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Case Report

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Original Research Article

The effects of asymmetric sitting postures on the trapezius and erector spinae during a computer mouse task in sedentary people

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ABSTRACT

Background: Although adopting a neutral sitting posture is recommended to avoid potentially painful positions, many sitting postures are still adopted in daily life. Few studies have examined the effects of sitting postures in daily life, such as the right cross-legged sitting posture and the left cross-legged sitting posture. ***Objectives:*** (1) to determine how personal characteristics, including gender, age, and BMI, influenced muscle activity when operating a computer mouse in sedentary people.; (2) to investigate the effects of asymmetric sitting postures on neck and back muscular activity, and to evaluate the differences in the right and left muscular activities in the neck and back during a computer mouse task in sedentary people. ***Methods:*** A 3x3x2 (Backrest x Lower extremity x Right-left difference of examined muscles) repeated experiments design was used. The activities of four muscles (the trapezius and erector spinae on both sides) were collected by surface electromyography. Sixty sedentary people were recruited and randomly assigned sitting postures. ***Results:*** The trapezius activity was higher in males than in females, and higher in the overweight group than in the healthy and underweight groups. The trapezius activity was lower in the left cross-legged sitting posture than in the symmetric sitting posture. The erector spinae activity was higher in the right side than in the left side in both the left and the right cross-legged sitting postures. ***Conclusion:*** The compensation mechanism of lower trunk and pelvis regions was found in asymmetric sitting posture. Therefore, asymmetric sitting postures are not appropriate options for sedentary people.

Keywords: Cross-legged sitting posture, Sedentary, Muscle activity, Symmetric sitting

INTRODUCTION

In modern occupational contexts, most office workers, namely sedentary people, sit for prolonged periods. Their sedentary behaviours are positively related to some personal characteristics including obesity, Body Mass Index (BMI), metabolic symptoms, and other health problems[1-4]. The studies reported that the neck, shoulder, and back discomfort increased when operating computer mouse at work and sit for prolonged periods in sedentary people[5,6]. The studies also stated that the sedentary people experiencing pain demonstrated inability to relax in upper trapezius compared to those without pain[7]. Sedentary people have lower muscle activity in erector spinae when maintaining the neutral spine curvature compared to when the spine is overly extended[8]. For alleviating the musculoskeletal discomfort, sedentary people often attempt to adopt inappropriate cross-legged sitting postures. The effects of cross-legged sitting postures on the spinal and pelvic regions have been examined in the previous researches[9-12]. The cross-legged sitting postures decreases abdominal muscle activity to prevent fatigue[9], increases hip flexion and hip adduction to contribute stability[10], and causes significant malalignment of the pelvis and trunk[11,12]. What the previous researches recommended to avoid potentially painful positions was not the cross-legged sitting posture but a neutral sitting posture[13,14].

Operating a computer mouse was a common task when sedentary people performed standard computer work. Operating a computer mouse was asymmetric task and tended to cause the imbalance muscle activity for their shoulder and neck regions[5]. Evidence suggests that cross-legged sitting during a computer typing task (symmetric task) has detrimental effects, and this posture cannot be recommended for long-term sedentary work[12]. As of now the impact of various sitting posture on shoulder and neck regions when operating a computer mouse (asymmetric task) still remained to be investigated. In addition, previous research focused on comparing the differences between right cross-legged sitting postures and neutral sitting postures[9,11,12,15], with little examination of the effects of the right cross-legged sitting posture and the left cross-legged sitting posture. Our research was conducted to understand the effects of right and left cross-legged sitting postures on right and left muscle activity of neck and lower back in sedentary people when performing a computer mouse task.

The present study aimed to determine how personal characteristics, including gender, age, and BMI, influenced muscle activity when operating a computer mouse in sedentary people. This research also aimed to investigate the relationships between muscular activity and various sitting postures in sedentary people. For muscular activity, the trapezius and erector spinae were chosen to indicate the workloads of the neck/shoulders and low back. For sitting postures, our research attempted to categorize the various sitting postures according to backrest conditions and lower extremity conditions. The backrest categories were full-backrest, non-backrest, and humpbacked-backrest. The lower extremity categories were right cross-legged posture (cross-legged with the right knee over the left knee), left cross-legged posture, and symmetric sitting. Nine sitting postures were developed based on backrest conditions (3) and lower extremity conditions (3).

MATERIALS AND METHODS

Subjects

Sixty subjects (30 males and 30 females) ranging in age from 21 to 54 years (mean 32.64 (SD± 8.41) years), all of whom worked with computers in their offices for over 8 hours each day, were recruited through an internet advertisement. All were sedentary, and none had a history of orthopaedic surgery or musculoskeletal injuries. The Institutional Review Board of Fu Jen Catholic University approved all protocols and consent forms (FJU-IRB NO: C103147). Informed consent was obtained directly from the participants. The demographics of the subjects are presented in Table 1.

Experimental protocol

Experimental design and posture assignment

A Backrest conditions (3) x Lower extremity conditions (3) x Right-Left difference of examined muscles (2) repeated measures experiment was designed. The Backrest factors was the full-backrest, non-backrest, and humpbacked-backrest conditions. The Lower extremity factors was the left cross-legged, right cross-legged, and symmetric sitting postures. The Right-Left difference of the examined muscles factor was the right and left sides. Backrest conditions and Lower extremity conditions were within-subject factors. The Right-Left difference of examined muscles was a between-subject factor.

Backrest conditions (3) x Lower extremity conditions (3) were integrated into 9 postures. For example, the full-backrest x left cross-legged sitting conditions featured a full-backrest and left

cross-legged sitting posture (Figure 1, left). The subjects were first introduced to all of the sitting postures. After the introduction, the sitting postures were randomized and assigned, and the subjects maintained each posture for three minutes while playing a computer game with a mouse. A competitive computer game was selected because muscle activity is greater during the performance of stressful computer tasks than during typing, editing, and precision tasks[5]. To increase motivation, our team provided extra gifts as rewards for the top three performers.

EMG Data Collection and Analysis

EMG data were concurrently collected while the subjects were seated in each assigned posture. Surface EMG data were recorded with a commercial recording system (Nexus-10 Mind Media BV, Roermond, The Netherlands) and surface electrodes. The surface electrodes, each having a diameter of 5 mm, were placed over the middle fibres of the left trapezius (Left Trapezius), middle fibres of the right trapezius (Right Trapezius), left lumbar part of the erector spinae (Left Erector), and right lumbar part of the erector spinae (Right Erector) with 2 cm between any two electrodes. After the skin was cleaned with alcohol, the electrodes were placed on the thickest area of the muscle belly based on the suggestion of Edlagi and Perotto[14]. The earth electrode was placed on the clavicle.

EMG data of maximum voluntary contraction (MVC) were measured by a research assistant during maximum isometric contraction against static resistance. For the MVC of the trapezius, the subjects performed maximum isometric shrugs against downward static resistance on the shoulders provided by a research assistant while in an upright sitting posture. For the MVC of the erector spinae, the subjects lay prone and performed maximum isometric trunk extension until the umbilicus left the mat while the assistant provided downward static resistance on the shoulders. Each time, the participant performed maximal contraction against resistance for 6 seconds. The EMG data were collected from the second to the fifth seconds. Each participant performed three trials separated by rest periods of 3 minutes. If the participants still felt tired after resting, the resting time was prolonged. The resistance was provided by the same research assistant and supervised by the principal investigator to ensure inter-rater reliability.

The EMG data of the experimental conditions were measured during each assigned sitting posture. While the subjects maintained an assigned sitting posture and played a computer game with a mouse for three minutes, the EMG data were collected for analysis during the third minute (2’00”-2’59”).

Data processing

Raw EMG data were collected at 1,024 Hz using BioTrace+ software and a data acquisition card on a notebook computer. EMG raw signals were recorded and processed with a 10-10,000 Hz band-pass filter, amplified by a gain of 500. Filtered signals were full-wave rectified and smoothed with a 50-msec time constant to produce a linear envelope. The EMG signals were quantified in terms of root mean square (RMS). RMS is used in EMG studies to describe the energy that a muscle generates in the time domain.

For the MVC trial, the EMG activities of each muscle were quantified in terms of RMS measured over a 3-second period, and the data of the first and last seconds were deleted. The curve of the rectified EMG signal was integrated; that is, the muscular activity value was the area under the 3-second period. For consistency in time series, the data were divided by 3. The rectified EMG data were averaged across the 3 trials under the same condition.

For each experimental trial, the EMG activities of each muscle were quantified in terms of RMS measured over a 60-second period, and the data of the first and last 15 seconds were deleted. The curve of the rectified EMG signal was integrated; that is, the muscular activity value was the area under the 30-second period. For consistency in time series, the data were divided by 30.

The dependent variable, normalized EMG (MVC %), was a supposed exertion level as a percentage of the MVC; that is, normalized EMG (MVC %) = (EMG for sitting posture / EMG for MVC) x 100.

Statistical analyses

A 2x3x3 repeated analysis of variance (ANOVA) was used to analyse the MVC% data of each muscle for the Gender conditions (2, male vs. female) x Age (3, 20–29 years; 30–39 years; >40 years) x BMI (3, Underweight: <18.4; Healthy weight: 18.5–24.9; Overweight: >25) experimental design. A 3x3x2 mixed repeated analysis of variance (ANOVA) was used to analyse the MVC% data of each muscle for the Backrest conditions (3) x Lower extremity conditions (3) x Right-Left difference of examined muscles (2) experimental design. Bonferroni post hoc tests and paired t tests were used as follow-up tests for pair-wise comparisons of means.

Sphericity was determined using Mauchly's Test, prior to the calculation of within-participant tests. Where sphericity could not be assumed, Huynh-Feldt adjustment for violations of sphericity was used and the degree of freedom was adjusted based on the value of epsilon. Significance was noted for a probability of a false positive of less than 5% ($p < .05$). Data were analysed in SPSS for Windows (IBM, NY, USA).

RESULTS

The relationship between personal characteristics and Trapezius activity

For EMG activity of the trapezius, only two factors (Gender and Age) interaction were found (p=0.001). But, the post hoc test indicated no significantly effect under gender condition or under age condition. The main effect of gender was significantly found (F(1,532)= 16.141, p<0.001). Post hoc test indicated that the EMG activity of the trapezius was lower in the female group than in the male group. The main effect of BMI was also significantly found (F(2,532)= 9.545, p<0.001). The post hoc test indicated that the EMG activity of the trapezius was lower in the underweight group than in the healthy and overweight groups, and the EMG activity of the trapezius was lower in the healthy group than in the overweight group. The variable Age was found to have no significant difference (F(1,532)= .976, p=0.377) (see Table 2).

The relationship between personal characteristics and Erector spinae activity

For EMG activity of the erector spinae, only two factors (Gender and BMI) interaction were found (p=0.002). But, the post hoc test indicated no significantly effect under gender condition or under BMI condition. The main effect of variable Age was found to have a significant difference (F(2,532)= 10.278, p<0.001). Post hoc test indicated that the EMG activity of the erector spinae was higher in the 20–29 and forty or older groups than in the 30–39 group, and no difference was found between the 20-29 and forty or older groups. The main effect of BMI was also found to have a significant difference (F(2,532)= 9.740, p<0.001). Post hoc test indicated that the EMG activity of the erector spinae was higher in the healthy group than in the underweight and overweight groups, and no difference was found between the underweight and overweight groups. The variable Gender was found to have no significant difference (F(1,532)= .041, p=0.839) (see Table 2).

Effects of sitting postures on Trapezius activity

No interaction effects were found (p > 0.05) for the EMG activity of the trapezius under Backrest conditions, Lower extremity conditions, and Right-left of examined muscles. Only one variable, Lower extremity conditions, was found to have a significant difference (F(2,236)=4.176, p=0.019) (see Table 3). The post hoc test indicated that the EMG activity of the trapezius was lower in the Left cross-legged sitting posture (mean=31.639±14.092) than in the Symmetric sitting posture (mean=33.145±14.393) (p=0.044). No difference was found between Symmetric posture and Right cross-legged sitting posture (mean=31.877±14.013) (p=0.090). No difference was found between the Right and Left cross-legged sitting postures (mean=31.639±14.092) (p=0.75). These results indicated that the EMG activity of the trapezius decreased in the Left cross-legged sitting posture, but no difference was found for this muscle in the Symmetric and Right cross-legged sitting postures (see Figure 2).

In addition, no significant differences were found in EMG activity of the trapezius in the Backrest factors (F(2,236)=0.161, p=0.850) and Right-Left difference of the Trapezius (F(1,236)=1.547, p=0.216) (see Table 3).

Effects of sitting postures on Erector spinae activity

For EMG activity of the erector spinae, a significant interaction of Lower Extremity conditions and Right-Left difference was found (F(2,236)=1.866, p=0.048) (see Table 3). Subsequent analysis of the Lower extremity conditions indicated that the EMG activity of the erector spinae was lower in the left side (mean=24.474±14.577) than in the right side (mean=27.356±13.942) in the left cross-legged sitting posture (p=0.005), and EMG activity of the erector spinae was lower in the left side (mean=24.661±15.375) than in the right side (mean=27.673±14.272) in the right crossed-legged sitting posture (p=0.004). However, no difference was found between the EMG activity of the erector spinae of the right (mean=26.050±14.655) and left sides (mean=24.465±15.029) in the symmetric sitting posture (p=0.163). These results indicated that the right side EMG activity of the erector spinae increased in the Asymmetric sitting posture (Left cross-legged sitting posture and Right cross-legged sitting posture), but no difference in the Right-Left EMG activity of the erector spinae was found when sitting in the Symmetric posture (see Figure 3). In addition, no significant difference in the EMG activity of the erector spinae was found for the Backrest conditions

(F(2,236)=0.029, p=0.968) (see Table 3).

