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ORIGINAL ARTICLE

Prediction of severe neurogenic bowel dysfunction in persons with spinal cord injury

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Study design: Cross-sectional study.
Objective: To analyze the predictors of severe neurogenic bowel dysfunction (NBD) in persons with spinal cord injury (SCI).
Setting: The Kaohsiung Medical University Hospital, Taiwan.
Methods: Two questionnaires—the NBD score and the Beck Depression Inventory second edition—were sent to 232 persons with SCI by mail. The demographic factors and injury-related factors were recorded to evaluate any relationships with severe NBD. The associations between the severity of NBD and psychological condition were also measured.
Results: In all, 39.4% of the respondents suffered from severe NBD. Multiple logistic regression analysis showed that those with a cervical injury (odds ratios (OR) = 10.5, 95% confidence interval (CI) 1.6–67.7) or a thoracic injury (OR = 7.1, 95% CI 1.2–40.3) had a higher risk of severe NBD than those with a lumbar injury. Persons with American Spinal Injury Association (ASIA) A had a 12.8-fold higher risk of severe NBD than persons with ASIA D (OR = 12.8, 95% CI 3.3–50.1). Longer duration of injury (≥10 years) was another risk factor of severe NBD. Moderate-to-severe depression was associated with reduced bowel function.
Conclusions: This study showed that high level of cord lesion, completeness of cord injury and longer duration of injury (≥10 years) could predict the severity of NBD in patients with SCI.
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Keywords: spinal cord injury; neurogenic bowel dysfunction; constipation; fecal incontinence; depression

Introduction

Neurogenic bowel dysfunction (NBD) is frequently devastating sequelae in patients with spinal cord injury (SCI) and can directly lead to major physical and psychological problems. In previous studies, more than 30% of patients with an SCI believed that bowel dysfunction was a greater problem than both bladder and sexual dysfunction.[1,2] Gore *et al*.[3] showed that NBD is the most common cause for hospitalization in the chronic stage of SCI. Clearly, NBD is of paramount importance to patients with SCI as it is regarded as one of their greatest disabilities.[4]

Traditional questionnaires and means of assessing bowel dysfunction were not always appropriate for SCI patients because the tests could not always adequately evaluate the simultaneous presence of the participants' constipation and fecal incontinence.[5,6] Krogh *et al*.[7] developed and validated a more advanced clinical assessment known as the 'NBD score', which allows quantitative measurement of the severity of a neurogenic bowel. This score makes it possible to accurately evaluate the bowel condition in persons with an SCI and has been shown to have acceptable validity and reproducibility for persons who suffered from either constipation and fecal incontinence or a combination of both.

A previous study revealed that persons with more severe neurogenic bowel conditions were found to have worse quality of life.[8] Krause and Kjorsvig[9] pointed out that quality of life is a good predictor of survival 15 years after injury. In addition, Furlan *et al*.[10] also showed that for patients with severe NBD refractory to conservative bowel management, early reassessment is necessary because it can offer beneficial information and prompt consideration of a surgical option. Therefore, it is important to know thoroughly what factors may lead to severe NBD.

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The aim of this study is to determine whether the severity of NBD is associated with gender, age, level of lesion, severity of cord injury, duration of injury, cause of injury, marital status, employment and educational level. In addition, the associations between psychological condition (depression) and severity of NBD are also analyzed.

Materials and methods

Participants

This study was approved by the research ethics committee of Kaohsiung Medical University Hospital before participants were collected. We reviewed the spine database at Kaohsiung Medical University Hospital in Taiwan to identify people who were admitted to the rehabilitation department and were diagnosed with an SCI between 2002 and 2008. A total of 254 cases were collected. Patients below the age of 13 and patients with the following conditions were excluded: being diagnosed with cognition impairment; having to use mechanical ventilation; and having suffered from SCI for <1 year (to avoid spinal shock status). In the end, no one under 18 years of age participated in the final study.

In total, 232 persons who met the criteria were recruited and contacted by mail. They were sent the NBD score and the Beck Depression Inventory second edition (BDI-II). Their demographic variables (including age, gender, marital status, employment and educational level) as well as injury-related variables (such as level of lesion, severity of cord injury, duration of injury and cause of injury) were also collected through questionnaire. In addition, each person contacted was given a consent form and an information sheet explaining the purpose and procedure of the research. The response was excluded if it lacked a valid consent form. The respondents were requested to post back these two questionnaires and the consent form together—not entirely anonymous.

