wake-up time (good sleep vs. long sleep and poor sleep:  $p < 0.001$ , long sleep vs. short sleep:  $p < 0.05$  and poor sleep:  $p < 0.001$ , short sleep vs. poor sleep:  $p < 0.001$ ), irregular sleep duration (good sleep vs. short sleep:  $p < 0.05$  and poor sleep:  $p < 0.001$ , long sleep vs.

poor sleep:  $p < 0.001$ , short sleep vs. poor sleep:  $p < 0.001$ ), irregular bedtime (good sleep vs. short sleep:  $p < 0.01$  and poor sleep:  $p < 0.001$ , long sleep vs. poor sleep:  $p < 0.001$ , short sleep vs. poor sleep:  $p < 0.05$ ), irregular wake-up time (good sleep vs. short sleep:  $p < 0.05$  and poor sleep:  $p < 0.001$ , long sleep vs. poor sleep:  $p < 0.001$ , short sleep vs. poor sleep:  $p < 0.001$ ), and time to fall asleep (good sleep vs. poor sleep:  $p < 0.001$ , short sleep vs. poor sleep:  $p < 0.01$ ).

#### Physical characteristics of subjects

The middle section of Table 2 describes the physi-

TABLE 2.  
 Characteristics of each type of sleep habits (mean  $\pm$  SD)

	Total	Good sleep	Long sleep	Short sleep	Poor sleep	p value	
n	90	25	31	20	14		
Sleep data	regular sleep duration (h)	6.7 $\pm$ 1.2	6.7 $\pm$ 0.8	7.3 $\pm$ 0.7	5.3 $\pm$ 0.9	7.1 $\pm$ 1.5	<0.001*
	ideal sleep duration (h)	7.4 $\pm$ 1.2	7.3 $\pm$ 0.9	7.7 $\pm$ 1.1	6.8 $\pm$ 0.7	8.1 $\pm$ 1.7	0.003*
	regular bedtime (o' clock)	24.7 $\pm$ 1.3	23.6 $\pm$ 1.1	24.6 $\pm$ 0.9	25.2 $\pm$ 1.0	26.1 $\pm$ 1.1	<0.001*
	regular wake-up time (o' clock)	7.8 $\pm$ 1.4	6.7 $\pm$ 0.9	8.2 $\pm$ 0.9	7.4 $\pm$ 0.9	9.6 $\pm$ 1.3	<0.001*
	irregular sleep duration (min)	71.0 $\pm$ 62.9	32.4 $\pm$ 35.6	60.0 $\pm$ 49.6	79.5 $\pm$ 53.6	152.1 $\pm$ 67.1	<0.001*
	irregular bedtime (min)	94.0 $\pm$ 73.6	50.0 $\pm$ 25.8	78.7 $\pm$ 42.3	117.0 $\pm$ 79.6	173.6 $\pm$ 102.7	<0.001*
	irregular wake-up time (min)	81.6 $\pm$ 74.1	41.2 $\pm$ 31.0	62.3 $\pm$ 37.9	90.0 $\pm$ 66.0	184.3 $\pm$ 103.2	<0.001*
	time to fall asleep (min)	25.3 $\pm$ 16.4	17.8 $\pm$ 9.3	28.1 $\pm$ 17.9	21.0 $\pm$ 11.1	38.6 $\pm$ 20.3	<0.001*
Physical data	Age (years)	19.4 $\pm$ 1.8	19.0 $\pm$ 0.9	19.6 $\pm$ 2.1	19.2 $\pm$ 2.4	19.9 $\pm$ 1.3	n.s.
	BMI (kg/m <sup>2</sup> )	21.0 $\pm$ 1.7	20.2 $\pm$ 1.6	21.2 $\pm$ 1.8	21.3 $\pm$ 1.5	21.3 $\pm$ 1.8	n.s.
	waist circumference (cm)	72.1 $\pm$ 5.1	69.9 $\pm$ 4.7	72.1 $\pm$ 5.6	73.9 $\pm$ 3.9	73.4 $\pm$ 5.2	0.040*
	systolic blood pressure (mmHg)	116.2 $\pm$ 10.1	110.1 $\pm$ 9.6	117.2 $\pm$ 10.6	118.0 $\pm$ 9.1	120.9 $\pm$ 7.7	0.011*
	diastolic blood pressure (mmHg)	66.3 $\pm$ 9.6	62.4 $\pm$ 6.6	68.1 $\pm$ 10.3	65.0 $\pm$ 9.4	70.9 $\pm$ 10.3	0.026*
	pulse (/min)	69.7 $\pm$ 10.3	64.8 $\pm$ 10.5	70.8 $\pm$ 10.3	71.9 $\pm$ 10.2	72.7 $\pm$ 7.6	0.038*
Blood test data	FBS (mg/dl)	86.8 $\pm$ 7.2	85.9 $\pm$ 5.0	86.1 $\pm$ 5.2	85.7 $\pm$ 4.5	91.7 $\pm$ 13.6	0.049*
	immunoreactive insulin ( $\mu$ U/ml)	6.9 $\pm$ 7.0	5.7 $\pm$ 2.2	6.3 $\pm$ 3.4	6.5 $\pm$ 3.0	11.1 $\pm$ 16.2	n.s.
	HOMA-IR	1.6 $\pm$ 2.3	1.2 $\pm$ 0.5	1.4 $\pm$ 0.7	1.4 $\pm$ 0.7	3.0 $\pm$ 5.5	n.s.
	HDL-C (mg/dl)	61.2 $\pm$ 10.0	63.5 $\pm$ 9.5	57.7 $\pm$ 8.4	65.0 $\pm$ 11.8	59.3 $\pm$ 9.3	0.035*
	LDL-C (mg/dl)	90.2 $\pm$ 19.3	93.7 $\pm$ 20.0	87.1 $\pm$ 18.4	85.9 $\pm$ 15.3	97.2 $\pm$ 23.4	n.s.
	leptin (ng/ml)	2.4 $\pm$ 1.1	2.0 $\pm$ 0.8	2.5 $\pm$ 1.3	2.7 $\pm$ 1.0	2.4 $\pm$ 1.0	0.024 <sup>†</sup>
	desacyl-ghrelin (fmol/ml)	203.7 $\pm$ 99.6	240.6 $\pm$ 129.5	182.5 $\pm$ 75.3	181.4 $\pm$ 88.6	216.4 $\pm$ 88.5	n.s.
	HMW-adiponectin ( $\mu$ g/ml)	5.2 $\pm$ 2.7	5.9 $\pm$ 2.7	5.1 $\pm$ 2.8	4.9 $\pm$ 2.7	4.6 $\pm$ 2.5	n.s.

\* significant difference (by ANOVA test), <sup>†</sup> significant difference (by Kruskal-Wallis H test), n.s. = not significant.

cal characteristics of subjects associated with the four types of sleep habits. There were significant differences in waist circumference (multiple comparison; good sleep vs. short sleep:  $p < 0.05$ ), systolic blood pressure (good sleep vs. poor sleep:  $p < 0.05$ ), diastolic blood pressure (good sleep vs. poor sleep:  $p < 0.05$ ), and pulse (no difference in multiple comparison). However, no significant differences were observed in age or BMI among the subjects.

#### Mental health of subjects

Figure 2 shows data for the four types of sleep habits based on responses to PCS and MCS of SF-36. While PCS scores of all groups were higher than the national standard value ( $\geq 50$ ), MCS scores of two groups (i.e., long sleep and poor sleep) were lower than the national average. There was a significant difference in MCS but no significant difference in PCS

among the subjects. Scores for poor sleep were significantly lower than for the other types of sleep with regard to MCS (vs. good sleep:  $p < 0.001$ , vs. long sleep:  $p < 0.05$ , vs. short sleep:  $p < 0.01$ ). Figure 3 shows data for the four types of sleep habits based on responses to SDS. Scores for poor sleep were significantly higher than those for the other types of sleep (vs. good sleep:  $p < 0.001$ , vs. long sleep:  $p < 0.05$ , vs. short sleep:  $p < 0.05$ ).