DISCUSSION

This study evaluated the differences in the right and left muscular activities of the trapezius and erector spinae when operating a computer mouse during various sitting postures (Backrest conditions (3) x Lower extremity conditions (3)). The effects of personal characteristics, asymmetric sitting posture, asymmetric task of upper extremity, and compensation mechanism on muscle activity will be discussed as follows. One important point in our discussions is that the lower muscle activity of trapezius should the better condition in musculoskeletal activity of neck/shoulders regions, and higher muscle activity of erectus spinae should the better condition in musculoskeletal activity of low back region. These considerations were based on the previous studies findings; the higher muscle activity of trapezius and the lower muscle activity of erector spinae in poor sitting postures were stated[17,18].

Effect of personal characteristics on trapezius activity

In this study, we found that the muscle activity of the trapezius was higher in males than in females, and higher in the overweight group than in the healthy and underweight groups. The previous studies also found that increased contraction of neck/shoulder muscles in poor sitting posture[18]. And, a significant trend for increased obesity risk and metabolic symptoms among office workers was found[4]. In our study, personal characteristics, male gender and overweight BMI, are indicative of a need for more attention to sitting postures and their effects on work-related musculoskeletal discomfort in the neck/shoulder regions in sedentary people.

Effect of personal characteristics on erector spinae activity

In this study, regarding the BMI variable, we found that the muscle activity of the erector spinae was higher in the healthy group than in the overweight and underweight groups. Regarding the age variable, the muscle activity of the erector spinae was higher in the 20–29 and forty-and-over groups than in the 30-39 group. A previous study reported that participants without low back pain could control their lumbar-pelvic regions better while sitting than could people without pain[17,19,20]. The previous studies also found that reduced contraction of trunk muscles in poor sitting posture[17]. The personal characteristics, such as 30–39 in the Age variable, and the overweight and underweight groups in the BMI variable, should indicate a need to pay more attention to sitting postures and their effects on work-related musculoskeletal discomfort in the low back in sedentary people.

Effect of sitting postures on trapezius activity

Our finding that trapezius activity was lower in the left cross-legged posture (asymmetric sitting posture) than in symmetric sitting posture, but no difference was found between the right cross-legged posture (asymmetric sitting posture) and the symmetric sitting posture. The game task with a computer mouse (an asymmetric task) was adopted in our research. All of the subjects were coincidentally right handed, so in this study, the right side was the task side and the left side was the non-task side. A previous study reported that trapezius activity was lower on the non-task side than on the task side when sedentary people performed computer mouse task in symmetric sitting[5]. The previous studies also found that the compensation mechanism in cross-legged sitting, such as weight shifting to the ipsilateral side[11], posterior pelvic tilt[9,10], and reduced contraction of abdominal muscles[9,17]. Therefore, the compensation mechanism might be an explanation for our finding. It suggested that the compensation mechanism have been adopted in the trunk and pelvic, so that both right and left sides of trapezius muscle activity decreased in non-task side cross-legged sitting than in symmetric sitting during the operation of a computer mouse.

Another finding of this study was that the trapezius activities were no significant differences in the backrest conditions is consistent with the study of Caneiro, O'Sullivan, Burnett, Barach, O'Neil, Tveit and Olafsdottir[21]. The backrest conditions, including full-backrest, non-backrest, and humpbacked-backrest, have a few minor effects on the trapezius activities.

Effect of sitting postures on erector spinae activity

Our research found greater muscle activity in the right erector spinae than in the left erector spinae in asymmetric sitting postures (both left and right cross-legged postures), but not in the symmetric sitting posture. Previous research showed that the muscle activity of the external oblique was significantly higher in asymmetrical sitting than in symmetric sitting[7]. Another study found that continuous cross-legged sitting caused significant malalignment of the pelvis[9] and trunk[10]. In our study, cross-legged sitting, in both right and left cross-legged sitting postures, was found to significantly increase right erector spi-

nae activity. The right side was task side during our computer mouse task. Therefore, it was suggested that the body using the right (task side) erector spinae muscles to compensate for the spine asymmetry caused by the cross-legged sitting postures.

Research limitations

The present study did not collect the information regarding the subjects' perception of musculoskeletal discomfort. In the future, the relationship between musculoskeletal discomfort and compensation mechanism should be investigated for sedentary people performing symmetric and asymmetric tasks in cross-legged sitting posture for prolonged periods.

CONCLUSIONS

This research began from the standpoint of asymmetric sitting postures, rather than a neutral sitting posture, to understand the muscle activity features during operation of a computer mouse for sedentary people. The results indicated that trapezius activity was significantly lower in the left (non-task side) cross-legged sitting posture than in the symmetric sitting postures. In addition, the muscle activity of the erector spinae was higher than that of the right (task side) erector spinae in both the left and the right cross-legged sitting postures. Even through the muscles activity of neck/shoulders regions decreased in the non-task side cross-legged sitting posture, the compensation mechanism of lower trunk and pelvis regions was found in asymmetric sitting posture. Therefore, asymmetric sitting postures are not appropriate options for sedentary people. The findings should be of relevance in the development of recommendations for sedentary people.

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FIGURE AND FIGURE LEGENDS

Figure 1. Full-backrest x left cross-legged sitting condition (left), non-backrest x left cross-legged sitting condition (middle), humpbacked-backrest x left cross-legged sitting condition (right).

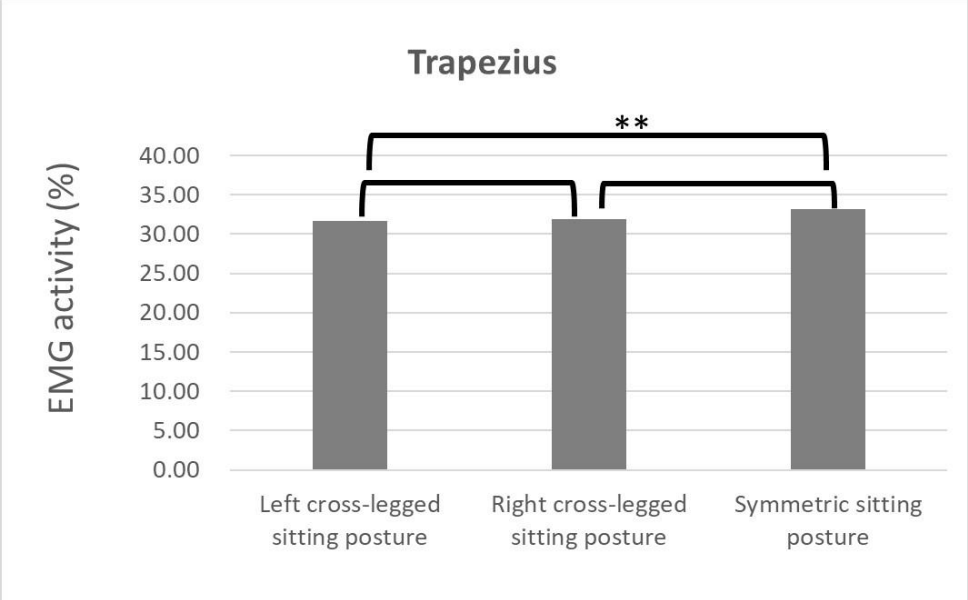

Figure 2. EMG activity (Mean (SD)) of the Trapezius in the three lower extremity posture conditions and two side conditions.

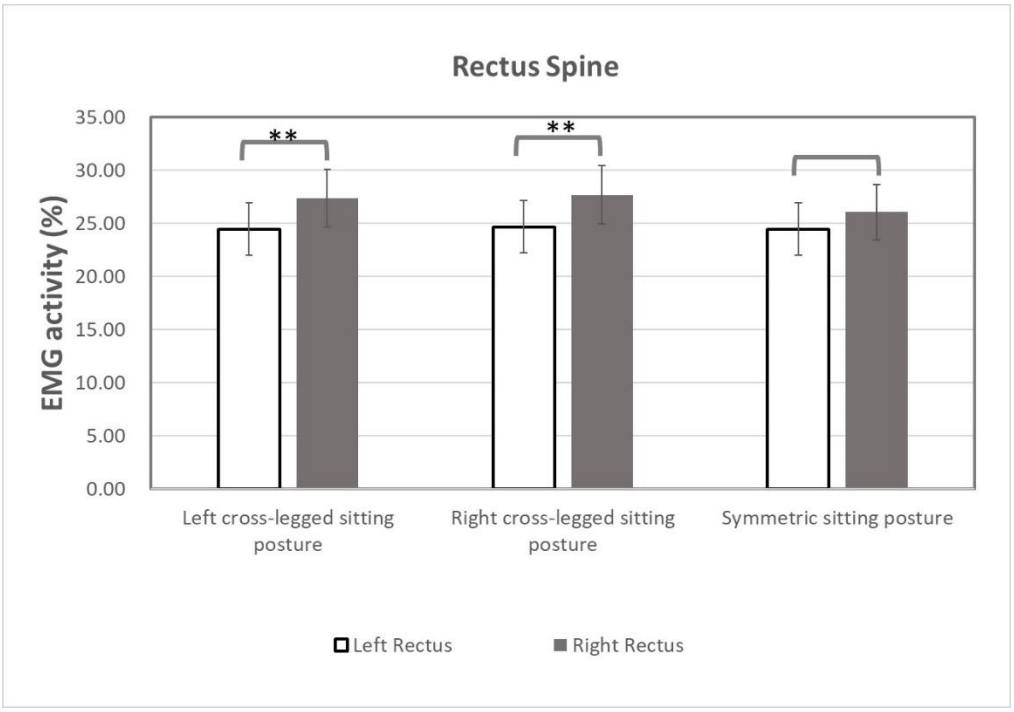

Figure 3. EMG activity (Mean (SD)) of the Erector spinae in the three lower extremity posture conditions and two side conditions.

TABLES

Table1. The descriptive data of the demographic data of the subjects

Items			Range	Mean	SD	Median
Age (years)	Male	n=30	21.00-54.00	33.70	8.63	32.00
	Female	n=30	21.00-48.00	29.57	8.16	26.00
Height (cm)	Male	n=30	163.00-189.00	174.93	5.38	174.50
	Female	n=30	147.00-173.00	158.27	6.45	157.50
Weight (kg)	Male	n=30	52.00-87.00	68.97	9.14	67.50
	Female	n=30	40.00-70.00	52.10	7.82	50.50
BMI	Male	n=30	17.78-28.74	22.55	2.89	21.90
	Female	n=30	16.56-27.77	20.82	3.09	20.10
Seat height (cm)	Male	n=30	31.00-44.00	39.83	2.34	39.00
	Female	n=30	27.00-41.00	35.13	4.11	36.00

Table2. The results of three-way repeated ANOVA for EMG activity in the anthropometric dimensions of examined muscles

Muscle	Trapezius		Erector Spinae	
Variances	F	p	F	p
Gender (G)	16.141	<.001** (F<M)	0.041	0.839
Age (A)	0.976	0.377	10.278	<.001** (A3<A2,A4)
BMI (B)	9.545	<.001** (U<H<O)	9.740	<.001** (U,O<H)
GxA	7.628	.001**	0.958	0.384
GxB	1.293	0.275	6.528	0.002*
AxB	1.880	0.131	1.370	0.250
GxAxB	13.176	<.001	3.152	0.043

*p<0.05, **p<0.01.

Male (M), Female (F); A2: 20–29 years; A3: 30–39 years; A4: >40 years; Underweight (U): <18.4; Healthy weight (H): 18.5–24.9; Overweight: (O) >25.