Measures

The NBD score, which is symptom based, consists of 10 items: frequency of defecation (0–6 points), time taken for each defecation (0–7 points), headache or perspiration during defecation (0–2 points), regular use of tablets or drops against constipation (0–2 points each), frequency of digital stimulation or evacuation (0–6 points), frequency of fecal incontinence (0–13 points), medication against fecal incontinence (0–4 points), flatus incontinence (0–2 points) and perianal skin condition (0–3 points). The overall NBD score is between 0 and 47 points. A higher score indicates more severe bowel dysfunction. Finally, the severity of NBD can be divided into four grades based on the scores: very minor NBD (0–6); minor NBD (7–9); moderate NBD (10–13); and severe NBD (score $\geqslant$14).

The BDI-II, which has shown sensitivity and reliability, is one of the most widely used instruments for measuring the severity of depression.[11] It is appropriate for people over 13 years of age. Respondents' depressive conditions were measured by the BDI-II traditional Chinese version. This score covers 21 items including: sadness, pessimism, experience of failure, guilt, feelings of being published, dissatisfaction, dislike of one's self, self-accusation, thoughts regarding suicide, crying, agitation, loss of pleasure, indecisiveness, loss of energy, change in sleep, change in appetite, poor concentration, fatigue, lack of interest in sex, feelings of being valueless and being angered easily. Each item has a score from 0 to 3. The total score ranges from 0 to 63, with higher scores indicating a greater level of a depressive mood. The total score can be further categorized into four grades: normal (0–13); mild depression (14–19); moderate depression (20–28); and severe depression (29–63).

Data analysis

The analysis of all the data were performed with SPSS version 14.0. The distributions and relationships between the NBD scores and the demographic/injury-related variables were analyzed by χ^2 tests with a P-value of <0.05 representing statistical significance. The logistic regressions were used to compute odds ratios (OR) and a 95% confidence interval (CI) to identify the risk factors associated with severe NBD (NBD score $\geqslant$14). Significant variables in the univariate analysis were further analyzed with a multivariate analysis. These analyzed variables included gender, age, severity of cord injury, level of injury, duration of injury, cause of injury, marital status, employment and educational status. Furthermore, simple (univariate) and multiple (multivariate) linear regression analyses were used to evaluate the influence of the psychological condition (BDI-II score) on the severity of NBD (NBD score). A P-value of <0.05 was considered to be significant.

Results

A total of 142 respondents whose age ranged from 18 to 84 years (mean 45. 2) were recruited into this study. In all, 106 were men (74.6%) and 36 were women (25.4%). The background characteristics of the participants are presented in Table 1. The severity of cord injury was divided into four groups based on the American Spinal Injury Association (ASIA) neurological classification.[12] The main causes of injury were vehicular accidents (42.9%), falls (28.2%), sports (6.3%) and violence (3.5%). Other causes of SCI (19.1%) included spinal cord infection, spinal artery occlusion, spinal arteriovenous malformation and surgical complications.

Associations of NBD with injury-related variables

Table 2 illustrates the distributions and relationships between the severity of NBD and injury-related variables in persons with an SCI. Overall, 56 persons (39.4%) with an SCI suffered from a severe degree of NBD. Nearly, 71% of the patients in the ASIA A group suffered from severe NBD, while roughly half of the patients (48.6%) in the ASIA D group had only a very minor degree of NBD ($P=0.001$). There were also significant differences between the level of injury and the severity of the NBD score. Many more patients with cervical or thoracic lesion had severe NBD ($P=0.012$) compared with those with a lumbar lesion. Patients with SCI for 10 years or