#### Blood test results

The bottom section of Table 2 lists the results of blood tests for each group. There were significant differences in FBS (no difference in multiple comparison), HDL-C (long sleep vs. short sleep:  $p < 0.05$ ), and leptin (good sleep vs. short sleep:  $p < 0.05$ ), but no significant differences in immunoreactive insulin levels, HOMA-IR, LDL-C, des-acyl ghrelin, and HMW-

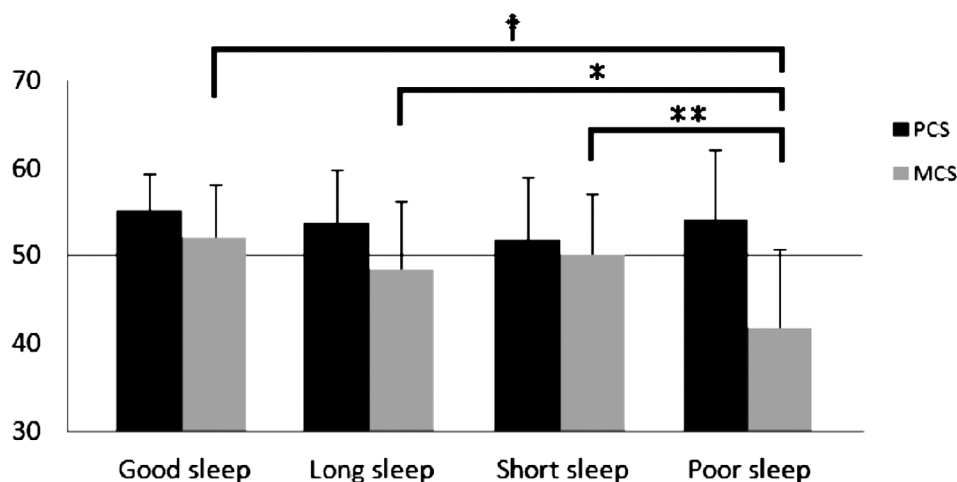


Fig. 2. PCS and MCS as measured by SF-36 (national standard value = 50, \*p<0.05, \*\* p<0.01, †p<0.001 by Tukey’s HSD test). While PCS scores of all groups were higher than national standard value ( $\geq 50$ ), MCS scores of long sleep and poor sleep were lower than it. Scores for poor sleep were significantly lower than for the other types of sleep with regard to MCS.

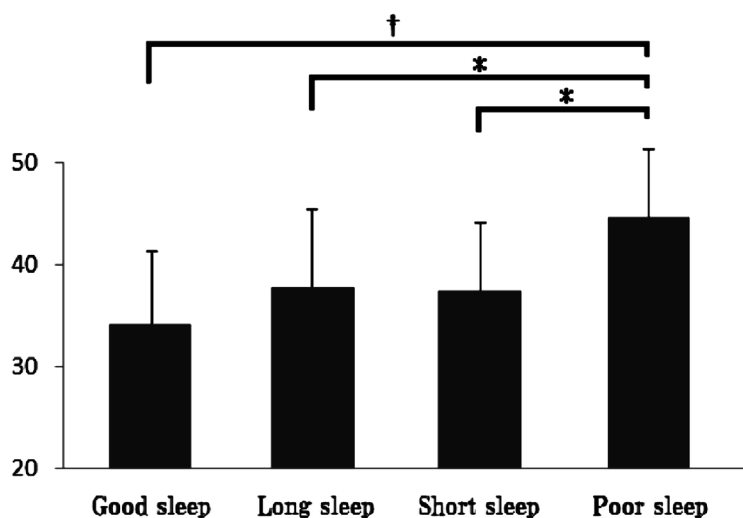


Fig. 2. SDS of four sleep habits (\*p<0.05, †p<0.001 by Tukey’s HSD test). Poor sleep had significantly higher score when compared to the scores for the other types.

adiponectin among the subjects.

## DISCUSSION

### Methodology

The purpose of this study was to measure the impact of different sleep habits (sleep hygiene) on physical and mental health in a cohort of 90 male university

students by classifying sleep habits. We developed comprehensive scales that described sleep regularity, quality, and quantity by factor analysis and principal component analysis. Cluster analysis was then employed to classify the sleep habits these students into four groups. Measures of sleep habits must consider not only the number of hours slept (quantity), but must also account for regularity and quality of sleep to

clearly identify those facets of sleep patterns that most influence mental and physical health. Takeuchi [15] classified sleep habits on the basis of all three factors, and this method proved to be more precise than methods that only evaluated single factors such as sleep duration. We investigated the physical and mental health of the present subjects after classifying sleep habits by means of Takeuchi's comprehensive scoring method. Our analysis underscores the importance of measuring all three dimensions to establish a consistent relation between sleep habits and physical and mental health.

#### *Interpretation of each type of sleep habits*

Good sleep is defined by consistent and normal sleep duration. Those subjects in the good sleep group kept very early hours and scored higher in Morningness. Daily changes of sleep duration, bedtime, and wake-up time were quite small. They also fell asleep easily. Good sleep is the exemplary sleeping pattern. In long sleep subjects, regular bedtimes were normal and regular, but regular wake-up time was later. In addition, both usual and ideal sleep durations were longer than the average. In other words, this group preferred to rise later. They fell asleep with difficulty and had lower quality sleep; that may cause them to oversleep. In the short sleep group, regular bedtimes were later and regular wake-up times were earlier. While this group fell asleep easily, they had irregular sleep habits. They preferred to stay up late and were less concerned about sleep because their ideal sleep duration was shorter than that of any of the other groups. These factors could be expected to result in short sleeping times. Subjects in the poor sleep group seemingly got plenty of sleep according to regular sleep duration, but sleep regularity was poor, and these subjects found it difficult to fall asleep. In addition, their ideal sleep duration was longer than that of any of the other groups. This group may lack sufficient sleep due to chronic insomnia.

In Takeuchi's study [15], several extracted sleep habits were similar to sleep disorders defined by the American Sleep Disorders Association (ASDA), including sleep deficit syndrome, circadian rhythm disorder, and delayed sleep phase syndrome. In the current study, both short and poor sleep subjects had lower than average total scale scores, indicating problematic sleep habits. Short sleep was similar to sleep deficit syndrome as defined by the ASDA in that there was a large gap between actual and ideal sleep durations. In contrast, poor sleep resembled exogenous circadian rhythm disorders such as jet lag. A change in time zone of over three hours causes jet lag with disturbance of sleep induction [27]. The sleep habits of

subjects with poor sleep appeared similar to those of daily travelers suffering from jet lag. If the subjects in the poor sleep group graduate from university with the same sleep habits, they might not be able to conform to regular office hours. Thus, they should receive therapy to correct irregular lifestyle habits and to manage insomnia.

#### *Physical characteristics of subjects*

Lack of sleep may be linked to obesity due to increased food consumption [8]. There was a significant difference in average waist circumference between the short and the good sleep groups. However, the good sleep group had the second shortest average sleep duration; thus, shorter sleep duration alone does not lead to weight gain. If individuals continue to sleep for irregular hours and have an inconsistent circadian rhythm, the clock gene begins to express abnormalities, which may lead to easy accumulation of visceral fat [28,29]. Therefore, it is suggested that people with irregular as well as short sleep habits, like the short sleep group in this study, may be prone to visceral fat obesity even if their age and BMI are similar to individuals with good sleep habits.

There were significant differences in blood pressure and pulse between the poor and good sleep groups. Ishii [30] demonstrated that irregular sleep habits could disrupt autonomic nervous system function leading to hypertension and rapid pulse. In addition, Javaheri [31] reported that sleep disturbance could cause hypertension even in young healthy men without arteriosclerosis such as the poor sleep subjects in this study. Extremely irregular sleep habits with insomnia, as exhibited by the poor sleep group, may increase blood pressure and pulse due to an autonomic disorder.

#### *Mental health of subjects*

Apropos of the relationship between sleep and mental disease, insomnia and depression are often associated with poor sleep habits. Predictably, poor sleep, the type for which the related Sleep Quality scores were extremely low, indicated the worst mental condition. With respect to MCS measured on the basis of SF-36 and SDS scores, subjects in the poor sleep group had very bad scores that were significantly poorer than the scores of subjects of any other sleep type. SDS scores in this group were  $\geq 40$ , which is considered to reflect a state of neurosis. People who have sleep habits like those in the poor sleep group are therefore prone to depression. The mental condition of subjects in the long sleep group, whose related Sleep Quality scores were second-lowest after those in the poor sleep



group, was also lower than national standard value in MCS in spite of surpassing that of subjects in the short sleep group whose total sleep habits scale score was far worse.

The timing of onset of depression and insomnia has not been sufficiently investigated. However, according to Ohayan [32], insomnia often precedes depression. Furthermore, for people who suffer from insomnia for more than one year, the risk of depression can be 40 times greater than that in those without insomnia [33]. It is important, therefore, that the symptoms observed in the poor sleep group of this study should be immediately resolved, and people whose sleep habits fall into the long sleep category should also be concerned about the relation between their sleep habits and mental condition.

#### *Blood test results*

Of the saccharometabolism items (FBS, immunoreactive insulin, and HOMA-IR), only FBS showed a significant difference among subjects with the four types of sleep habits. However, for all three items, the good sleep group had the lowest values and the poor sleep group showed the highest values. As mentioned above, an inconsistent circadian rhythm because of irregular sleep habits leads to abnormalities in the clock gene, which in turn may lead to visceral fat accumulation [28,29]. Eventually, insulin resistance and impaired glucose tolerance can also result.

Of the lipometabolism items (HDL-C and LDL-C), only HDL-C showed a significant difference between long sleep and short sleep. While subjects in the good sleep and short sleep groups had high levels of HDL-C, those in the long sleep and poor sleep groups had low levels of HDL-C. It has been suggested that deterioration in sleep quality and hypersomnia play a role in decreasing HDL-C. Contrary to our result, however, Bjorvatn [34] reported that sleep of short duration decreased HDL-C. This point, therefore, needs further study and consideration.