Table3. The results of three-way mixed repeated ANOVA for EMG activity in the Backrest, Lower extremity posture, and Right-Left difference of examined muscles conditions

Muscle / Variances	Trapezius		Erector Spinae	
	F	p	F	p
Backrest (B)	0.161	0.850	0.029	0.968
Lower extremity posture (L)	4.176	0.019* (L<S,R)	0.942	0.388
Right-Left difference of examined muscles (D)	1.547	0.216	0.825	0.005** (LM<RM)
B x L	0.472	0.737	1.763	0.150
B x D	0.416	0.660	0.118	0.887
L x D	0.630	0.512	1.866	0.048*
B x L x D	0.402	0.775	1.440	0.221

*p<0.05, **p<0.01.

left cross-legged sitting condition (L), right cross-legged sitting condition (R), symmetric sitting condition (S), right examined muscles (RM), left examined muscles (LM)

The effects of asymmetric sitting postures on the trapezius and erector spinae during a computer mouse task in sedentary people

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中文摘要

背景和目的：直立坐姿是一般推薦辦公室工作人員的坐姿，是避免潛在肌肉骨骼疼痛發生的姿勢。但在日常生活中仍會採取多種不同的坐姿。少有研究探討不對稱坐姿的影響，如右盤腿坐姿和左盤腿坐姿等。本研究欲（1）確定個人特徵(包括性別、年齡和體重指數)如何影響久坐人員操作電腦滑鼠時的肌肉活動；（2）探討不對稱坐姿對頸部和背部肌肉活動的影響，並評估久坐人員在執行電腦滑鼠任務時左、右肌肉活動的差異。**方法：**3x3x2（靠背x下肢x肌肉的左右側）重複量測實驗設計。透過表面肌電圖採集四塊肌肉（兩側斜方肌和豎脊肌）的肌電訊號活動。共招募 60 位久坐人員，並隨機分配 9 種坐姿。**結果：**男性斜方肌活動顯著高於女性，體重過重組之斜方肌活動顯著高於健康組和體重偏低組。左盤腿坐姿的斜方肌活動顯著低於對稱坐姿的斜方肌活動。在左、右盤腿坐姿，右側豎脊肌活動均顯著高於左側。**結論：**不對稱坐姿之下軀幹和骨盆區域存在代償機制，不對稱坐姿不適合久坐人員。

關鍵字：盤腿坐姿、久坐、肌肉活動、對稱坐姿

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Original Research Article

The Relationships Among Anger, Separation Anxiety, and Social Anxiety in School-age Children: The Moderating Effect of Verbal Ability

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ABSTRACT

Background and purpose: Separation anxiety and social anxiety are common forms of anxiety in school-age children and are closely related to affective disorders in adulthood. Investigations of the factors associated with these symptoms and their mechanisms are critical for interventions. Trait anger and anger expression of two components of anger have important associations with externalizing behaviors; however, their relationships with internalizing symptoms remain largely unexamined. The aims of this study were to examine the direct relationship between children's frustration and aggression and their separation anxiety and social anxiety, respectively. The moderating effect of children's verbal ability on the relationships among frustration, aggression, and symptoms of separation and social anxiety were also investigated. ***Methods:*** This study recruited seventy-one typically developing children attending elementary schools in northern Taiwan (mean age 9.24 years; 45 boys) and their parents. Parents completed demographic information, and children self-reported their frustration (i.e. trait anger), aggression (i.e. anger expression), separation anxiety, and social anxiety symptoms on inventories. Children's verbal abilities were assessed with the Wechsler Intelligence Scale for Children, Fourth Edition. ***Results:*** Frustration positively correlated with symptoms of separation anxiety and social anxiety; however, only frustration had a significant predicting effect on separation anxiety after controlling for gender and age. Aggression had no significant correlations with separation or social anxiety; however, verbal ability moderated the relationship between aggression and social anxiety. ***Conclusions:*** Frustration increases the risk of separation anxiety in school-age children. The association between aggressive behavior and social anxiety symptoms depends on the level of children's verbal ability.

Keywords: aggression, anxiety, frustration, verbal ability, school-age children

INTRODUCTION

Anxiety disorders are common mental disorders in children and adolescents[1], and anxiety symptoms in childhood have a stable association with later anxiety disorders[2]. Separation anxiety and social anxiety, which involve social interaction contexts, are two common types of anxiety in school-age children. Negative emotions are directly related to their anxiety symptoms[3]. Anger, an emotion closely related to externalizing problems, and its associations with children's separation anxiety and social anxiety symptoms require further investigation. The relationship between emotions and anxiety symptoms may also involve indirect mechanisms, wherein children's self-regulation abilities can buffer the association between negative emotions and anxiety symptoms[4,5]. Language serve an emotion regulation function[6] and help regulate anger[7]. However, the moderating role of language ability on the relationship between anger and separation or social anxiety in school-age children, who are rapidly accumulating verbal skills, remains unclear. The purposes of this study were to explore the direct associations of trait anger and anger expression with separation anxiety and social anxiety symptoms in elementary school children, as well as the moderating effect of verbal ability in these associations.

Separation anxiety and social anxiety are two types that commonly occur during childhood and adolescence[8,9]. Factor analysis shows that separation anxiety and social anxiety symptoms represent two distinct dimensions[10.] However, high comorbidity exists between the two, and childhood separation anxiety is closely related to social anxiety in adulthood[11]. Therefore, it is important to explore the pathological mechanisms of both disorders and any possible common or related factors.

Despite moderate or higher correlations between children's self-reports and parent reports of children's anxiety symptoms[12], differences remain in their reports of separation anxiety and social anxiety[13,14]. Since anxiety symptoms are internal experiences and unobvious, parents may have difficulty understanding their children's anxiety symptoms[15], highlighting the importance of children's self-report.

Negative affect in school-age children is directly related to their overall anxiety symptoms[4]. However, the relationships between negative affect and different types of anxiety symptoms may vary. For instance, negative affect is positively correlated with social anxiety, but it shows no significant correlation with separation anxiety[16]. These findings suggest the necessity of distinguishing between different anxiety symptoms in research. In addition, negative affect composed of many discrete emotions and different emotions serve specific functions. Since emotions in childhood have already differentiated and negative emotions in children are associated with anxiety disorders[17]. It is important to explore the relationships of specific emotion with symptoms of separation anxiety and social anxiety.

The tendency to experience anger frequently and intensely (i.e. trait anger), and the external expression of anger (i.e. anger expression), are two important components of the multifaceted construct of anger[18]. Compared to the frustration-aggression hypothesis, which suggests a sequential relationship between frustration/anger and aggressive responses, the multidimensional view of anger posits that anger and aggressive response are the two key components of anger.

Trait anger and anger expression may be risk factors for anxiety symptoms, with different facets of anger potentially having varying associations with anxiety[19,20]. Trait anger are significantly higher in children with anxiety than in the general population and are associated with the severity of anxiety in adults[21]; Children has inappropriate anger expression is linked to higher anxiety symptoms[22,23]. Additionally, trait anger of children and adolescents with anxiety disorders, positively correlates with overall anxiety severity, while anger expression is not significantly related to anxiety severity[20].

In Rothbart's temperament framework and the Early Adolescent Temperament Questionnaire, frustration and aggression are two subscales within the broader factor of negative affect. Frustration refers to the negative emotions that arise when a child encounters obstacles or is unable to achieve a goal, while aggression measures the physical and verbal behaviors of direct or indirect aggression toward others[24]. From the definition, we thinks that the two concepts of frustration and aggression from temperament perspective are akin to, the tendency to experience anger (i.e. trait anger), and the external expression of anger (i.e. anger expression), respectively.

A study focusing on Chinese school-aged children found that child frustration was positively associated with the child's self-reported internalizing problems[25]. Evi-

dence suggests that children with anxiety disorders are more prone to frustration when they face unexpected outcomes or cannot obtain positive reinforcement[26]. Currently, very few studies have explored the relationship between frustration and separation, social anxiety. Separation anxiety is characterized by excessive fear or worry in the face of separation from an attachment figure, and its symptoms are related to the activation of the attachment system. Anger has an important association with attachment behaviors and anger is not felt frequently for children with secure attachment[27]. Thereby the anger trait might be the risk of separation anxiety.

Frustration can trigger avoidance behaviors and is positively associated with withdrawal symptoms of children[26], which are related to social anxiety disorders[28]. Social anxiety involves distress when engaging in social situations and often leads to avoidance of social encounters. Aggressive behavior may be closely related to social anxiety. According to research, experiences of bullying are the important causes of social anxiety[29]. Aggressive behavior in children and adolescents is positively correlated with overall anxiety symptoms[30]. Moreover, physical or verbal aggression can effectively predict their social anxiety symptoms in college students[31,32], children's withdraw and levels of social anxiety[33,34]. In contrast, since separation anxiety involves excessive fear or anxiety in the face of separation from an attachment figure, it may have a less direct connection to aggression. However, the relationships among trait anger, anger expression, and anxiety symptoms in typically developing school-age children remains unclear.

In addition, Indirect mechanisms exist between negative emotions and anxiety symptoms[35]. Language plays a role in regulating children's emotion[36,37] and children's language abilities negatively predicted physical aggression[38]. Children with language disorders have more difficulty using emotion regulation strategies and exhibit more externalizing behavior problems than do children with normal language development[39]. However, very little research has explored the moderating effect of verbal ability, which rapidly develops during the school years, on the relationships among frustration, aggression, and anxiety symptoms.

The aims of this study were to examine the direct associations of children's trait anger (i.e. frustration) and anger expression (i.e. aggression) with separation anxiety and social anxiety, as well as the moderating effects of children's verbal abilities on the relationship between anger and symptoms of separation and social anxiety. Frustration is positively associated with withdrawal related to social anxiety[25] and triggers avoidance behaviors, leading to a need for caregiver support and an increase in separation anxiety. We hypothesized that frustration, as a characteristic of anger, would be significantly positively related to both separation anxiety and social anxiety. Evidence has suggested a positive correlation between external expression of anger and social anxiety symptoms[33,34], so we hypothesized that children's aggression would positively predict social anxiety, despite aggression not having a significant positive correlation with separation anxiety. Language abilities have been found to regulate emotions[7,40]. Therefore, we hypothesized that children's verbal abilities would moderate the relationships among frustration, aggression, and separation anxiety and social anxiety (see Figure 1). Gender and age are associated with anxiety symptoms in children[8,41], so these two factors were controlled for in testing the above hypotheses.

MATERIALS AND METHODS

Participants

Seventy-one typically developing children and their parents in northern Taiwan were included. The children were aged 8–12 years (M = 9.24, SD = 1.36); there were 45 boys (63.4%) and 26 girls (36.6%). Among the parents, 56 were mothers (79%) and 15 were fathers, with an average education level of 15.6 years (SD = 2.03) and an average age of 41.91 years (SD = 3.86).

Measurements

Demographic variables

Demographics including the child's gender, age, school status, and diagnoses and information on the parent's age, educational level, and occupation were collected by parent report.

Children's frustration and aggression

Children's frustration and aggression were rated using the Chinese version of the Early Adolescent Temperament Questionnaire, Revised Short Form[24,42]. This questionnaire consists of 65 items rated on a five-point Likert-type scale by children. The frustration and aggression subscales were used, each consisting of 7 items. These subscales measure children's frustration (e.g. If I want to do something but my parents don't allow it, I get very angry) and aggression (e.g. When I am angry, I

throw things or break things). The Cronbach's alphas for frustration and aggression were .65 and .63 in this study.

Anxiety symptoms

Children's anxiety symptoms were measured using the Traditional Chinese version of the Spence Children's Anxiety Scale Child Report[10,43]. This scale consists of 38 items rated on a four-point Likert-type scale (0 for never, 3 for always). The children's self-report version has good reliability and validity[41]. The subscales of separation anxiety and social anxiety each with 6 items were used, and the Cronbach's alphas were .65 and .68.

Verbal ability

Children's verbal abilities were individually administered using the Chinese version of the Wechsler Intelligence Scale for Children, Fourth Edition[44]. The Verbal Comprehension Index (VCI) includes three subscales, namely, similarities, vocabulary, and comprehension, which measure the ability to comprehend abstract meaning, comprehension of social contexts, and language expression abilities[45].

Procedure

After approval was received from the Human Research Ethics Committee (Number ECKIRB1070304), participants were recruited. Demographics and the EATQ-R were mailed to the parents and children for completion. About a week later, during the administration of the intelligence test, questionnaires were collected again.

Analysis plan

Descriptive statistics and Pearson's correlations were calculated for all variables. Then a three-step hierarchical regression analysis was executed for the separation and social anxiety as outcome variables, respectively. Children's gender and age were entered in the first step, and frustration and aggression were entered as predictor variables to examine their direct predictive effects, respectively. Interaction terms of frustration and VCI, as well as aggression and VCI, were entered in the third step as predictors. The Johnson–Neyman technique was applied to identify the values of the VCI as a moderator.

RESULTS

Descriptive statistics and correlations of variables

Children's gender and age significantly correlated with their social anxiety symptoms (*rs* = -.26, .38, *ps* = .027, <.001). The VCI did not significantly correlate with either social anxiety or separation anxiety symptoms. Frustration significantly positively correlated with both social and separation anxiety (*rs* = .29, .26, *ps* = .029, .014), while aggression did not significantly correlate with anxiety symptoms (Table 1).

Hierarchical regression analysis

Table 2 presents the results of the hierarchical regression analysis for the prediction model for frustration on social anxiety and separate anxiety. In step one, children's gender and age accounted for 21% of the variance in social anxiety ($F(1,67) = 9.11$, $p < .001$), with both variables showing significant negative and positive predictive effects, respectively (βs = -.26, .38, *ps* = .021, < .001). They accounted for 1% of the variance, with no significantly prediction on separation anxiety.

In step two, frustration added 4% to the explained variance and had no significantly predictive effect on social anxiety. However, frustration increased the explained variance by 8% ($F(1,67) = 5.79$, $p = .019$) and had a significant positive predictive effect on separation anxiety(β = .28; $p = .019$). In step three, VCI and its interaction with frustration had no significant predictive effect on the two types of anxiety symptoms (βs =- .01, -.06).

Children's gender and age accounted for 21% of the variance in social anxiety symptoms ($F(1,67) = 9.11$, $p < .001$), with significant negative and positive predictive effects, respectively (βs = -.26, .38; *ps* = .021, < .001). They accounted for 1% of the variance and had no significant predictive effects on separation anxiety. In step two, aggression had no significant predictive effect on separation anxiety. After inclusion of the VCI and its interaction with aggression, there was an increase of 9% in the explained variance ($F(2,65) = 4.14$, $p = .020$). The interaction term showed a significant predictive effect (β = -.27; $p = .014$). Johnson–Neyman analysis indicated that when the VCI was above 126, aggression negatively predicted social anxiety (effect = -.35, 95% CI [-.719, .000]). Conversely, when the VCI was below 100, aggression positively predicted social anxiety symptoms (effect = .26, 95% CI [.000, .531]) (Figure 2). VCI and its interaction with aggression increased the explained variance by 2%, and the interaction term had no significant predictive effect on separation anxiety (β = -.14, $p > .05$).