Table 1 Demographic characteristic of participants

	Patients (n)	*Percentage (%)*
Severity of injury		
ASIA A	38	26.8
ASIA B	34	23.9
ASIA C	33	23.2
ASIA D	37	26.1
Level of injury		
Cervical	56	39.4
Thoracic	65	45.8
Lumbar	21	14.8
Duration of injury		
1–2 years	42	29.6
3–5 years	31	21.8
6–9 years	23	16.2
⩾10 years	46	32.4
Cause of injury		
Vehicular	61	42.9
Falling down	40	28.2
Sports	9	6.3
Violence	5	3.5
Others	27	19.1
Marital status		
Single	65	45.8
Married	48	33.8
Divorced/widowed	29	20.4
Employment		
Employed	48	33.8
Unemployed	94	66.2
Educational status		
Middle school	27	19.1
High school	49	34.4
College	39	27.4
University and above	27	19.1

Abbreviation: ASIA, American Spinal Injury Association.

more also had a higher percentage (53.3%) of severe NBD and had worse bowel function ($P=0.042$).

Associations of NBD with demographic variables

The participants were divided into four subgroups according to age. Table 3 shows their distributions across various NBD severities. In all, 50% of the participants in the oldest age group (⩾65 years) suffered from severe NBD. There is a significant difference toward a rise in severe cases of NBD as the participants age increases ($P=0.045$). Except for age, there was no significant association of NBD with other demographic variables, such as gender, marital status, employment and educational level in this study.

Factors for predicting severe NBD in patients with SCI

The results of the logistic regression analysis (univariate vs multivariate) are shown in Table 4. In the univariate logistic regression, severe NBD is associated with old age (⩾65 years), level of injury, severity of injury and duration of injury (⩾10 years). After the multiple logistic regression analysis, severe NBD is still associated with the level of injury (cervical:

Table 2 Distributions and relationships between NBD score and injury-related variables

		Very minor	*Minor*	*Moderate*	*Severe*	$\chi 2$
		(NBD 0–6)	*NBD (7–9)*	*NBD (10–13)*	*NBD (⩾14)*	P-*value*
	Total	n *(%)*	n *(%)*	n *(%)*	n *(%)*	
Severity of injury						
ASIA A	38	3 (7.9)	2 (5.2)	6 (15.8)	27 (71.1)	0.001
ASIA B	34	6 (17.6)	6 (17.6)	11 (32.4)	11 (32.4)	
ASIA C	33	14 (42.4)	9 (27.3)	2 (6.1)	8 (24.2)	
ASIA D	37	18 (48.6)	5 (13.5)	4 (10.8)	10 (27.1)	
Level of injury						
Cervical	56	13 (23.2)	10 (17.9)	6 (10.7)	27 (48.2)	0.012
Thoracic	65	15 (23.1)	9 (13.8)	15 (23.1)	26 (40.0)	
Lumbar	21	13 (61.9)	3 (14.3)	2 (9.5)	3 (14.3)	
Duration of injury						
1–2 years	42	16 (38.1)	8 (19.1)	5 (11.9)	13 (30.9)	0.042
3–5 years	31	11 (35.5)	4 (12.9)	6 (19.3)	10 (32.3)	
6–9 years	24	6 (25.0)	3 (12.5)	6 (25.0)	9 (37.5)	
⩾10 years	45	8 (17.8)	7 (15.6)	6 (13.3)	24 (53.3)	

Abbreviations: ASIA, American Spinal Injury Association; NBD, neurogenic bowel dysfunction.
The χ^2 test was used to investigate the relationships between NBD score and injury-related variables in patients with spinal cord injury ($n=142$).

Table 3 Distribution and relationship of NBD score across different age groups

		Very minor	*Minor*	*Moderate*	*Severe*	$\chi 2$
		(NBD 0–6)	*NBD (7–9)*	*NBD (10–13)*	*NBD (14)*	P-*value*
	Total	n *(%)*	n *(%)*	n *(%)*	n *(%)*	
Age (years)						
<35	17	6 (35.3)	3 (17.7)	4 (23.5)	4 (23.5)	0.045
35–49	65	21 (32.4)	11 (16.9)	9 (13.8)	24 (36.9)	
50–64	50	12 (24.0)	6 (12.0)	9 (18.0)	23 (46.0)	
⩾65	10	2 (20.0)	2 (20.0)	1 (10.0)	5 (50.0)	

Abbreviation: NBD, neurogenic bowel dysfunction.
The χ^2 test was used to investigate the NBD score in different age groups of patients with spinal cord injury ($n=142$).