In the blood tests for leptin, des-acyl ghrelin, and HMW-adiponectin, only leptin showed a significant difference among subjects with the four types of sleep habits. Leptin and des-acyl ghrelin are appetat factors that are influenced by sleep. Sleep of short duration decreases leptin and increases des-acyl ghrelin, which in turn can bring about obesity due to enhanced appetite [35]. We predicted that leptin would decrease and des-acyl ghrelin would increase in the short sleep and poor sleep groups. However, there was no difference in des-acyl ghrelin, and leptin increased in subjects in the short sleep group. There was a significant difference in

circulating leptin between the short and good sleep groups. Leptin levels often increase with obesity because increased visceral fat leads to leptin resistance [36]. Visceral fat accumulation resulting from a chronic lack of sleep and irregular sleep habits might cause leptin resistance. Most previous studies were short-term (i.e., they analyzed acute sleep insufficiency). The effects of long-term sleep habits have not been adequately considered. Other studies analyzed only sleep duration and not regularity and quality. Therefore, it has been suggested that irregular as well as short sleep habits over the long-term, like short sleep in this study, cause leptin resistance and a compensatory increase in leptin.

In this study, there was no significant difference in HMW-adiponectin between groups. However, HMW-adiponectin levels were highest in the good sleep group and lowest in the poor sleep group. Few studies have reported the relationship between adiponectin and sleep. There is a possibility that the small number of subjects in our study prevented us from finding a significant difference for this parameter. Therefore, the relationship between adiponectin and sleep requires further analysis with a larger study sample.

The limitations of this study include the inclusion of males only and the relatively small sample population. Triglyceride, which is one of the diagnostic criteria of metabolic syndrome, was not measured, so we were unable to estimate the relation between sleep habits and metabolic syndrome. We also did not ask about club activities and part-time jobs, factors which could impact regularity of sleep. In addition, TMIN-LHI is a not scale for scoring but a simply questionnaire, and is not subject to validation. Finally, the analyses in this study have a variability related to the subjects. University students have unique lifestyles and sleep habits compared to the general population, and their sleep characteristics may differ from those in heterogeneous subjects like general members of society or the aged.

#### CONCLUSION

We found significant differences in certain physical characteristics, mental health, and blood test results among four different sleep habit groups in male university students. Although all subjects in this study were young men with normal BMI, irregular sleep habits caused increases in waist circumference, blood pressure, and pulse, and impaired saccharometabolism and lipometabolism even if sleep duration was kept constant. In addition, the mental condition of subjects with poor quality sleep was not as good as that of sub-

jects with good quality sleep. It is important to gain a comprehensive understanding of sleep habits in order to maintain good physical and mental health among male university students. Further studies to validate these scales may be required in the fields of sleep medicine and preventive medicine.

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## Preoperative Visualization of the Artery of Adamkiewicz by Dual-Phase CT Angiography in Patients with Aortic Aneurysm

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**Summary:** To improve our ability to visualize the Adamkiewicz artery (AKA), we developed a modified intravenous CT angiography technique, which we refer to as right atrial CT (RA-CT) angiography. In this study, AKA detection rate and visualization of the arterial continuity from the aorta to the anterior spinal cord artery (ASA) was evaluated using RA-CT angiography.

We performed RA-CT angiography in 110 patients with abdominal, thoracic descending, or thoracoabdominal aortic aneurysms. In RA-CT angiography, contrast medium with a high iodine concentration (370 mg/dl) was injected twice into the right atrium at a high injection rate (8.0 ml/sec), and two CT scans, starting at 20 sec after the first injection and at 35 sec after the second injection, respectively, were performed. All CT images were obtained using an 8- or 16-detector CT scanner at a slice thickness of 0.625 mm. The AKA was defined as the largest radiculomedullary artery with a characteristic hairpin turn, and with continuity from the aorta to the ASA.

The AKA with hairpin turn was detected in all patients (100%), and continuity from the aorta to the ASA was confirmed in 99 of the 110 patients (90.0%). The AKA arose between Th8 and L1 in 86 of these patients (86.8%), and originated from the left side in 71 patients (71.7%).

RA-CT angiography may be useful for visualizing the AKA and the arterial continuity from the aorta to the ASA in patients with aortic aneurysm, although the use of more advanced CT machines will provide safe and easy identification of the AKA and arterial continuity with a small amount of contrast medium and a single scan.

**Key words** spinal cord ischemia, paraplegia, CT angiography, Adamkiewicz artery, anterior spinal artery.

### INTRODUCTION

Paraplegia and paraparesis due to spinal cord ischemia are the most serious complications after repair of thoracic descending and thoracoabdominal aortic aneurysms. Spinal cord ischemia has been reported to occur in 5-10% of patients who undergo operative repair of these aneurysms [1-4].

Blood supply to the spinal cord is primarily main-

tained through the anterior spinal artery (ASA) in which blood flow is supplied via the radiculomedullary arteries arising from the segmental arteries such as the intercostal, the lumbar, or the subclavian artery. Among the radiculomedullary arteries, the most dominant artery in the thoracoabdominal region is called the Adamkiewicz artery (AKA). Accordingly, preoperative identification of the AKA, together with intraoperative reconstruction of the segmental artery from

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Abbreviations: AAA, abdominal aortic aneurysm; AKA, Adamkiewicz artery; ASA, anterior spinal artery; FOV, field of view; IA-CT, intra-arterial CT; IV-CT, Intravenous CT; MR, magnetic resonance; RA-CT, right atrial CT; TAA, thoracic descending aortic aneurysm; TAAA, thoracoabdominal aortic aneurysm.

which the AKA originates, is very important to minimize the risk of postoperative spinal cord ischemia.

Previous studies have shown that selective spinal cord angiography [5,6], multi-detector row computed tomography (CT) angiography [7-11], and magnetic resonance (MR) angiography [12,13] are useful for identifying the AKA and the ASA preoperatively. However, the visualization of the AKA and of the continuity between the aorta and the ASA with these techniques may not be adequate to prevent spinal cord ischemia after surgery. To improve visualization of the AKA using CT angiography, we developed a modified intravenous CT angiography technique, which we refer to as right atrial CT (RA-CT) angiography. So far as we are aware, this is the first report of this technique.

In the present study, visualization of the AKA, and of the continuity between the aorta and the ASA using RA-CT angiography were assessed, and the branching level and laterality of the origin of the AKA were determined.

## MATERIALS AND METHODS

Between January 2004 and June 2010, 110 patients with abdominal aortic aneurysm (AAA), thoracic descending aortic aneurysm (TAA) or thoracoabdominal aortic aneurysm (TAAA) underwent RA-CT angiography to identify the AKA and the ASA, as a preoperative procedure. The 110 patients included 87 male and 23 female patients who ranged in age from 23 to 85 years, with a mean age of  $68.4 \pm 10.6$  years. The aneurysm was AAA in 8 of the 110 patients, TAA in 67, and TAAA in 35. As to etiology, the aneurysm was atherosclerotic in 61 patients and dissecting in 49. Clinical characteristics of the 110 patients were summarized in Table 1. The exclusion criteria for RA-CT angiography were a previous allergic reaction to contrast medium and renal insufficiency (serum creatinine  $>2.0$  mg/dl). Informed consent was obtained from all patients after explaining the possible complications of CT angiography and the side effects of large doses of contrast medium.

For RA-CT angiography, a 5F straight catheter (CATHEX, Tokyo, Japan) was inserted into the RA via the femoral vein under fluoroscopic guidance, after which the patient was transferred to a CT room. Contrast medium (100ml) containing 370 mg/ml iopamidol (Shering, Berlin, Germany) was injected into the RA at a rate of 8 ml/sec with a power injector (Nemoto-Kyourindo, Tokyo, Japan), followed by a 20 ml physiological saline solution flush at the same rate, and then a CT scan was performed in each patient. In our RA-CT

TABLE 1.  
*Patient Characteristics*

Variable	Years (Mean $\pm$ SD)	N (%)
Age (years)	36-85 ( $68.4 \pm 10.6$ )	
Gender (male)		87 (79)
Diabetes mellitus		18 (16)
Hypertension		96 (87)
Hyperlipidemia		23 (21)
CAD (by history or ECG)		14 (13)
Cerebrovascular disease		16 (14)
COPD		41 (38)
Aneurysm pathology		
atherosclerotic		61 (55)
dissection		49 (45)
AAA		8 ( 7)
TAA		67 (61)
TAAA		35 (32)

CAD = coronary artery disease, COPD = chronic obstructive pulmonary disease, AAA = abdominal aortic aneurysm, TAA = thoracic aortic aneurysm, TAAA = thoracoabdominal aortic aneurysm

angiography protocol, injection of contrast medium and CT scan were performed twice to improve visualization of the AKA and of the arterial continuity, particularly in patients with hemodynamic disorders such as poor cardiac function, arrhythmias, bradycardia, or valve disease, and to obtain denser enhancement of the AKA in patients with a large aortic aneurysm or collateral arteries connecting with the ASA. The first CT scan was started 20 sec after the commencement of the first injection of contrast. The second CT scan was begun 35 sec after initiation of the second injection of contrast medium with the same injection protocol. Consequently, the scanning period for the opacified aorta and arteries feeding the spinal cord was expected to total 30 sec. The detailed RA-CT angiography procedures were schematically shown in Fig. 1.