DISCUSSION

This study explored the direct relationships between frustration, aggression, and

social anxiety, as well as separation anxiety symptoms in school-age children, and the moderating effect of children's verbal ability on these relationships. The results showed that frustration was significantly positively correlated with both social anxiety and separation anxiety. After accounting for children's age and gender, frustration still had a significant predictive effect on separation anxiety. Aggression was not significantly related to social anxiety or separation anxiety symptoms. Verbal ability was found to moderate the relationship between aggression and social anxiety symptoms.

The direct associations of frustration, aggression and anxiety symptoms

This study found that frustration was significantly positively correlated with social and separation anxiety symptoms. This finding aligns with previous researches that reported a significant positive association between trait anger and the severity of anxiety in adults[20]; frustration was positively associated with the child's self-reported internalizing problems of Chinese school-aged children[25], and findings that children with anxiety disorders are more likely to become frustrated when faced with unexpected outcomes[26]. Furthermore, our study indicated that the predictive effect of frustration on separation anxiety was higher than those of gender and age, and it had a direct predictive effect. In contrast, for social anxiety symptoms, gender and age had higher predictive effects than frustration, and when gender and age were controlled for, frustration had no significant direct predictive effect on social anxiety.

Aggression was not significantly associated with social and separation anxiety symptoms. The results implied that the significant positive association between aggression and overall anxiety symptoms in typically developing children and adolescents[30] does not generalize to specific types of social anxiety and separation anxiety. This finding is inconsistent with previous studies on college students, where relational aggression positively predicted social anxiety symptoms[32]. The inconsistency may arise from the fact that the study on college students included relational aggression, and victimization in relational bullying is particularly associated with higher social anxiety[30]. Our study focused on behavioral and verbal aggression, which may explain the inconsistency, highlighting the need to consider other aspects, such as relational aggression, in future research.

The moderating effect of verbal ability

Verbal ability was found to moderate the relationship between aggression (i.e. external expression of anger) and social anxiety symptoms. Previous research has shown a link between language deficits and social anxiety[46]. This study further reveals an indirect association between verbal ability and social anxiety in school-age children. Higher levels of verbal ability can buffer concerns about negative evaluations from others in social situations associated with high aggression In contrast, below-average verbal ability does not buffer the relationship between high aggression and social anxiety symptom. However, among school-age children, language comprehension and expression skills measured by intelligence tests did not moderate the association between frustration and anxiety symptoms in social contexts.

The results of this study indicate that the moderating effect of children's language ability exists only between specific anger components and particular anxiety symptoms.

Clinical applications and suggestions

This study examined the relationships between these elements of trait anger and expression of anger with specific internalizing symptoms, as well as the indirect association of language knowledge and skills, contributing to the understanding of the pathological mechanisms of social and separation anxiety symptoms in typically developing school-aged children. Since this study is based on cross-sectional data, it cannot confirm causal relationships; Exploring these factors in typically developing school-age children could aid in the prevention of anxiety symptoms, but the findings may not necessarily generalize to populations with anxiety disorders or those at high risk for anxiety symptoms. Future research could include longitudinal studies and involve children diagnosed with or at risk of separation anxiety and social anxiety to examine causal mechanisms.

Frustration is related to separation anxiety and social anxiety in children, especially separation anxiety symptoms. In addition, language abilities can buffer the relationship between physical or verbal aggression and social anxiety symptoms. These results implied that promoting children's anger management and language abilities should be considered for anxiety prevention.

CONCLUSIONS

Anger which are closely associated with

externalizing problems, are also related to social anxiety and separation anxiety in school-age children. Trait anger and external expressions of anger, part of the multifaceted construct of anger had different association with these two type of anxiety.

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FIGURE AND FIGURE LEGENDS

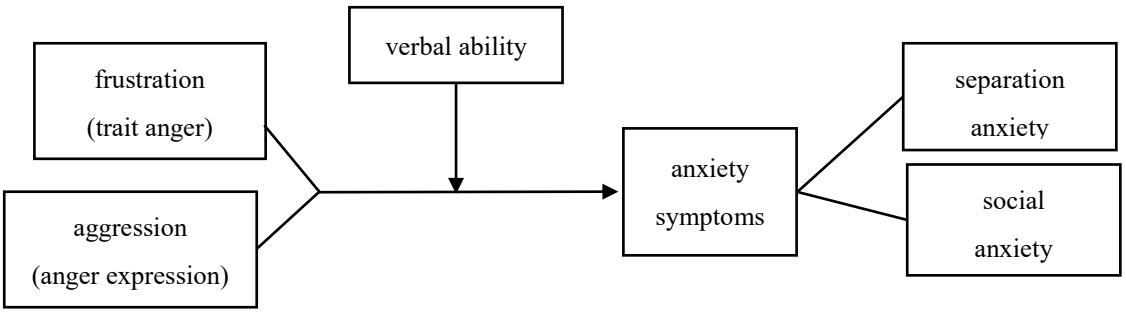

Figure 1. The relationships among variables

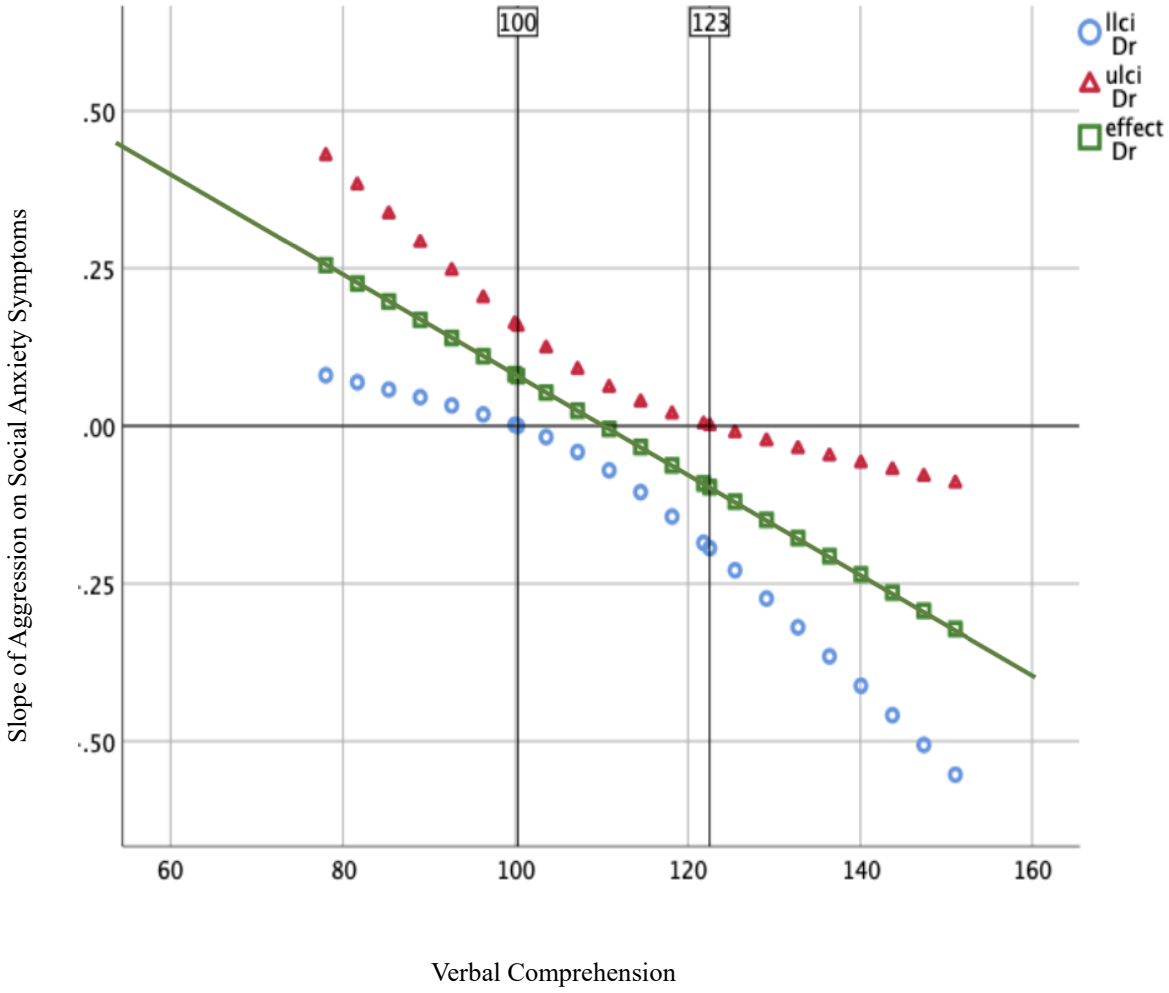

Figure 2. Johnson-Neyman plot showing the moderating effects of verbal comprehension on the association be-tween aggression and social anxiety.

Note：llci Dr = Lower Limit of Confident Interval Difference or Ratio, ulci Dr = Upper Limit of Confident Interval Difference or Ratio, effect Dr = Effect size Difference or Ratio.

TABLES

Table1. Descriptive statistics and correlations of children（N = 71）

Variables	1	2	3	4	5	6	7
1. Gender	-						
2. Age	-.02						
3. Verbal comprehension	.13	-.18	-				
4. Frustration	-.07	.13	-.06	-			
5. Aggression	-.14	.28*	.09	.46***	-		
6. Social anxiety	-.26*	.38***	-.23	.26*	.17	-	
7. Separation anxiety	-.06	.06	-.07	.29*	.07	.51***	-
Mean	-	9.24	109.41	2.93	2.09	1.33	1.15
SD	-	1.36	13.81	0.73	0.69	0.66	0.68

*p < .05. *** p < .001

Table2. Hierarchical regression analysis for frustration and VCI as predictors on anxiety symptoms (N = 71)

	Social Anxiety				Separation Anxiety			
	B	SE	β	ΔR^2	B	SE	β	ΔR^2
Step 1				.21***				.01
Gender	-.53	.22	-.26*		-.11	.25	-.05	
Age	.02	.01	.38***		.00	.01	.06	
Step 2				.04				.08*
Gender	-.50	.22	-.24*		-.08	.25	-.04	
Age	.02	.01	.35**		.00	.01	.02	
Frustration	.20	.11	.20		.28	.12	.28*	
Step 3				.02				.00
Gender	-.48	.22	-.23*		-.06	.25	-.03	
Age	.02	.01	.33**		.00	.01	.02	
Frustration	.20	.11	.20		.27	.12	.27*	
VCI	-.13	.11	-.13		-.05	.12	-.05	
FrustrationxVCI	-.01	.12	-.01		-.06	.13	-.06	

*p < .05. **p < .01. ***p < .001.

Note. VCI = Verbal Comprehension Index

Table3. Hierarchical regression analysis for aggression and VCI as predictors on anxiety symptoms

	Social anxiety				Separation anxiety			
	B	SE	β	ΔR^2	B	SE	β	ΔR^2
Step 1				.21***				.01
Gender	-.53	.22	-.26*		-.11	.25	-.05	
Age	.02	.01	.38***		.00	.01	.06	
Step 2				.00				.00
Gender	-.52	.22	-.25*		-.10	.25	-.05	
Age	.02	.01	.36**		.00	.01	.05	
Aggression	.04	.11	.04		.05	.13	.05	
Step 3				.09*				.02
Gender	-.52	.22	-.25*		-.11	.26	-.05	
Age	.02	.01	.30**		.00	.01	.02	
Aggression	.06	.11	.06		.06	.13	.06	
VCI	-.09	.11	-.09		-.04	.13	-.04	
Aggression x VCI	-.31	.12	-.27*		-.16	.15	-.14	

*p < .05. **p < .01. ***p < .001

Note. VCI = Verbal Comprehension Index

Anger, Separation Anxiety, and Social Anxiety in School-age Children

The Levels of Mastery Motivation in Preschoolers with Developmental Delay and Associations with Temperament

學齡兒童生氣與分離焦慮、社會焦慮之關聯：語文能力的調節效果

彭詩媛[1]　黃素英[1,*]

中文摘要

背景與目的：分離焦慮及社交焦慮為學齡兒童常見的焦慮形式，與成年期的情感障礙有密切關聯，探討其風險因子及機制對介入極為重要。生氣與外化性行為有關，然而與內化性行為的關聯有待澄清。本研究目的為檢驗兒童的生氣特質、生氣表達與社交焦慮、分離焦慮症狀的直接關聯，以及兒童語文能力在兩者與社交焦慮、分離焦慮症狀之關聯的調節效果。**方法：**以 71 位臺灣北部就讀小學之典型發展兒童（平均年齡 9.24 歲，男童 45 位）及其家長為對象，家長填寫基本資料表、兒童自我評量挫折（亦即生氣特質）及攻擊性（亦即生氣表達）及分離焦慮、社交焦慮症狀，以魏氏兒童智力測驗第四版中的語文理解指數作為兒童語文能力指標。**結果：**挫折與分離、社交焦慮症狀顯著正相關，控制兒童性別及年齡後，挫折顯著預測分離焦慮。兒童的攻擊性與社交焦慮、分離焦慮無顯著相關，語文理解指數與攻擊性的交互作用顯著預測兒童社交焦慮症狀。**結論：**學齡兒童的生氣特質增加分離焦慮風險，生氣表達對社交焦慮的關聯受語文能力調節。

關鍵字：攻擊性、焦慮症狀、挫折、語文能力、學齡期兒童

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Case Report

Discrepancy Between Bispectral Index Values and Actual Anesthesia Depth During On-Pump Beating-Heart Coronary Artery Bypass Grafting: Insights From an Electroencephalography Signal Analysis

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ABSTRACT

The unique pathophysiological effects of cardiopulmonary bypass can alter the pharmacokinetics and pharmacodynamics of anesthetics, increasing the risk of inadvertent intraoperative awareness, a rare but devastating complication of cardiac surgery. Anesthesiologists commonly rely on the bispectral index (BIS) to ensure appropriate anesthesia depth; however, different anesthetics exhibit distinct electroencephalogram (EEG) signatures, thereby influencing BIS values differently. Herein, we present the case of a 58-year-old patient undergoing on-pump beating-heart coronary artery bypass grafting (CABG) and the anesthesia was maintained with midazolam and fentanyl during cardiopulmonary bypass. We observed a peculiar phenomenon that despite administering higher doses, BIS values remained above our target range. This elevation in BIS values was inconsistent with the observed clinical manifestations. After the administration of a very small dose of propofol, the BIS decreased dramatically and disproportionately. The discrepancy between BIS values and actual anesthesia depth prompted a detailed exploration of the patient's EEG patterns. We observed a subtle alternation in the power spectral densities of EEG signals associated with propofol administration, which emphasizes the importance of interpreting BIS values with caution, considering the clinical context and medication. Our findings may facilitate the improvement of anesthesia care during complex cardiac procedures.