OR = 10.5; $P=0.013$ and thoracic: OR = 7.1; $P=0.035$ when compared with lumbar). There also existed a greater association between severity of injury and more severe NBD. Patients who were in the ASIA A group had a 12.8-fold greater risk of severe NBD than those who were in ASIA D (OR = 12.8; $P<0.001$). In addition, patients who suffered from SCI for 10 years or more also had a higher risk of acquiring severe NBD than patients who suffered from SCI for only 1–2 years (OR = 2.3; $P=0.043$). Although old age (⩾65 years) seemed to be a possible factor for severe NBD in the univariate analysis, the effect of age was no longer significant in the multivariate analysis.

Associations of NBD with patients' psychological condition

With regard to the severity of depression in this study as assessed through the BDI-II score, 23 persons (16.2%)

Table 4 Logistic regressions of associated risk factors on severe NBD (NBD score14) in the sample of patients with spinal cord injury

Factors	*Univariate*			*Multivariate* [a]		
	Odds ratio (OR)	*95% CI (lower–upper)*	P-*value*	*Odds ratio (OR)*	*95% CI*	P-*value*
Age (years)						
<35	1			1		
35–49	1.2	(0.4–2.9)	0.372	1.2	(0.4–2.8)	0.874
50–64	1.9	(0.7–3.7)	0.647	1.8	(0.6–3.0)	0.589
⩾65	2.2	(1.2–8.4)	0.046	2.1	(0.9–7.3)	0.073
Severity of injury						
ASIA A	11.7	(3.9–34.5)	<0.001	12.8	(3.3–50.1)	<0.001
ASIA B	1.7	(0.6–5.1)	0.312	1.7	(0.8–5.3)	0.385
ASIA C	1.2	(0.4–3.5)	0.794	1.3	(0.5–3.2)	0.961
ASIA D	1			1		
Level of injury						
Cervical	8.2	(1.8–38.7)	0.008	10.5	(1.6–67.7)	0.013
Thoracic	7.2	(1.5–33.5)	0.012	7.1	(1.2–40.3)	0.035
Lumbar	1			1		
Duration of injury						
1–2 years	1			1		
3–5 years	1.2	(0.4–2.7)	0.978	1.1	(0.4–3.8)	0.752
6–9 years	1.2	(0.4–3.2)	0.855	1.1	(0.8–3.6)	0.113
⩾10 years	2.7	(1.1–5.6)	0.037	2.3	(1.1–5.4)	0.043

Abbreviations: ASIA, American Spinal Injury Association; CI: confidence interval; NBD, neurogenic bowel dysfunction.
[a]Stepwise selection.

Table 5 The influence of psychological condition (depressive status) on NBD score in the sample of patients with spinal cord injury

	Univariate			*Multivariate*[a]		
	95% confidence interval			*95% confidence interval*		
	Unstandardized coefficient B	(*Lower–upper)*	P-*value*	*Unstandardized coefficient B*	(*Lower–upper)*	P-*value*
BDI-II score (0–63)	0.4	(0.2–0.5)	<0.001	0.3	(0.1–0.5)	<0.001
BDI-II grades						
Normal	Reference			Reference		
Mild	0.7	(−3.9–4.3)	0.765	1.3	(−3.3–5.8)	0.591
Moderate	6.2	(1.7–10.7)	0.008	5.2	(0.4–10.0)	0.033
Severe	8.4	(4.8–12.0)	<0.001	7.4	(3.7–11.5)	<0.001

Abbreviation: NBD, neurogenic bowel dysfunction.
[a]Adjusted by age, severity of injury, level of injury and duration of injury.

did not present with the features associated with depression; 39 persons (27.5%) showed the features of mild depression; 32 persons (22.5%) fit the features of moderate depression; and 48 persons (33.8%) presented with the features associated with severe depression. Table 5 illustrates the influence of the psychological condition (BDI-II score) on the severity of NBD (NBD score) in people with an SCI. Adjusting for age, severity of injury, level of injury and duration of injury, the unstandardized coefficient B is 0.3, meaning that the NBD score will increase 0.3 points for each one point gain in the BDI-II score. In addition, compared with those with no sign of depression, the patients presenting with moderate and severe depression had a significantly increased NBD score (unstandardized coefficient B = 5.2 and 7.4, respectively), which means they have worse bowel function and suffer from a higher risk of acquiring more severe NBD.