For this study, an 8- or 16-row MDCT scanner (Lightspeed; GE Medical Systems, Milwaukee, USA) was used, and CT scans were obtained from the level of the first cervical vertebra to the inferior margin of the symphysis pubis. Shallow breathing was permitted for all patients throughout the scanning procedure. Each CT scan was performed using the following parameters: helical pitch, 1.375; 0.8 sec per rotation; 120 kV; 300-400 mA; calibration field of view (FOV), 500 mm; display FOV, 160-210 mm; and image slice thick-



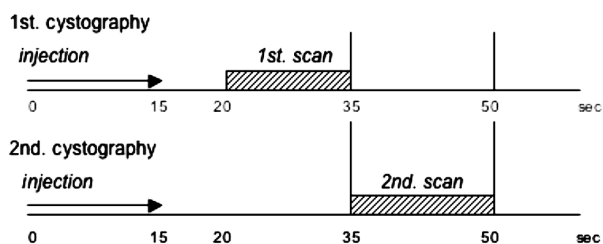


Fig. 1. Before each scan was started, 120 ml of a contrast material containing saline was injected at a rate of 8.0 mL/sec. The scan delay after the start of the first injection was 20 seconds and after the second injection was 35 seconds.

ness, 0.625 mm. Images were processed on a 3D workstation (Virtual place; AZE, Tokyo, Japan). Visualization of the hairpin turn and of the continuity between the aorta and the ASA were obtained by curved- and multiplanar reformations. All CT images were evaluated by one cardiovascular surgeon (S.T.) and 2 experienced radiologists (Y.Y, K.N) who were blinded to this study. In case of disagreement about the evaluation of an image, final consensus was reached through interobserver discussion. In this study, the diagnostic criteria for the AKA were both the presence of a so-called hairpin turn connecting to the ASA and the confirmation of the continuity of the aorta, the segmental artery such as the intercostal or lumbar artery, the AKA, and the ASA. Differentiation of the AKA from the anterior radiculomedullary vein is very difficult on the basis of their characteristic shapes; thus, the AKA was confirmed by visualizing the arterial continuity between the aorta and the ASA. The branching level of the AKA was determined on the basis of the anatomic level of the segmental artery from which the AKA originated, and the anatomic level of the segmental artery was defined as the level of the rib below which the segmental artery ran.

## STATISTICAL ANALYSIS

Continuous data presented as mean  $\pm$  standard deviation. They were analyzed using a 2-sided paired t test. Data analysis was performed on JMP version 5.1 (SAS Institute, Inc, Cary, NC)

## RESULTS

No complications related to the RA-CT angiography procedure such as paraplegia, bleeding, or aneurysm rupture were experienced, however, renal impairment caused by contrast medium (elevation of serum creatinine  $\geq 0.5$  mg/dl from the baseline creatinine value before the procedure) was observed in one patient, who was successfully managed with conservative treatment. The obtained data could be analyzed in all cases.

The AKA with hairpin turn was detected in all 110 patients (100%), and visualization of the continuity between the aorta and the ASA was confirmed in 99 patients (90.0%), as shown in Table 2 and Fig. 2. The arterial continuity was not traceable in the remaining 11 patients (10.0%). Of these 11 patients, 5 (45.5%) had a dissecting aortic aneurysm with very slow blood flow in the false lumen, and 7 (63.7%) had a large aneurysm with massive mural thrombi leading to occlusion of an ostium of the intercostal or lumbar artery. On scan timing, the AKA and the arterial continuity were visualized in the first scan (20 to 35 sec after beginning the injection of contrast medium) in 81 (81.8%) of the 99 patients and were observed in the second scan (35 to 50 sec after beginning the injection) in 18 (18.2%), as shown in Table 2. Among these 18 patients, 13 (72.2%) had a dissecting aneurysm. With regard to aneurysm etiology, the AKA and arterial continuity were observed in 61 (100%) and 55 (90.2%) of the 61 patients with a true aneurysm, respectively, and in 49 (100%) and 44 (89.8%) of the 49 patients with a dissecting aortic aneurysm, respectively. The difference in the detection rate of the AKA or visualization of the arterial continuity between these two patient-groups

TABLE 2.  
Detection rate on etiology

	Detection rate of the AKA	Detection rate of continuity
All patients	110 (100%)	99 (90%)
<b>Aortic etiology</b>		
True aneurysm	61 (100%)	55 (90.2%)
Dissection	49 (100%)	44 (89.8%)

p=0.9719

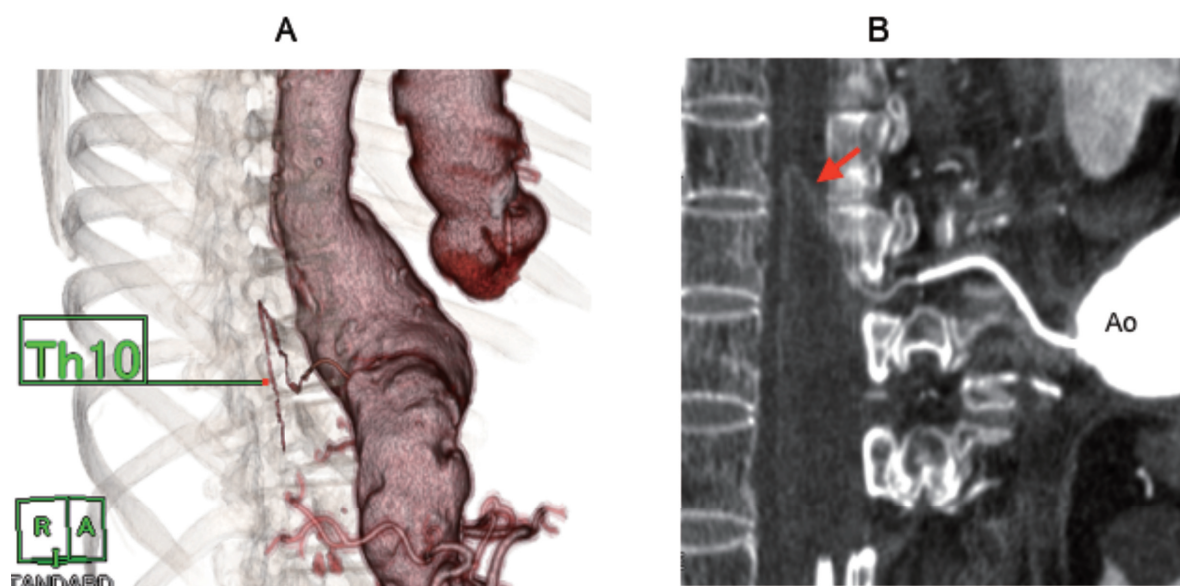


Fig. 2. One radicular artery. A) The right anterior oblique three-dimensional VR image. B) A 2D curved-MPR demonstrates connection from aorta to anterior spinal artery by the AKA, and its continuity. Red arrow points to AKA. Th10=10th thoracic vertebra, Ao=aorta, VR: volume rendering, MPR; multi planar reconstruction

TABLE 3.  
Origins of AKA in 99 patients

Level of AKA origin	Left	Right	No.	%	
TH6	1	0	1	1.0	
Th7	1	0	1	1.0	
Th8	8	2	10	10.1	} 86.8% } 95.0%
Th9	14	8	22	22.2	
Th10	18	1	19	19.2	
Th11	6	5	11	11.1	
Th12	8	3	11	11.1	
L1	7	6	13	13.1	
L2	7	1	8	8.0	
L3	1	1	2	2.0	
L4	0	1	1	1.0	
	71 (72%)	28 (28%)	99/99		

was not significant ( $p=0.9719$ ).

Among the 99 patients in whom the AKA and the arterial continuity were confirmed by RA-CT angiography, the segmental artery from which the AKA arose originated from the Th8 to L2 level in the aorta in 94 patients (95.0%), and particularly between Th8 and L1 in 86 patients (86.8%), as shown in Table 3. The segmental artery connecting with the AKA originated on the left side in 71 patients (71.7%) and on the right side in 28 patients (28.3%). Of the 99 patients, 79 (79.8%)

had a single AKA, however, multiple radiculomedullary arteries supplying the AKA were found in 20 patients (20.2%). In 19 of these 20 patients, 2 radiculomedullary arteries were recognized (Fig. 3-A) and 4 radiculomedullary arteries were observed in 1 patient (Fig. 3-B).