Keywords: bispectral index; cardiac surgery; cardiopulmonary bypass; electroencephalography; general anesthesia; propofol

INTRODUCTION

CHANGES IN THE PHARMACOKINETICS and pharmacodynamics of anesthetics due to the unique pathophysiological effects of cardiopulmonary bypass (CPB) expose patients undergoing cardiac surgery to elevated risk of inadvertent intraoperative awareness, which, although rare, is a potentially severe complication.[1] Anesthesiologists commonly use the bispectral index (BIS) value, a continuous processed electroencephalography (EEG) parameter, to ensure adequate depth of anesthesia. However, BIS values vary across anesthetics. The use of certain anesthetics can lead to a false increase in the BIS value, which hinders the accurate representation of the true hypnotic state.[2] This article presents the case of a patient who underwent on-pump beating-heart coronary artery bypass grafting (CABG) where the BIS value recorded during CPB did not align with the clinical signs of the patient's hypnotic state and exhibited inconsistent responses to various anesthetics administered. This study sought to clarify this phenomenon by analyzing the original EEG signal.

CASE REPORT

This study was approved by the Institutional Review Board of Shin Kong Wu Ho-Su Memorial Hospital (approval number: 20181205R). A 58-year-old man with type 2 diabetes mellitus underwent CABG due to triple-vessel coronary artery disease. The patient's preoperative cognitive function was normal, and he had no history of any neurological or psychological disorders. The preparation of anesthesia followed our standard protocol for cardiac surgery, which involved the use of standard monitoring devices and an arterial catheter for continuous blood pressure monitoring. BIS and cerebral oximetry measurements were performed. Anesthesia was induced, namely, 300 μg of fentanyl, 12 mg of etomidate, and 50 mg of rocuronium. The BIS value declined to 40 after anesthesia induction, and endotracheal intubation was successfully performed. We used desflurane for anesthesia maintenance; the concentration of desflurane was adjusted to maintain the BIS value between 60 and 40. Approximately 95 min into the operation, partial CPB was initiated, and we promptly administered 200 μg of fentanyl and 5 mg of midazolam. During CPB, we discontinued desflurane and switched to total intravenous anesthesia(Figure. 1). In brief, midazolam and fentanyl were administered during CPB to maintain anesthesia in accordance with our standard clinical practice (0.1 to 0.2 mg/kg/h and 2 to 4 mcg/kg/h, respectively). Additional bolus doses (0.05 to 0.1 mg/kg and 1 to 2 mcg/kg, respectively) were given if the BIS exceeded 60 or in response to hemodynamic changes associated with awareness or noxious stimuli, such as tachycardia or hypertension. Our dosing strategy was to maintain stable hemodynamics and BIS values between 40 and 60 with careful titration of anesthetics. However, the BIS fluctuated between 65 and 70, and exhibited no apparent response to the fentanyl or midazolam. Although the patient exhibited no sign of intraoperative awareness and all of his vital signs remained unchanged, we adopted an alternative anesthetic approach: 50 mg of propofol was administered. Consequently, the patient's BIS value rapidly decreased to <30 within 5 min and then gradually increased to >60 within the next 10 min. No major changes were observed in the raw EEG trace or hemodynamic parameters that could have correlated with the sharp fluctuation in the BIS value in response to propofol. Throughout CPB, we noted no apparent changes in surgical stimulation or any other clinical condition. At the end of CPB, we switched back to desflurane; consequently, the BIS value returned to the pre-CPB range, namely, 40–60, without the need for additional anesthetic administration. Postoperative care was provided in the intensive care unit, where the patient made a smooth recovery. He exhibited no signs of intraoperative awareness or any other anesthesia-related complications during the routine post-anesthesia follow-up assessment.

DISCUSSION

Balanced general anesthesia is the predominant approach in modern anesthesia care. This approach involves the concurrent administration of multiple drugs to induce a reversible anesthetic state, which is characterized by unconsciousness, amnesia, analgesia, and immobility. In addition, this approach allows for the reduction of individual drug dosages to effectively mitigate the potential risks associated with sole reliance on a high-dose single anesthetic drug to maintain general anesthesia[3,4] These risks include hemodynamic depression and excessive anesthesia depth, which may lead to unfavorable outcomes and increased morbidity and mortality.[5-10] During CPB, anesthesia can be maintained using a combination of opioids and intravenous anes-

thetics (e.g., midazolam and propofol) or inhaled anesthetics (e.g., sevoflurane and desflurane).[1] However, ensuring adequate anesthesia depth and preventing intraoperative awareness constitute challenges because of CPB-induced pathophysiological changes, including hemodilution, hypothermia, and unreliable or absent hemodynamic responses. Hence, many anesthesiologists routinely monitor processed EEG parameters (e.g., BIS values) or unprocessed EEG signals during CPB in an attempt to gain additional insights beyond clinical signs.[1,11]

BIS was first introduced by Aspect Medical Systems in 1994. This empirically derived complex statistical parameter is commonly used to assess the level of consciousness in a patient under general anesthesia and sedation.[12] BIS monitors rely on a four-lead frontal EEG montage to record EEG signals for processing and near-real-time BIS values. The BIS algorithm is proprietary, and the actual computation process used to calculate the BIS value has not been publicly disclosed. Nonetheless, BIS values are calculated using information from three EEG analyses, namely, the bispectral, power spectrum, and time domain analyses. Subparameters from these analytical techniques—such as the burst suppression ratio, QUAZI suppression, the BetaRatio (relative beta ratio), and SynchFastSlow (fast/slow synchronization)—are weighed and summed to calculate a single numerical parameter that correlates most closely with the clinical effects of anesthesia, namely, the BIS value.[13,14] This value ranges from 0 to 100, with 0 indicating profound unconsciousness (isoelectric EEG) and 100 indicating complete wakefulness. For most surgical procedures, a BIS value between 40 and 60 is considered to be appropriate for anesthesia. However, despite the high reliability of the BIS value in predicting consciousness, its use for preventing intraoperative awareness remains debatable.[15,16] Furthermore, the ability of a BIS monitor to accurately assess changes in anesthesia depth can be influenced by factors such as age, hypothermia, and specific anesthetic agents.[2,17,18]

In 2000, Barr et al. evaluated BIS values when patients were under fentanyl-and-midazolam-induced anesthesia during CABG.[19] The researchers noted substantial variations in BIS values during clinically adequate anesthesia, and this fluctuation could not be attributed to drug concentration. Although the researchers recognized the limitations of BIS as a measure of the depth of anesthesia induced by this combination of anesthetics, they did not delve into the underlying reasons behind these limitations at the time. In the present study, raw EEG data were directly downloaded from the BIS monitor after surgery and analyzed using Fast Fourier Transform computer programs in MATLAB R2021b (MathWorks Inc., Nattick, MA, USA) to extract time and frequency domain features. Figure. 2 shows the rapid decrease in the BIS value from >60 to <40 after the administration of a small dose of propofol. Notably, no substantial differences were observed in the EEG signals or their corresponding spectrograms between 10 min before (EEG segment 1) and 10 min after (EEG segment 2) propofol administration. The burst suppression ratio and QUAZI suppression values were 0, indicating the absence of burst suppression activity. Minimal changes were noted in the BetaRatio and in SynchFastSlow before and after propofol administration (BetaRatio, from −1.24 to −1.16; SynchFastSlow, from −2.14 to −2.21). We meticulously compared power spectral density between the two EEG segments (Figure. 3); the results revealed subtle changes following the administration of propofol. When midazolam was used alone, the highest peak in the power spectral density of the EEG signal was observed at 11.8 Hz. After propofol administration, this peak shifted leftward to 10.1 Hz, leading to an increase in the ratio of alpha-band power (8–12 Hz) to total power (from 28.2% to 41.5%) and a decrease in that of beta-band power (12.1–30 Hz) to total power (from 30.6% to 21.2%). No significant change was noted in the ratio of delta- or theta-band power to total power. The spectral edge frequency 95 (SEF95) remained relatively stable (minimal fluctuations only) at approximately 19 Hz throughout the process. The changes in alpha- and beta-band activity may explain the rapid decline in the BIS value after the administration of a small dose of propofol; the magnitudes of these changes were disproportionate to the dose administered.

Although volatile anesthetic gases are theoretically considered to be cardioprotective and may improve clinical outcomes in patients undergoing cardiac surgery, recent evidence suggests that their use does not reduce the rate of 1-year mortality compared with the use of total intravenous anesthesia.[21] Moreover, the uptake of volatile anesthetics through oxygenators is unpredictable, and monitoring the de-

livery of volatile anesthetics is challenging during various phases of CPB. These factors hinder the maintenance of consistent plasma concentrations of volatile anesthetic gases. Therefore, regardless of whether volatile anesthesia or total intravenous anesthesia is used during CPB, anesthesiologists often use BIS to ensure an adequate depth of anesthesia. However, the use of BIS value has its limitations and thus solely relying on this value to gauge anesthesia depth is inappropriate; clinical manifestations, EEG patterns, and spectrogram characteristics should also be considered to facilitate comprehensive assessment. In our case, we used a small dose of propofol to clarify the discrepancy between observed BIS value and the clinical signs. The results proved that the patient was under appropriate depth of anesthesia; and with the analysis of the EEG wave afterwards, we could attribute the abnormally high BIS value to its inconsistent response to various anesthetic. Alternative EEG tools utilizing different algorithms, such as entropy and narcotrend index, could also be used to assess anesthesia depth during CPB. These methods might potentially offer a more accurate assessment in the context of our case.

In conclusion, anesthesia providers should exercise caution when interpreting BIS values and consider patients' clinical status and medication use to facilitate comprehensive assessment. Our report could serve as a reference for the improvement of patient care and safety during complex cardiac procedures. We recognize that the findings from our single case may not be applicable to all cardiac surgery patients, and further research is needed to identify which patient populations may exhibit similar BIS variations.

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FIGURE AND FIGURE LEGENDS

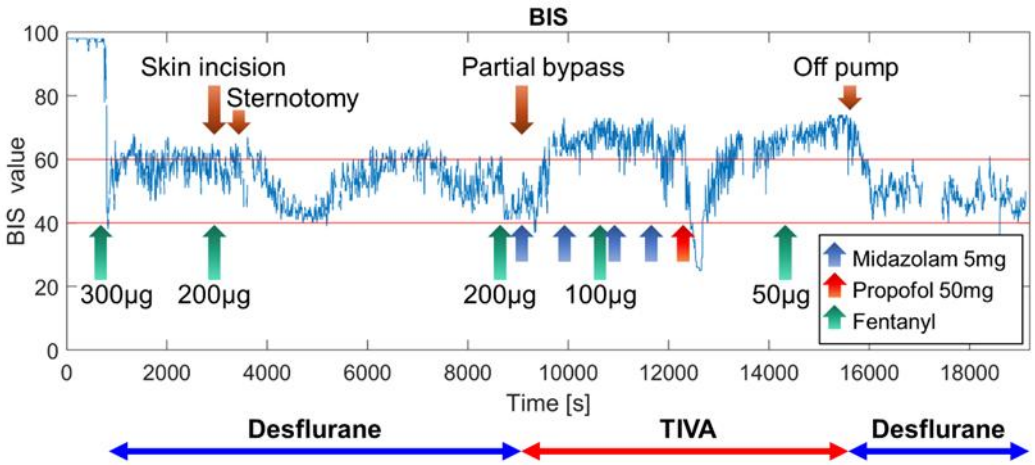

Figure 1. Time course of BIS value changes, intraoperative events, and anesthesia management. BIS, bispectral index; TIVA, total intravenous anesthesia.