Discussion

It is known that an SCI can impede the normal physiologic pathways of the gastrointestinal tract and lead to many bowel problems such as decreased colonic motility, delayed gastric emptying time, abnormal colonic myoenteric movement, difficulty with defecation and fecal incontinence.[13] A previous study found that patients with higher tetraplegia had the highest prevalence of bowel problems compared with patients with lower paraplegia.[14] Lynch *et al.*[15] also reported that the level of the spinal cord lesion determines

the effect on colonic motility, and cervical injuries can result in more remarkable constipation, abdominal distention and discomfort. From the results of our study, we can clearly see that cervical and thoracic level of injury carry a higher risk of severe NBD than lumbar level injury (OR = 10.5 and 7.1, respectively) and the severity of bowel dysfunction is strongly associated with the level of cord injury. This may well be because lack of both thoracic sympathetic innervations and sacral parasympathetic control can contribute to more serious NBD.[16]

Although Kirshblum *et al*.[17] pointed out that bowel dysfunction was not related to the neurologic severity of injury in chronic SCI patients, Table 4 shows that patients who were ASIA A had a 12.8-fold greater risk of severe NBD than those who were ASIA D (OR = 12.8, $P<0.001$). However, there were no significant differences between the ASIA B and ASIA C groups compared with the ASIA D group in this study. This means that completeness of cord injury appears to carry a higher risk of acquiring severe NBD than incompleteness of cord injury, suggesting completeness of cord injury would be a risk factor in severe NBD.

Previous studies showed that colorectal dysfunction after SCI worsens as time goes by.[1,2] In this study, we found that there was a correspondence between the incidents of severe NBD and increased duration of injury. Longer duration of injury ($\geqslant$10 years) appears to be another apparent risk factor for severe NBD. As a result, appropriate bowel care and bowel management would be more important for chronic SCI patients to guard against the potential for more serious bowel problems.

A previous study showed that older patients seemed to have worse neurological recovery than young patients.[18] Madsen and Graff[19] also found that the colonic transit was delayed in the older group and that older individuals had a slower colonic transit than young individuals ($P=0.008$). In this study, old age ($\geqslant$65 years) was a factor for severe NBD in the univariate analysis, however, the effect of old age became no longer significant in multivariate analysis. The effect of old age might be confounded by duration because the older patients are more likely to suffer from SCI for 10 years or more.

It is difficult to disentangle whether a bowel problem was a cause of depressive symptoms or whether more serious depressive symptoms led to worse bowel dysfunction. In this study, patients with an apparently more serious depressive status had higher NBD scores. This suggests that there is a significant correlation between NBD and the patient's psychological condition. Moderate-to-severe depression may have an effect on bowel function in patients with an SCI,[20] and support for their psychological state may potentially lead to a decrease in their bowel-related symptoms.

There are a number of limitations to our study. First, the BDI-II is only appropriate for people aged 13 years or above, so patients younger than 13 years had to be excluded from this study, thus creating a possible bias. In the end, no one under the age of 18 participated. Second, these respondents, who agreed to participate in this study, had to sign their names on the consent form, meaning the questionnaires, which accompanied these forms could not be kept anonymous. As a result, some patients may have answered questions toward perceived expectations, potentially misrepresenting and underestimating the severity of bowel dysfunction and depression. Hence, some of the nonsignificant factors may also be important to severe NBD. Third, there were no therapeutic interventions or recommendations for improving bowel dysfunction in this study. A worthy goal may be an attempt to discover methods, which could reduce these risk factors and relieve bowel discomfort of SCI patients in the future. However, our findings did clarify the risk factors of severe NBD and the associations of these risk factors with the severity of NBD, providing a useful initial stage toward future progress.

Conclusion

This study shows that bowel problems are very common in patients with an SCI and approximately 40% of respondents suffered from a severe degree of NBD. High level of injury, completeness of cord injury and SCI for 10 years or more were risk factors for severe NBD. Patients with moderate-to-severe depression also had a higher risk of developing severe NBD.

Conflict of interest

The authors declare no conflict of interest.

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