The presence of collateral circulation resulting from occlusion of the intercostal or lumbar arteries was depicted in 3 (2.7%) of the 110 patients. The intercostal artery was the source of collateral vessels to the AKA

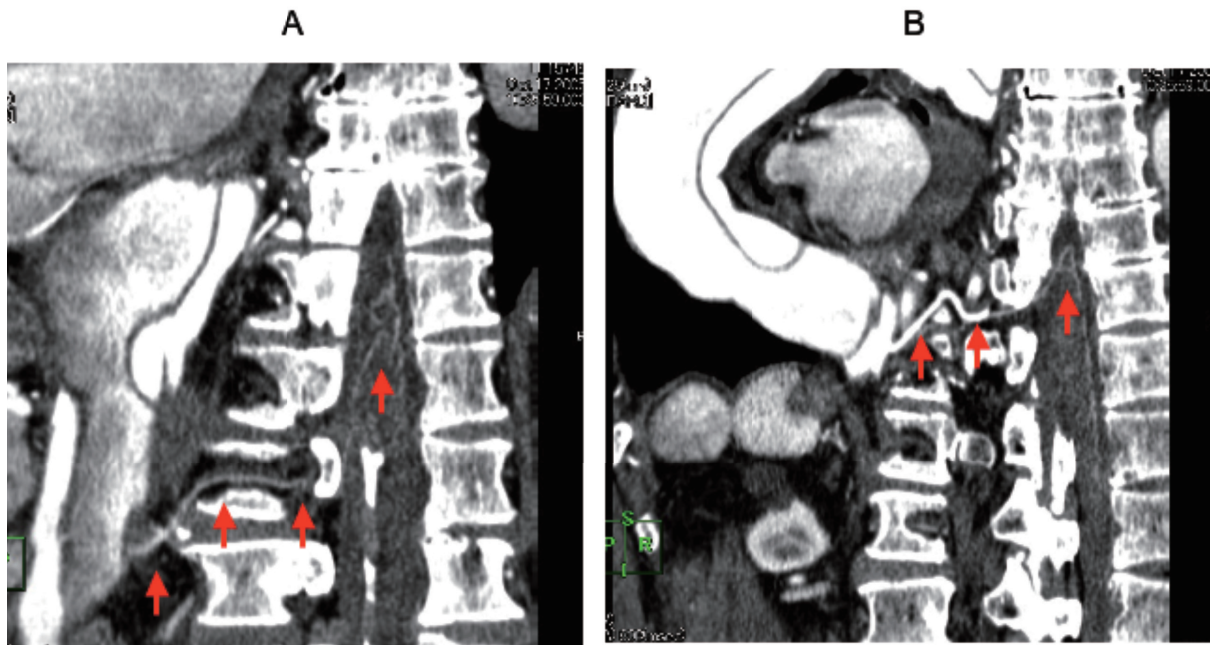


Fig. 3. 2D curved MPR images obtained at the 1st scan (A), and at the 2nd scan (B) in the same patient. Red arrow indicates the artery connecting the aorta to the anterior spinal artery. The 2nd scan image (B) showed higher enhancement of the AKA than the 1st scan image (A). MPR; multi planar reconstruction

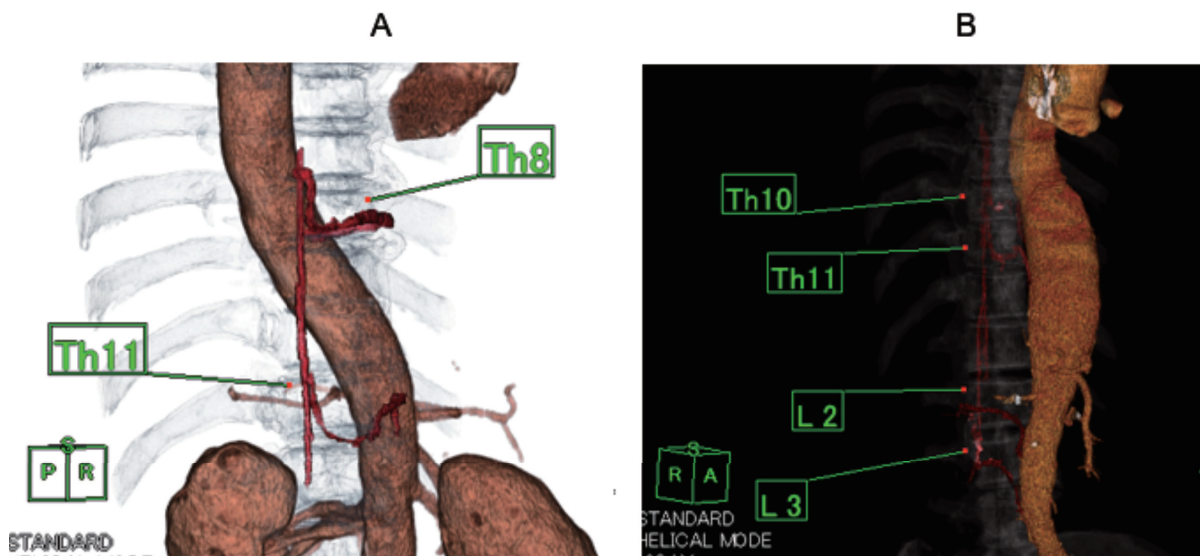


Fig. 4. A) Two radicular arteries. The right posterior oblique three-dimensional VR image. Two radicular arteries join the anterior spinal artery (Th8, Th11) ICA=intercostals artery, Th8=8th thoracic vertebra, Th11=11th thoracic vertebra, VR: volume rendering  
 B) Four radicular arteries. The right anterior oblique three-dimensional VR image. Th10=10th thoracic vertebra, Th11=11th thoracic vertebra, L2=2nd lumbar vertebra, L3=3rd lumbar vertebra, VR: volume rendering.

in 2 of the 3 patients. Collateral circulation was shown from the 11th to 9th intercostal artery (Fig. 4-A), from the 1st lumbar artery to 12th intercostal artery, and from

the posterior spinal artery to the anterior spinal artery in one patient each.



## DISCUSSION

Spinal cord ischemia resulting in paraplegia and paraparesis is the most serious complication that can occur after thoracic descending and thoracoabdominal aortic aneurysm repair, and is mainly caused by interruption of blood supply to the spinal cord during the aortic operation. The ASA, which feeds the anterior two thirds of the spinal cord, is supplied from the AKA and is the major supplier of blood to the spinal cord in

the thoracolumbar region. Therefore, preoperative visualization of the AKA and the ASA, and intra-operative reconstruction of the segmental artery from which the AKA arises, may help reduce the risk of postoperative spinal cord ischemia.

For preoperative identification of the AKA and the ASA, several angiographic techniques including selective spinal cord angiography [5,6], MR angiography [12,13], and CT angiography [7-11] have been used. Conventional selective spinal cord angiography is an

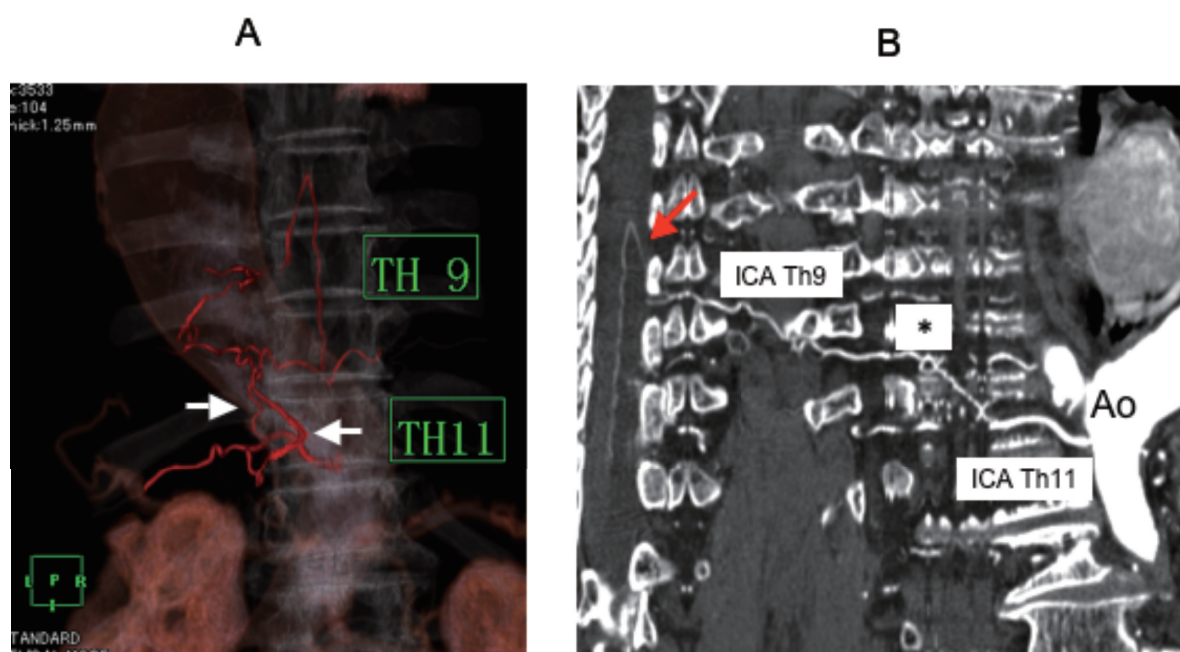


Fig. 5. Demonstration of collateral circulation to the AKA. A) The posterior inferior oblique three-dimensional dimensional VR image. ICA9 is occluded proximally. It shows collateral circulation (white arrow) from the ICA11 to the ICA 9.