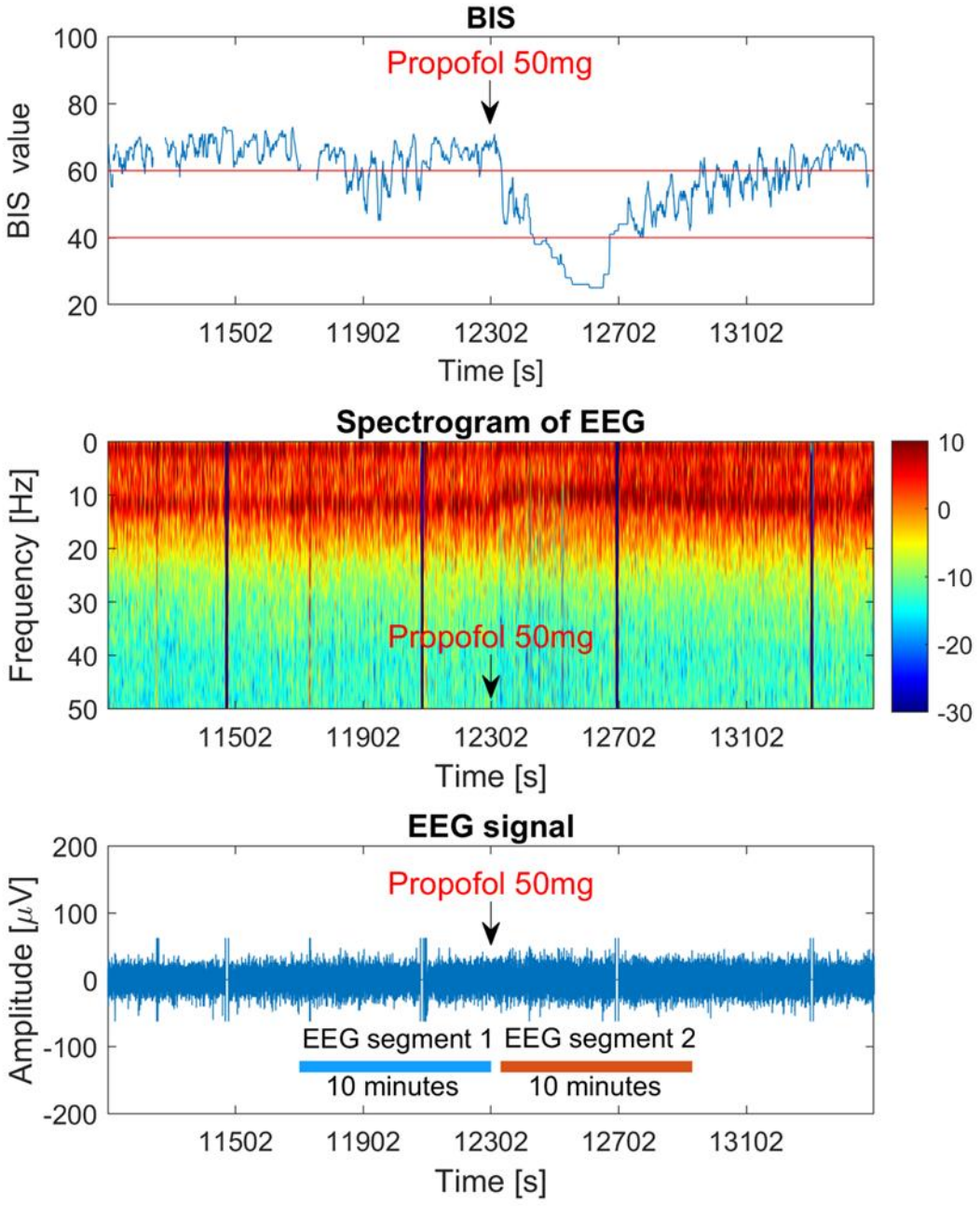

Figure 2. EEG signal recorded 20 min before and after propofol administration and corresponding BIS values and spectrogram. BIS, bispectral index. EEG, electroencephalography.

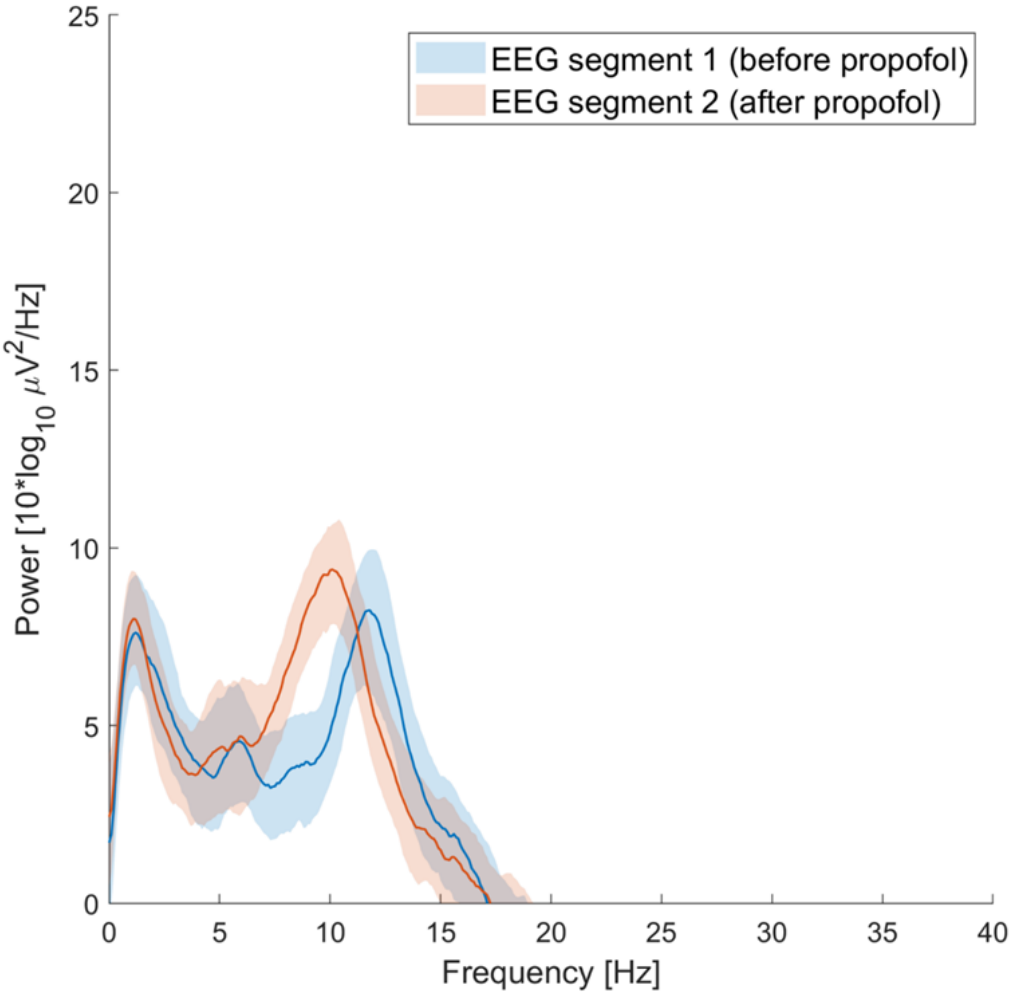

Figure 3. Power spectral densities of two 10-min EEG segments (before and after propofol administration). Absolute power was calculated using a discrete Fourier transform with 10-s epoch size and 90% overlapping. The solid line indicates the median value, and the shaded area indicates the interquartile range.

Discrepancy Between Bispectral Index Values and Actual Anesthesia Depth During On-Pump Beating-Heart Coronary Artery Bypass Grafting: Insights From an Electroencephalography Signal Analysis

體外循環心臟不停跳之冠狀動脈繞道手術中雙頻指數值與實際麻醉深度之間的差異：來自腦電波訊號分析的見解

丁煦 [1,2,] 張正熹 [1,2,*]

中文摘要

體外心肺循環的獨特病生理效應可以改變麻醉藥物的藥物動力學和藥效學，增加術中意外甦醒的風險，這是心臟手術中罕見但災難性的併發症。 麻醉醫師常依靠雙頻指數來確保適當的麻醉深度； 然而，不同麻醉劑表現出明顯不同的腦電波特徵，因此對雙頻指數的影響也各異。 在此，我們報告一位在體外心肺循環下進行心臟不停跳之冠狀動脈繞道手術的 58 歲患者，其體外心肺循環期間使用咪達唑侖和吩坦尼來維持麻醉。奇特的是，儘管給予更高的劑量，雙頻指數仍然持續高於目標範圍，並與觀察到的臨床表現不一致。但在給予小劑量的異丙酚後，雙頻指數卻劇烈而不成比例地下降。雙頻指數與實際麻醉深度之間的差異促使我們詳細探討該病患的腦電波訊號。結果我們在功率譜密度上觀察到與異丙酚相關的微妙變化，這強調在解讀雙頻指數時需同時謹慎考慮臨床狀況和所使用之藥物的重要性。我們的結果將有助於改善複雜心臟手術期間的麻醉照護。

關鍵字：雙頻指數、心臟手術、體外心肺循環、腦波、全身麻醉、異丙酚

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Case Report

Syringosubarachnoid Shunt for Cervical and Thoracic Syringomyelia Associated with Type I Chiari Malformation: A Long-term Follow-up Case Report

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ABSTRACT

Syringomyelia defined as the presence of abnormal, CSF-filled cavities in the spinal cord, presents with diverse etiologies, such as congenital anomalies, trauma, tumor and idiopathic origins. The diverse neurological conditions make the definitive diagnosis and optimal management challenging. This case report explores the long-term outcomes of syringosubarachnoid shunt in cervical and thoracic syringomyelia patient. A 38-year-old female presented persistent itchiness, decreased touch sensation, and left forearm/digits pain for one month. Neurological examinations indicated a cervical lesion, confirmed via MRI as Chiari I malformation with C3-T9 syringomyelia. Surgical intervention involved partial hemilaminectomy and syringosubarachnoid shunt, effectively relieving symptoms and reducing the syrinx size after operation. Syringomyelia treatments should be tailored toward the underlying mechanism whenever possible. Surgical options for treatment of symptomatic syringomyelia associated to Chiari I malformation include foramen magnum decompression with or without duraplasty and various shunting procedures. This case without receiving foramen magnum decompression demonstrates the efficacy of a syringosubarachnoid shunt in managing cervical and thoracic syringomyelia associated with Chiari malformation. Over 13 years of follow-up, stable syrinx size and sustained neurological improvement were observed.

Keywords: Syringomyelia, Syringosubarachnoid shunt, Chiari malformation

INTRODUCTION

Syringomyelia represents the formation of an intramedullary cystic cavity (syrinx), which may arise from various causes, including idiopathic origins, congenital factors, associations with congenital abnormalities like Chiari malformations, trauma-induced occurrences, arachnoiditis, or as a satellite cyst linked to a tumor. The estimated prevalence of syringomyelia stands at 9 per 100,000 individuals[1,2].

Patients afflicted with syringomyelia present a spectrum of symptoms, often associated with the size and location of the syrinx. The condition might present as asymptomatic or gradually progress with neurological signs and symptoms. Initial symptoms of syringomyelia commonly include sensory loss and a dull or burning pain attributable to spinothalamic tract involvement. The sensory loss is typically suspended and cape-like in distribution. Additionally, there is characteristically a dissociated pattern of pain and temperature sensation loss with preservation of light touch and proprioception. As the syrinx progresses, motor function loss occurs, frequently appearing asymmetric due to uneven extension of the syrinx into the ventral horn of the spinal cord[3].

Chiari malformations are responsible for nearly half of the syringomyelia population, and spinal cord trauma and arachnoiditis account for another quarter of adult patients with syrinxes. Chiari I malformation is a disorder characterized by caudal displacement of the cerebellar tonsils below the level of the foramen magnum, resulting in altered cerebrospinal fluid flow dynamics. Surgical intervention involving foramen magnum decompression, C1 laminectomy, or shunting the syrinx towards the subarachnoid space, pleural, or peritoneal cavities through a valveless tube. However, a consensus of the optimal management strategy is yet to be established. The efficacy of syringe-subarachnoid shunts remains a subject of debate[3,4]. In this article, we showed the long-term outcomes of a Chiari I malformation case with cervical and thoracic syringomyelia treated with only syringosubarachnoid shunting.

CASE REPORT

A 38-year-old female, without any systemic diseases, presented with persistent itchiness in her left forearm and digits over a month. Scratching provided no relief, and she also experienced decreased touch sensation. The abnormal sensations worsening progressively, with the development of pain along the ulnar side of the 4th and 5th fingers induced by coughing. She denied weakness, incontinence, or unsteady gaits.

Neurological examinations revealed normal cranial nerves, but decreased pin-prick sensation in the left C7-C8 dermatomes. Muscle power was intact in all four limbs, while lower limbs exhibited increased deep tendon reflexes compared to normal upper limb reflexes. There were no findings for Hoffman's and Babinski sign. Considering her symptoms and neurological findings, a cervical lesion was suspected. Spine magnetic resonance image (MRI) was done and revealed Chiari I malformation with C3-T9 syringomyelia (Figure1).

With the knowledge of a C3-T9 syringomyelia contributed to cervical myelopathy, the patient underwent left C5 & partial C6 hemilaminectomy. A subsequent opening of the dura mater, approximately 1.5cm in size, was performed. Following this, 3mm myelotomy, 1.5mm in depth, was executed medial to the dorsal root at C6, resulting in the cerebrospinal fluid (CSF) gushing out. To establish a syringo-subarachnoid shunt, a 4cm-long, 1 mm-diameter silicon tube with bilateral side-holes was implanted as a syringosubarachnoid drainage and secured with a hemoclip (Figure 2). Pathology analysis of the lamina bone and ligamentum flavum showed normal histology.