B) A 2D curved-MPR demonstrates connection from aorta to anterior spinal artery by the AKA, and its continuity through the collateral circulation (\*). Red arrow points to AKA. ICA=intercostals artery, Th9=9th thoracic vertebra, Th11=th11 thoracic vertebra, Ao=aorta, VR; VR: volume rendering, MPR; multi planar reconstruction

TABLE 4.  
Detection rates of the AKA by IV-CTA, SCA, IA-CTA and RA-CTA

	Method	No. patients	Detectior rows	Slice thickness (mm)	Detection rate (%) hairpin turn	Detection rate (%) confinity	injection rate (ml/sec)
Takase K et al, 2002 <sup>9)</sup>	IV-CTA	70	4	2	90	29	3.5
Yoshioka K et al, 2006 <sup>8)</sup>	IV-CTA	30	16	0.5	83	60	3.5
Utsunomiya D et al, 2008 <sup>11)</sup>	IV-CTA	20	64	0.5	80	50	5.0
Kieffer E et al, 2002 <sup>5)</sup>	SCA	480	–	–	91	83	–
Uotani K et al, 2009 <sup>14)</sup>	IA-CTA	23	16	0.75	91	83	–
Present study	RA-CTA	110	8 or 16	0.625	100	90	8.0

SCA; spinal cord angiography, RA-CTA; night arid CT angiography

effective and established technique, and the detectability of the AKA has been reported to be 43% to 86% [5,6]. This technique, however, is invasive, time-consuming, technically difficult to perform, and may be hazardous. Kieffer et al. [5] reported that major complications developed in 6 (1.2%) of 480 patients, including paraplegia in 2 patients. With recent advances in MR angiography and CT angiography technologies, CT angiography and MR angiography have gained acceptance as effective and noninvasive alternative methods that allow visualization of the AKA and the ASA. According to several previous reports [12,13], the AKA was detected in 69% to 84% of patients by MR angiography without any complications. Furthermore, the use of both MR angiography and CT angiography can provide a very high detection rate of 90% for the AKA, which is superior to that of conventional selective spinal cord angiography [8]. However, compared with CT angiography, a more limited field of view is a major disadvantage in MR angiography [8]. Therefore, MR angiography may fail to depict the clinically important collateral vessels to the AKA in some patients, when a collateral source is the internal thoracic artery or the thoracodorsal artery [8,15,16].

In CT angiography, contrast medium was principally administered intravenously or intra-arterially to opacify the AKA and the ASA. Intravenous CT (IV-CT) angiography, in which contrast medium is injected into a peripheral vein such as the antecubital vein, is non-invasive and easy to perform. Takase et al. [9] examined 70 patients with suspected thoracoabdominal vascular disease using 100 ml contrast medium (300 mg/ml) injected at 3.5 ml/sec and 2 mm thick CT sections, and identified the AKA in 63 (90%) of patients. The AKA was successfully visualized in 25 (83%) of 30 patients with 1-mm thick, 4-row CT angiography in a study by Yoshioka et al. [8]. For these CT scans, a total of 2.5 ml/kg of contrast medium (370 mg/ml) was injected at 3 ml/sec. After injecting 100 ml of contrast medium (350 mg/ml) at 5 ml/sec, Kudo et al. [10] reported 68% AKA detection on arterial phase abdominal CT scans (2 mm section thickness) in 19 patients with liver disease but without known thoracic aortic disease. In these studies, the reported detection rate of the AKA has been relatively high, however, visualization of the arterial continuity from the aorta to the ASA was achieved in only 32% to 60% of patients [8-10]. Considering that confirmation of the arterial continuity is surgically more important than identification of the AKA and the ASA for minimizing postoperative spinal cord ischemia, visualization of the arterial continuity using IV-CT angiography may not be satisfac-

tory in thoracic descending and thoracoabdominal aortic aneurysm repair. Such low visibility of the arterial continuity is generally a major disadvantage in IV-CT angiography. On the other hand, intra-arterial CT (IA-CT) angiography, where contrast medium is injected into the descending thoracic aorta, has an advantage because of higher arterial enhancement compared with IV-CT angiography. Uotani et al. [14] reported visualization of the AKA in 21 (91.3%) of 23 patients and confirmation of the arterial continuity in 19 (82.6%) of the 23 patients. IA-CT angiography, however, is invasive. Furthermore, difficulty in determining the proper scan timing is a major disadvantage in IA-CT angiography because of the short duration of arterial enhancement.

The quality of CT angiographic images is influenced by many factors, including the imaging parameters of the CT machine, the method of injecting contrast medium, and the imaging delay. Utsunomiya et al. [11] applied 64-row MDCT for identifying the AKA. In their study, no improvement in the detection rate of the AKA was observed despite an increase in the number of detector rows, however, the traceability of the AKA was superior at a 0.5-mm slice thickness compared with a 2-mm slice thickness [11]. Since the AKA is approximately 1 mm in diameter, a slice thickness of 0.5 to 1 mm may be adequate for detection of the AKA.

It is well known that osseous structures sometimes interfere with visualization of arteries. Even when the osseous structures are normal, it may be difficult to visualize the artery that runs into an intervertebral foramen because not only is the artery very thin, it also runs close to the osseous structures. To improve the visualization of the AKA and the arterial continuity, it is essential to increase the contrast-to-noise ratio of a CT scan by both increasing arterial enhancement and decreasing the noise by anatomical structure [7]. Utsunomiya et al. [11] investigated a protocol for injecting contrast medium to obtain higher quality CT angiographic images, and have demonstrated that the injection protocol with a higher iodine concentration (350 mg/ml) and a faster injection rate (5 ml/sec) is significantly superior to that with a lower iodine concentration (300 mg/ml) and a slower injection rate (3.5 ml/s) for obtaining sufficient vascular enhancement and visualization of the AKA. Their protocol improved the detection rate of the AKA from 50% to 80%.

Both detection rate of the AKA and visualization of the arterial continuity in our RA-CT angiography were higher than those in conventional IV-CT angiography. In our method, contrast medium containing a high iodine concentration (370 mg/dl) was injected at



a high injection rate (8 ml/sec), and moreover, it was directly administered into the RA. This injection protocol is expected to lead to higher arterial enhancement than the conventional injection protocol (3.5-5.0 ml/sec), in which contrast medium was injected into a peripheral vein. Our injection protocol may reduce dilution of contrast medium in the right heart and the lung, and may also work as a bolus injection of contrast medium. This modification of the contrast medium injection protocol may have been a major factor in enabling us to achieve not only very high detection rates of the AKA and the ASA, but also visualization of the arterial continuity in 90.0% of the patients, in our CT angiography.

On the other hand, the quality of CT angiographic images is also influenced by many hemodynamic factors, including cardiac function, heart rate, aneurysm size, and the presence of arrhythmia or valve disease in patients. In addition, the AKA and the ASA were enhanced through collateral vessels in some patients [15,16]. In these patients, visualization of the AKA and the ASA may be difficult when an automatic triggering system for the scan delay is employed because contrast enhancement of the AKA and the ASA may be slow and weak. Yoshioka et al. [8] have indicated that depiction of the AKA and the start of scanning at the optimal timing to obtain a good image in CT angiography are very difficult in patients with a dissecting aneurysm because blood flow in the false lumen is generally very slow. In our RA-CT angiography, two CT scans starting at 20 sec after commencement of the first injection and at 35 sec after initiation of the second injection, respectively, were performed for 15 sec each. Consequently, the contrast enhanced arterial continuity from the aorta to the AKA, and the ASA was scanned for a total of 30 sec. This long scan duration may provide better visibility of the arterial continuity in some patients with slow blood flow, particularly patients with collateral circulation to the AKA such as patients with a dissecting aneurysm. Although no statistically significant difference was found in the detectability of the AKA and the arterial continuity between patients with a true aneurysm and those with a dissecting aneurysm in our study, the AKA and the arterial continuity were depicted plainly in the second scan in 18 (18.2%) of the 99 patients, as compared with 81 (81.8%) in the first scan. This long scan duration may also be one of factors responsible for the high detection rate of the AKA and the arterial continuity in our RA-CT angiography.

In our experience, visualization of arterial continuity was most difficult in patients with a dissecting

aneurysm (5 cases) or patients with a large aneurysm containing massive mural thrombi (7 cases). However, no statistically significant differences were found in the mean maximal diameter of the aneurysm ( $p=0.834$ ) and aortic pathology (true aneurysm or dissecting aneurysm) regardless of whether the arterial continuity was visualized or not.

In this study, the level of origin of the AKA ranged from Th8 to L2 in 95.0% and the left side origin was 71.7%. These results were in agreement with those of previous reports including anatomic studies, MR angiography, and CT angiography [7-12].

Although RA-CT angiography achieved a high visualization rate of the AKA and of the arterial continuity from the aorta to the ASA, there are some drawbacks. Dual-phase injection and scan procedures in this technique increase the patient's exposure to radiation and the dosage of contrast medium. The use of a total of 200 ml of the contrast medium may be clinically problematic for patients with inherent atherosclerotic disease because they sometimes have marginal renal functions. For such patients, a single biphasic injection of contrast medium at a rapid injection rate might be helpful for depiction of the AKA and preservation of renal function [17]. Furthermore, RA-CT angiography is time-consuming and troublesome because of the need to transfer patients to a CT room after catheter insertion in a fluoroscopy room. The use of a flow-directed catheter might simplify RA-CT angiography procedures without requiring patient transfer or use of a fluoroscope. Finally, an early model CT scanner was used in this study, however, the use of more advanced CT machines will provide safe and easy identification of the AKA and arterial continuity with a small amount of contrast medium and a single scan.

Our study has several limitations. First, it is inherently limited by its retrospective nature. Second, the lack of a reference standard, such as conventional IV-CT angiography and IA-CT angiography, to evaluate the usefulness of RA-CT angiography is another drawback. Third, although this study included a relatively large number of patients (over 100) with aortic aneurysm, even this number of patients may be not sufficient to draw a firm conclusion about the role of this RA-CT angiography. Fourth, we gave the patients double the standard radiation dose and volume of contrast medium, compared with the usual method. Further study is needed to clarify the usefulness of RA-CT angiography in visualizing the AKA in patients with aortic aneurysm.

In conclusion, this study demonstrated that RA-CT angiography could achieve a very high detection rate

of the AKA and visualization of the arterial continuity without any complications in patients with aortic aneurysm. These results suggest that RA-CT angiography is a safe and effective technique for identifying the AKA and the ASA and for visualization of the arterial continuity between the aorta and the AKA.

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## Prenatal Diagnosis of a Case of Partial Monosomy/Monosomy 13 Mosaicism: 46,XX,r(13)(p11q33)/45,XX,-13 Suspected by Nuchal Fold Translucency Increasing

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**Summary:** Large numbers of patients with deletions of the long arm of chromosome 13 have been described. However, only a few instances have been reported of monosomy 13/r(13) mosaicism. A 31-year-old Japanese woman underwent an ultrasound tomographic screening, which detected a fetus with a nuchal translucency (NT) of >5.8mm, indicating an increased risk of fetal chromosomal abnormality. An amniocentesis (AC) was performed, and the karyotype was 46,XX,r(13)(p11q33)[18]/45XX[12]. Ultrasound showed echogenic skin edema. Phenotype of the fetus after delivery revealed some anomalies, including hyponasal bridge, hypertelorism, ambiguous genitalia with huge clitoris, low-set ear, neck edema and webbing.

Deletion of the long arm of chromosome 13 is associated with a wide spectrum of abnormalities, including retinoblastoma, mental and growth retardation, brain malformations, heart defects, distal limb deformities, and digestive, urogenital, and other abnormalities. The present case, however, had anomalies which were too faint to be detected by ultrasound tomography. Prenatal diagnosis of deletion 13q syndrome is rare. A number of reports have documented an association between increased NT and chromosomal defects. Ultrasound did not identify any major anomaly in this case, however amniocentesis was able to detect this rare abnormality.

**Key words** monosomy 13, ring chromosome, deletion 13q syndrome, nuchal fold translucency, amniocentesis

### INTRODUCTION

Large numbers of patients with deletions of the long arm of chromosome 13 have been described over the past 20 years [1-12]. The phenotypes of such patients have varied widely. A similar phenotype has been noted in patients with ring chromosome 13 syndrome who are missing part of the short arm as well as part of the long arm of chromosome 13 [1-12]. Monosomy for autosomes, when non-mosaic, is virtually always prenatally lethal [13]. The vast majority probably spontaneously abort before pregnancy is recognized. Significant postnatal survival for monosomy 21 was

reported by Wiseniewsky et al, [14] however no live-borns with non-mosaic monosomy 13 have been documented in the literature. More than 160 cases of deletion 13q syndrome have been reported. They include both those with a chromosome 13 with a partial deletion of the long arm (13q-), and those with a ring chromosome 13[r(13)] [1-12]. However, few instances have been reported of monosomy 13/r(13) mosaicism. This paper describes a case of partial monosomy/monosomy 13 mosaicism with prenatal diagnosis by nuchal translucency (NT). Possible mechanisms for the occurrence of the mosaicism are discussed.





Fig. 1. The nuchal translucency was observed. The thickness was 5.8 mm.

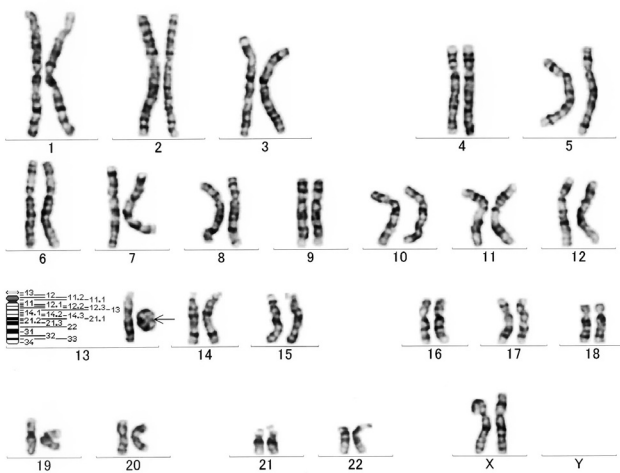


Fig. 2. The karyotype showed 18 of 30 cells to have 46,XX,r(13)(p11q33).

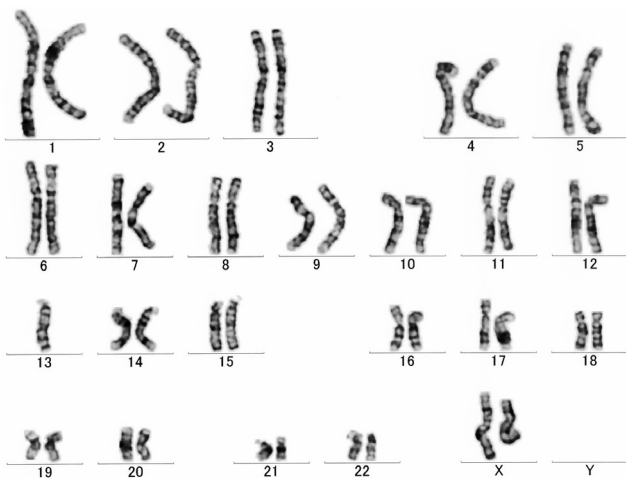


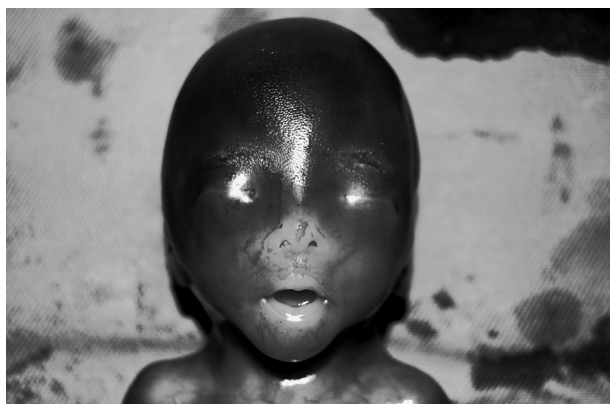
Fig. 3. The karyotype showed 12 of 30 cells to have monosomy 13 (45,XX,-r(13)(p11q33)).

CASE REPORT

A 31-year-old gravida 1, para 1, ethnic Japanese mother received an ultrasound tomographic screening. Ultrasound examination detected a fetus with NT (>5.8 mm) at 9 to 12 weeks (Fig. 1). The incidence of chromosomal abnormalities or anomalies with NT was explained to the mother and informed consent was obtained. She had an amniocentesis (AC) at 16 1/7 weeks. A total of 30 metaphase cells of the AC were analyzed photographically. AC karyotype showed 18 of 30 cells to be 46,XX,r(13)(p11q33), with the remainder having monosomy 13 (45,XX,-r(13)(p11q33)). Thus the karyotype was 46,XX,r(13)(p11q33) [18]/45XX,-r(13)(p11q33) [12] (Fig. 2 and 3). Karyotypes were not done on the patient or her husband. Meanwhile, detailed prenatal fetal anomalous scanning by 2D, Color Doppler, and 3D ultrasound were performed. There were no significant abnormal findings with regard to head structure, chest abdominal organs, cardiovascular system and limbs. Only echogenic skin edema was noted. Genetic counseling was performed regarding the pathogenesis and prognosis of this phenotype. After counseling, the patient and her husband chose to terminate the pregnancy at 19 2/7 weeks. The delivered fetal weight was 224 g, length was 21 cm and head circumference was 15.5 cm (appropriate for the gestational age). Phenotype of the fetus after delivery showed a few minor



Fig. 4. The phenotypes of whole body of the fetus showed no significant major anomaly.



*Fig. 5.* The phenotypes of face of the fetus showed small head with slightly sloping forehead, hyponasal bridge and hypertelorism.



*Fig. 6.* The phenotypes of the fetus showed low-set ear, neck edema and webbing.