Postoperatively, the patient's symptoms significantly improved, confirmed by a follow-up MRI on post-operation day 24, which indicated reduced syrinx. Subsequent follow-ups at 2 and 13 years (Figure 3) demonstrated stable syrinx without progression. An upper limb electromyography (EMG) conducted at the 13-year follow-up revealed normal findings.

DISCUSSION

Syringomyelia is often difficult to manage, because patients may remain asymptomatic for several years even with significant syrinxes. Surgical treatment is generally deferred until the patient develops a progressive neurological decline or severe pain. When an identifiable etiology is clear (i.e., tumor, tethering, Chiari malformation), management is aimed at treating this underlying cause[4].

For patients without an identifiable cause, but with imaging demonstrating evidence of abnormal CSF flow dynamics and arachnoid adhesions, a decompression including arachnolysis is recommended. In cases refractory

to decompression or without imaging evidence of arachnoid webbing, shunting techniques have been employed, including syringo-subarachnoid, -peritoneal, and -pleural shunting[5,6]. When compared to the three operation methods, a systematic review and meta-analysis reported the rate of clinical improvement was estimated as 61% for syringosubarachnoid, 64% for syringoperitoneal, and 71% for syringopleural shunts. The rate of clinical deterioration following placement was estimated as 13% for syringosubarachnoid, 13% for syringoperitoneal, and 10% for syringopleural shunts; incidences of revision surgery were estimated as 13% for syringosubarachnoid, 28% for syringoperitoneal, and 10% for syringopleural shunts, respectively. This study suggests that while all three modalities offer similar rates of clinical improvement and deterioration after placement, syringoperitoneal shunts have a greater rate of malfunction requiring surgical revision[7]. Syringosubarachnoid shunts may minimize the risk of overdrainage of CSF and extradural fluid collection in comparison to the other two techniques[8].

In the past, most syringomyelia cavities were associated with Chiari malformations, also known as hindbrain hernia. Up to 3 mm of descent below McRae's line (drawn, on plain X-rays, mid-sagittal CT or MR images, from the tip of the clivus to the posterior rim of the foramen magnum) is regarded as in normal range, whereas 5 mm or more is deemed abnormal. Investigators demonstrated various factors associated with syringomyelia in Chiari I malformation patients. One of the consensus is severely narrowed CSF pathways in and around the foramen magnum[9].

Surgical treatment of syringomyelia in patients with Chiari I malformation remains controversial. Foramen magnum decompression has become the preferred procedure because it improves cerebrospinal fluid circulation around the foramen magnum. Some studies indicated that placement of a syringosubarachnoid shunt, however, can cause the syrinx, even a large-sized syrinx, to deflate rapidly[10, 11].

In a study which treated 70 symptomatic syringomyelia patients with Chiari I malformation either with foramen magnum decompression or syringosubarachnoid shunt placement procedure. They preferentially treated patients with lower cranial nerve palsy or nystagmus and small syrinx cavity via foramen magnum decompression procedure (33 patients); patients with large syringomyelia (syrinx width more than 70% of the spinal cord width at the same level) with shunt method (37 patients). The results depicted that neurological improvement was gained in 82% of patients operated with foramen magnum decompression, in 97% of the patients treated with syringosubarachnoid shunt[12]. In our study, the case who exhibited no signs of brainstem compression or cranial nerve deficits, and presented solely with symptoms of spinal myelopathy, was initially treated with a syringosubarachnoid shunt, leading to a favorable outcome.

CONCLUSION

The utilization of a syringosubarachnoid shunt in this case report shows an effective therapeutic approach for managing cervical and thoracic syringomyelia associated with Chiari malformation. Although there was no foramen magnum decompression, the intervention aimed at diverting CSF and relieving pressure within the syrinx, thereby arresting its progression. The follow-up MRI at 2 and 13 years post-operation consistently demonstrated stable syrinx size without recurrence or progression, affirming the long-term effects of the shunting procedure. Additionally, the EMG performed at the 13-year follow-up revealed normal upper limb function, emphasizing sustained symptomatic relief and neurological stability.

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FIGURE AND FIGURE LEGENDS

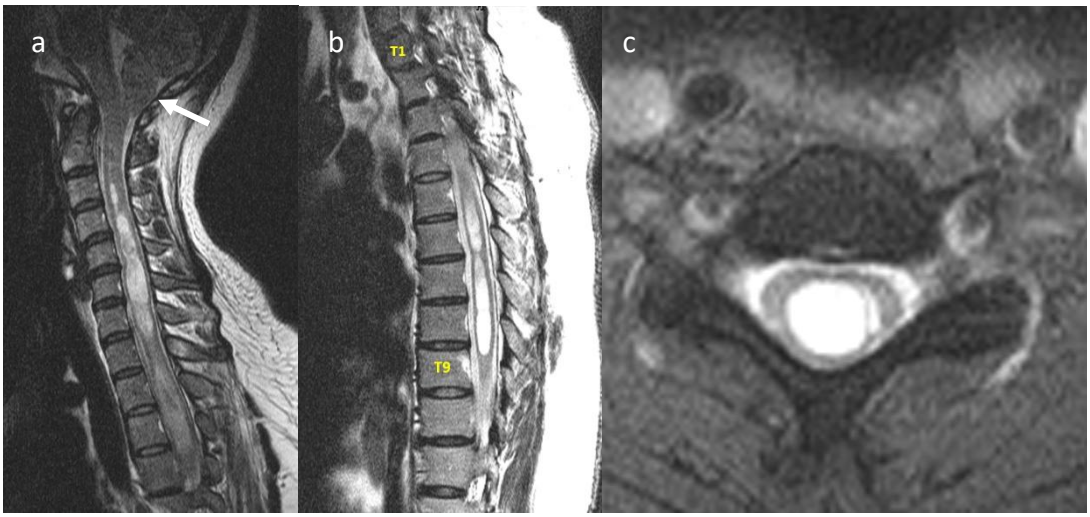

Figure 1. T2-weighted midline sagittal cervical and upper thoracic spine MRI demonstrates an extensive, segmented spinal cord syrinx extending from the C3 to T9 levels. The presence of pronounced tonsillar herniation (white arrow) is evident, indicative of Chiari I Malformation (a,b). Additionally, the axial section at C6 level exhibits intramedullary fluid collection causing cord compression(c).

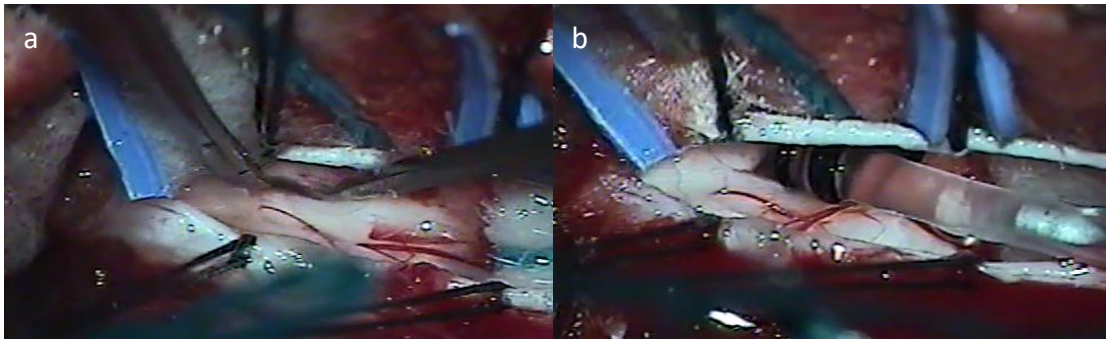

Figure 2. Left C6 paramedian myelotomy to drain the syrinx (a) and set a syringosubarachnoid shunt with 1 mm-diameter silicon tube (b).

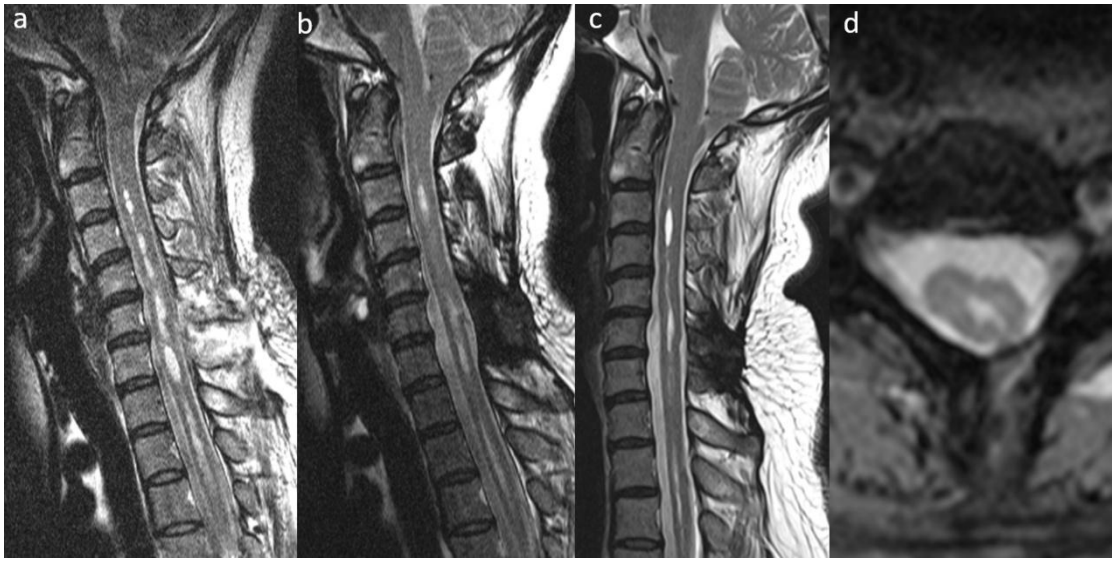

Figure 3. The postoperative MRI conducted on the 24th day following the operation revealed a notable reduction in syrinx size (Figure a). Subsequent imaging at 2 years post-operation indicated no signs of progression or recurrence (Figure b). Further, the 13-year follow-up MRI demonstrated stable conditions in both sagittal and axial views, showing no significant changes (Figures c,d).

Syringosubarachnoid Shunt for Cervical and Thoracic Syringomyelia Associated with Type I Chiari Malformation: A Long-term Follow-up Case Report

脊髓硬膜下腔分流術於頸部和胸部脊髓空洞症患者長期追蹤：病例報告

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中文摘要

脊髓空洞症被定義為脊髓內存在異常、充滿積液的腔隙，其病因多樣，如先天異常、外傷、腫瘤和不明原因。該病以多樣化的神經症狀呈現，讓診斷和治療充滿挑戰。本病例報告探討了頸部和胸部脊髓空洞症患者接受脊髓硬膜下腔分流術的長期效果。這是一名 38 歲女性的左上肢出現持續的癢感、輕觸覺喪失以及前臂和手指疼痛持續約一個月。神經學檢查符合頸髓病變，MRI 顯示為 I 型 Chiari 畸形合併 C3-T9 脊髓空洞症。手術治療包括部分椎板切除術及脊髓硬膜下腔分流術，術後明顯改善症狀並減少脊髓空洞的大小。脊髓空洞症的治療首先應針對潛在原因，手術選擇包括直接解除蛛網膜沾黏以及多種分流術。本病例展示了脊髓硬膜下腔分流術在治療與 Chiari 畸形相關的頸部和胸部脊髓空洞症中的療效，長達 13 年的追蹤顯示神經學改善及脊髓空洞症穩定未復發。

關鍵字：脊髓空洞症、脊髓硬膜下腔分流術、Chiari 畸形

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Case Report

Lumbar radiculopathy caused by ganglion cyst: Case report

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ABSTRACT

Purpose: A 56-year-old female with a medical background presented with persistent lower back pain. Initially attributing the pain to muscle strain, the discomfort extended from her buttocks to both legs, predominantly on the left side, over a span of three months. An MRI of her lumbar spine revealed a round hypointense lesion at L5/S1 on T1WI that brightened on T2WI, suggestive of a left-sided spinal canal synovial cyst. Under the provisional diagnosis of a spinal tumor, she was admitted for surgical intervention. ***Materials and Methods:*** With informed consent, a surgical intervention was performed, where the left L5/S1 ligamentum flavum was removed, along with the extradural cystic lesion, relieving pressure on the left S1 root. The histology showed a collagenous fibrous wall, devoid of a synovial lining cell, which is compatible with ganglion cyst. ***Results:*** Postoperatively, the patient exhibited a significant improvement in her S1 root pain during a one-month follow-up. This case underscores the importance of accurate diagnosis and timely surgical intervention in managing spinal cystic lesions. ***Conclusion:*** Synovial and ganglion cysts are typically found around peripheral joints and tendon covers, yet they are infrequently observed within the spine. While these cysts often originate from the facet joint, there have been instances where they are connected to various spinal structures, including the ligamentum flavum and even the disc. As these cysts grow, particularly when linked with degenerative alterations, they can press against the nearby thecal sac or nerve root. We presented a case of ganglion cyst at the lumbosacral spine and discussed clinical, radiological, and surgical findings with good prognosis.

Keywords: spinal cystic lesion, juxta-facet cyst, ganglion cyst, synovial cyst, low back pain, lumbar radiculopathy

INTRODUCTION

Synovial and ganglion cysts are typically found around peripheral joints and tendon covers, yet they are infrequently observed within the spine[1-2]. While these cysts often originate from the facet joint, there have been instances where they are connected to various spinal structures, including the ligamentum flavum and even the disc[2-3]. As these cysts grow, particularly when linked with degenerative alterations, they can press against the nearby thecal sac or nerve root[4-7]. We presented a case of ganglion cyst at the lumbar spine and discussed clinical, radiological, and surgical findings.

CASE REPORT

A 56-year-old female with a medical background including End-Stage Renal Disease, Coronary Artery Disease (post Coronary Artery Bypass Graft in 2016), Hypertension, Gastroesophageal Reflux Disease, and a bilateral femoral neck fracture (treated with bipolar hemiarthroplasty in 2018) presented with persistent lower back pain. Initially attributing the pain to muscle strain, the discomfort extended from her buttocks to both legs, predominantly on the left side, over a span of three months.

An MRI of her lumbar spine revealed a round hypointense lesion at L5/S1 on T1WI that brightened on T2WI, suggestive of a left-sided spinal canal synovial cyst (Figure. 1). Under the provisional diagnosis of a spinal tumor, she was admitted for surgical evaluation.

With informed consent, a surgical intervention of left L5 hemi-laminectomy was performed, where the left L5S1 ligamentum flavum was removed, along with the extradural cystic lesion, relieving pressure on the left S 1 root (Figure. 2). Pathology reported the cystic lesion to have a collagenous fibrous wall devoid of a synovial lining cell, ganglion cyst was diagnosed (Figure. 3).

Postoperatively, the patient exhibited a significant improvement in her S 1 root pain during a one-month follow-up. This case underscores the importance of accurate diagnosis and timely surgical intervention in managing spinal cystic lesions.

roved by our human subject committee.

This study was approved by Institutional Ethics Review Board (permission number: 20240201R)

DISCUSSION

There are two varieties of cysts originate from the tissues surrounding joints in the body. They are typically related to the degeneration of spine facet joints. The first type features a lining of synovial membrane, aptly named a "synovial cyst," while the second lacks a distinct lining, leading to its classification as a "ganglion cyst." They can be distinguished historically by the presence or absence of the synovial lining[4,5,8]. This histological difference suggests that ganglion cysts and synovial cysts may have different etiologies and potentially different responses to treatment.

Most of the cases reported about the lumbar facet cysts arise at the lumbar 4-5 level[5,9]. The cause is believed to be associated with increased motion4. The proposed mechanism of synovial cyst formation is the rupture of the synovial membrane with extrusion of fluid and cells[10-11]. A synovial cyst usually contains clear serous or xanthochromic fluid[7]. Compared to a synovial cyst with the communication with the joint cavity, ganglion cysts are not connected to the synovial cavity[4,7]. Ganglion cysts contain a protein-rich, viscous fluid and have a well-vascularized, fibrous connective tissue wall[11]. Ganglion cysts is believed originating from fibrous tissues around the facet joints[12]. The fibrocytes form an incomplete lining that resembles the synovium of the joint capsule[13].

The characteristic features of spine facet cyst on MRI may be described as a well-defined mass with variable intensity on T1-weighted images, hyperintensity on T2 weighted images and contrast enhancement. MRI is considered the gold standard for diagnosing these cysts, but histological examination is necessary to definitively differentiate between ganglion and synovial cysts. The further differentiation requires gross and histological exam[3-5].

The clinical presentation may be variable, depending on location and surrounding structures. It can cause symptoms of nerve root or spinal cord compression, neurogenic claudication, myelopathy, cauda equina syndrome or even Brown-Sequard syndrome[14-16]. The chief complaints in our case were lower back pain with radiculopathy.

Surgical treatment is generally recommended with the case of intractable pain or neurological deficits are present. Maximal safe resection is preferred for both types of cysts to reduce the risk of recurrence and alleviate symptoms[11]. Surgical approach must totally remove the lesion due to a ganglion cyst is likely to recur when the cyst is partially removed. Subtotal excision only be advisable when part of the capsule appear tightly adherent to the dura[8]. Besides cystectomy, spinal fusion may be also considered if the spinal instability is prospective[4,8]. Surgical resection is also common for synovial cysts, but given their communication with the joint cavity, additional

procedures to address joint instability (such as spinal fusion) might be considered more frequently[8,11]. Conservative management options like steroid injections or cyst aspiration might be more effective compared to ganglion cysts[11]. It can be planned when preoperative showed spondylolisthesis or can be decided during surgery when facet joint is damaged to achieve decompression and total cystectomy. We performed only simple laminectomy to achieve total cystectomy in our case.

Despite synovial and ganglion cysts being distinct in their pathologies, their management approaches are comparable[7]. Both types are effectively treated through surgical decompression and excision, which typically result in favorable outcomes concerning functional status and reduced recurrence rates. However, synovial cysts are more likely to recur if the underlying joint instability is not addressed during the initial surgery[11]. The post-operative outcomes with surgical intervention are usually good according to the literature review[8,9,17].

CONCLUSION

Ganglion cysts, originating from periarticular tissues, are typically found in peripheral joints can also occur in or around the spinal canal, potentially causing radiculopathy or myelopathy. Surgical intervention is recommended for the removal of cysts that apply pressure on nerve roots to alleviate symptoms and prevent further complications.

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FIGURE AND FIGURE LEGENDS

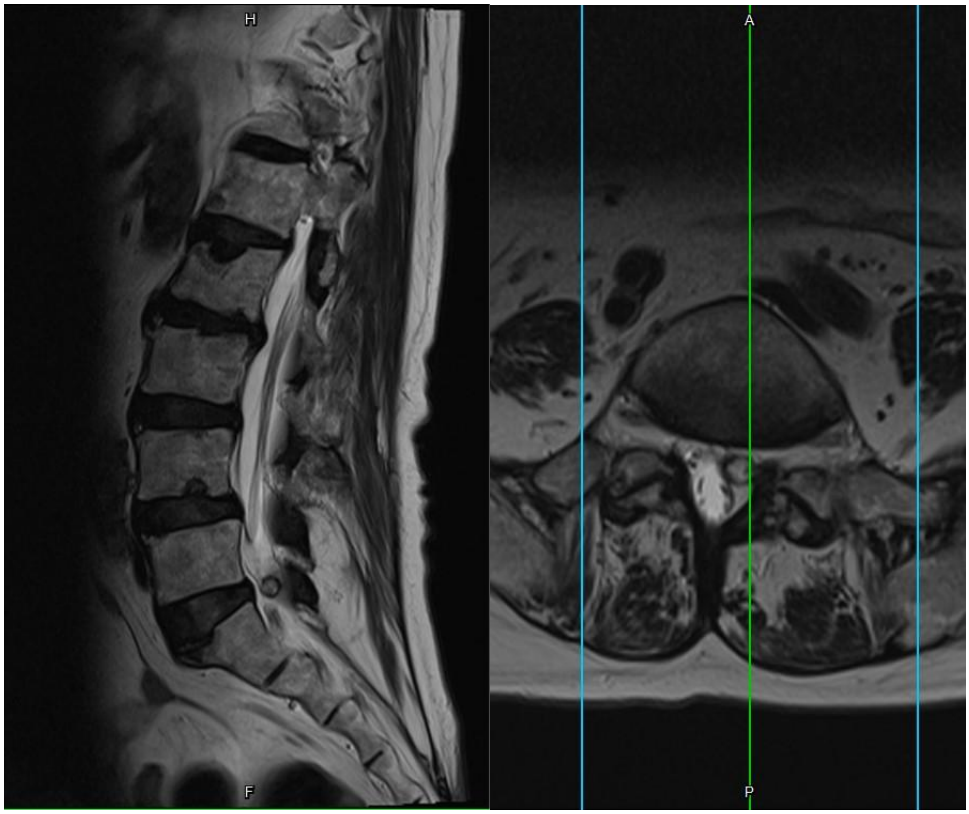

Figure 1. Magnetic resonance images showing a cystic lesion at the lumbar 5-Sacrum 1 level in a T2-weighted image. Sagittal view (left), Axial view(right) image showed a cystic lesion showed compression to the dura sac at the left side epidural space.

Figure 2. Magnetic resonance images also showing a cystic lesion at the lumbar 5-Sacrum 1 level in a T1-weighted image. Sagittal view (left), Axial view(right) image showed a hypointense cystic lesion.

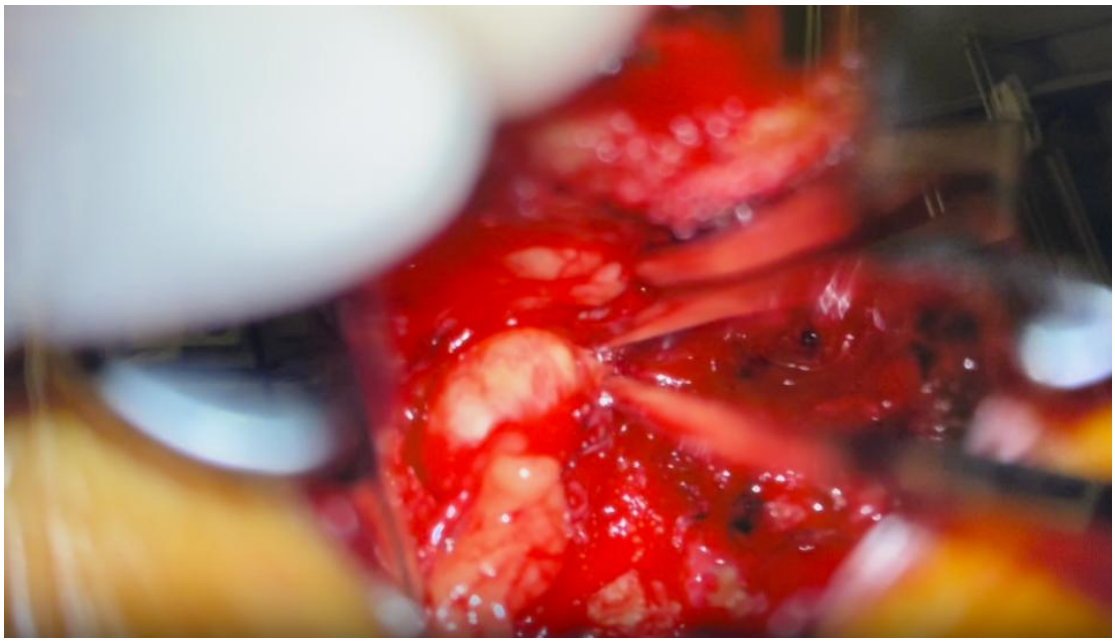

Figure 3. Lesion gross appearance under microscope

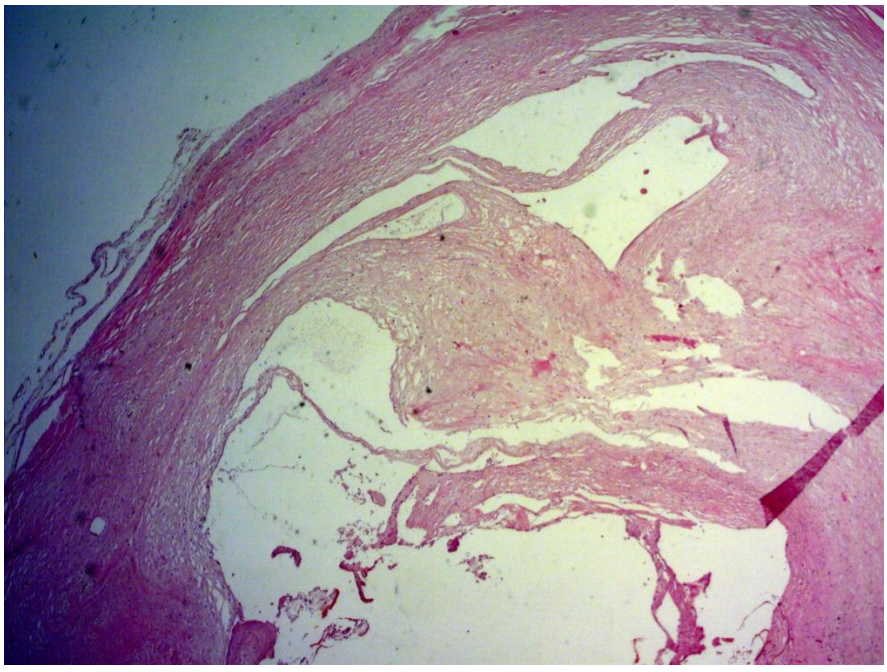

Figure 4. The cyst with fibrous wall and without specialized lining cells

Lumbar radiculopathy caused by ganglion cyst: Case report

神經節囊腫引起的腰椎神經根病變：病例報告

李佳翰[1]　蔡明達[1,2,]　李進成[3,*]

中文摘要

囊性病變之病灶常見於周邊關節，在脊椎內不常見。隨著這些囊腫的增長，特別是與退化相關時，它們可能壓迫附近的神經組織造成病變。本文報告一例腰椎神經節囊腫的病例，並討論臨床、放射學和手術方面的發現。一名 56 歲的女性患者出現持續的下背部疼痛。在三個月內，不適感從臀部延伸至雙腿，主要在左側。腰椎核磁共振影像顯示在的脊椎腔內，有一個囊性病變。在知情同意的情況下，安排手術切除腰椎第五薦椎第一左側椎間黃韌帶以及硬膜外囊性病變，術後病患的疼痛完全消失，神經根功能恢復正常。組織學檢查顯示具有膠原纖維壁的囊腫，缺乏滑膜內皮細胞，符合神經節囊腫的診斷。

關鍵字：脊椎囊性病變、神經節囊腫、滑液膜囊腫、下背痛、腰椎神經根病變

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