*Fig. 7.* The phenotypes of the fetus showed ambiguous genitalia with huge clitoris.

anomalies, including hyponasal bridge, hypertelorism, ambiguous genitalia with huge clitoris, low-set ear, neck edema and webbing (Fig. 4, 5, 6 and 7). Postmortem autopsy was not performed.

### DISCUSSION

The occurrence of mosaicism for a ring 13 chromosome resulting in deletion is rare [10-12]. Partial deletion of the long arm of one of the D-group chromosomes was reported as deletion 13q syndrome, and was associated with growth-deficient patients with retinoblastoma [1]. A similar phenotype has been noted in 13 ring chromosome patients who were missing part of the short arm as well as part of long arm of chromosome 13 [1-3]. Lorentz et al. [8] identified four categories of deletion 13q. The first category of the phenotype consisted of mosaic rearrangements that led to 13q deletions. The second category involved distal 13q deletions in all cells. The third category involved not only cell lines with a deletion of 13q, but also alternate cell lines with the loss of an entire chromosome 13. The fourth category involved partial duplications of chromosome 13 in addition to partial deletions. The present case falls into the third category as a kind of deletion 13. Deletion of the long arm of chromosome 13 is associated with a wide spectrum of abnormalities, including retinoblastoma, mental and growth retardation, brain malformations, heart defects, distal limb deformities, and digestive, urogenital, and other abnormalities [1-8]. Deletions limited to proximal bands (q32) are characterized mainly by growth retardation but no major deformities. Those involving band q32 are usually associated with numerous major malformations, and distal deletions are usually complicated by severe mental retardation with comparatively minor abnormalities. Garcia-Lurie syndrome and this disorder share many common clinical features [1-12]. Monosomy 13q3 may arise as a result of a de novo deletion or may occur as a result of abnormal segregation of a parental translocation [13]. Of the cases in which parental karyotypes are reported, it appears that approximately 60% result from parental translocations [2,3,6,9,11,12]. The male to female ratio of deletion 13q syndrome is 1:1. There is no specific treatment. Psychomotor retardation, usually moderate to severe, is always present [1-12]. The exact life span is unknown; the oldest patient included in the above survey was 8 years old. The present case had some anomalies usually found in deletion 13q syndrome with deletion of



bands distal to q32. They included hyponasal bridge, hypertelorism, ambiguous genitalia with huge clitoris, low-set ear, neck edema and webbing. The level of mosaicism of monosomy cells was 6-33% in the four categories described above, but was 40% in the present case. More reports of this chromosomal anomaly are needed to determine the presence, or lack thereof, of a consistent phenotypic pattern.

The prenatal diagnosis of deletion 13q syndrome is rare [1-12]. Deletion 13q syndrome is associated with a wide spectrum of abnormalities, however some of the anomalies in the present case were too faint to be detected by ultrasound tomography. As the present case showed an NT thickness of 5.8 mm by ultrasound, we carried out the amniocentesis. In the early 1990's a number of reports documented an association between increased NT and chromosomal defects [16-21]. These included cardiac failure in association with abnormalities of the heart and great vessels; venous congestion of the head and neck due to constriction or compression from amniotic bands, congenital diaphragmatic hernia or narrow chest seen in skeletal dysplasia; altered composition of the extracellular matrix; abnormal or delayed development of the lymphatic system; failure of lymphatic drainage due to impaired fetal movements such as in various neuromuscular disorders; fetal anemia or hypoproteinemia; and congenital infection. The present case showed no major anomaly by ultrasound tomography, however amniocentesis enabled us to detect this rare abnormality.

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## Isolated Fracture of the Lesser Tuberosity of the Humerus: A Case Report

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**Summary:** Fracture of the lesser tuberosity of the humerus often occurs concomitant with posterior shoulder dislocation or proximal humeral fracture, while isolated fractures are extremely rare. We report a case in which an isolated fracture of the lesser tuberosity of the humerus occurred due to a distinctive pathogenic mechanism. A 43-year-old male had his right shoulder forced into internal-rotation (i.e. back reach position) when he fell into a ditch approximately 70 cm wide and 1.5 m deep. Subcutaneous bleeding and tenderness were detected anteriorly in the shoulder, with restricted range of motion. Radiographs indicated a fracture of the lesser tuberosity of the humerus. Three-dimensional computed tomography (CT) confirmed an isolated fracture of the lesser tuberosity, which was displaced anteromedially by more than 5 mm from its previous anatomical position. During operation, the fractured fragment of the lesser tuberosity was reduced easily and fixed by a cancellous bone screw. At postoperative 2 years, the patient has recovered full range of motion with sufficient muscle strength, and has returned to work. The pathogenic mechanisms in this case were unique, differing from those that have been previously reported.

**Key words** lesser tuberosity of the humerus, isolated fracture, three-dimensional computed tomography

### INTRODUCTION

Fracture of the lesser tuberosity of the humerus often occurs concurrently with fracture of the proximal humerus or dislocation of the posterior shoulder joint [1,2]. Isolated fractures of the lesser tuberosity of the humerus are extremely rare, occurring in only 0.46 persons per 100,000 [2].

Here we report a case involving isolated fracture of the lesser tuberosity of the humerus, with a distinctive pathogenic mechanism never previously reported.

### CASE REPORT

A 43-year-old man injured his left shoulder due to forced internal rotation in the extended position (i.e. the back-reach position) when he fell into a ditch ap-

proximately 1.5 m deep and 70 cm wide. He visited our hospital after the accident.

The initial examination revealed subcutaneous hematoma and tenderness around the left shoulder anteriorly. The patient complained of pain on active internal rotation of the shoulder. Active abduction of the shoulder was restricted to 60°. The drop-arm sign was positive, but the lift-off test was invalid because of pain.

Radiographs did not confirm fracture in the anteroposterior view, but an isolated fracture of the lesser tuberosity was identified in the axial view (Fig. 1). A computed tomography (CT) scan substantiated the isolated fracture of the lesser tuberosity with the bone fragment dislocated: the bone fragment was inverted, being pulled internally and inferiorly (Fig. 2).

Using a delto-pectoral approach, the fractured site

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Abbreviations: CT, computed tomography.



Fig. 1. Plain radiograph of axial view.



Fig. 2. 3D-CT of the left shoulder.



Fig. 3. Plain radiograph of anteroposterior view after the surgery.

was exposed. The bone fragment of the lesser tuberosity was pulled by the subscapularis internally and inferiorly, consistent with the preoperative 3D-CT findings. The fragment was easily repositioned and fixed using a cancellous bone screw with a washer (Fig. 3).

Presently, at two years after surgery, the patient

does not experience muscle weakness or limited range of motion: the lift-off test is negative, and medial rotation strength of the left shoulder is similar to that of the uninjured right side. He has returned to his previous work doing heavy labor.

## DISCUSSION

The pathogenic mechanics of an isolated fracture of the lesser tuberosity of the humerus can involve traction or direct external force from the subscapularis muscle tendon, or impact on the glenoid cavity [3]. Most cases that have been previously reported were caused by traction of the subscapularis muscle tendon when abduction and excessive external rotation of the shoulder joint occurred [2-5]. The fracture in this report was caused by forced extension and internal rotation of the shoulder joint (i.e. back-reach position) (Fig. 4). Thus, unlike the usual pathogenic mechanisms, the fracture in this case may have occurred when excessive traction caused by contraction of the subscapularis muscle acted on the lesser tuberosity of the humerus when the shoulder joint was locked in the back-reach position. Alternatively, it is conceivable that the lesser tuberosity impacted the glenoid cavity when the shoulder was locked in the back-reach position, which caused the fracture; however, this mechanism appears unlikely because there were no findings suggesting a glenoid fracture in this case.



Fig. 4. "Back-reach" position at which the patient sustained.

Careful attention is needed when diagnosing isolated fractures of the lesser tuberosity of the humerus. Large displaced fractures can easily be seen on plain anteroposterior radiographs, but the axillary view is often necessary to detect smaller fragments with minimal displacement [4, 6]. van Laarhoven et al. [7] reported that CT image analysis was useful in evaluating the fracture area. In the present case, 3D-CT image analysis was extremely useful for evaluating the bone fragment, e.g. its shape, size and the degree of dislocation of the fragment.

The most appropriate surgical method for such fractures is open fixation surgery if the dislocation is greater than 5 mm or 45° of angulation [8]. Robinson et al. [2] strongly recommend open surgery because disloca-

tion caused by the subscapularis muscle tendon may lead to aggravation, malunion, impingement of the coracoid process, or dislocation of the tendon of the long head of the biceps muscle. In the present case, open reduction and internal fixation were performed because the bone fragment showed a dislocation greater than 5 mm. This led to favorable results at 2 years follow-up after the surgery.

In this report, we presented a case involving the isolated fracture of the lesser tuberosity of the humerus, caused by a distinctive pathogenic mechanism. To the best of our knowledge, this is the first report describing an isolated fracture of the lesser tuberosity, occurring with the shoulder forced in the internally-rotated and extended position (i.e. the back-reach position).

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