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Evaluation of Serum Lipid Levels in Patients with Chronic Spinal Cord Injury

Kronik Omurilik Yaralanmalı Hastalarda Serum Lipid Seviyelerinin Değerlendirilmesi

Arzu Atıcı

ABSTRACT

Objectives: The present study is intended to evaluate serum lipid levels in patients with spinal cord injury (SCI) and to investigate the factors affecting lipid levels.

Methods: A total of 96 patients with SCI who were followed up in our Physical Medicine and Rehabilitation Clinic between 2018 and 2023 were included in this retrospective study. The American Spinal Injury Association Impairment Scale, Functional Ambulation Categories (FAC), SCI Spasticity Evaluation Tool and Spinal Cord Independence Measure, version III (SCIM III) assessments of the included patients were obtained from patient files and recorded. Serum total cholesterol (TC), low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c), triglyceride (TG) levels, and TC/HDL-c ratios were evaluated.

Results: Among the patients included, 41.7% had TC over 200 mg/dL, 32.3% had LDL-c over 130 mg/dL, 47.9% had HDL-c below 40 mg/dL, and 41.7% had a TC level above 150 mg/dL. In 29.2% of patients, the TC/HDL ratio was 4.5 or higher. 74 patients (77.1%) had an abnormality in at least one lipid profile. Male patients with SCI had lower HDL-c levels and higher TG levels and TC/HDL-c ratios than female SCI patients ($p<0.05$). There was a statistically significant correlation between TC and LDL-c and Body mass index (BMI) and FAC ($p<0.05$). HDL-c was significantly correlated with the duration of SCI, FAC, and SCIM III total score ($p<0.05$). There was a significant correlation between TG levels and BMI only ($p<0.05$). There was a statistically significant positive correlation between TC/HDL-c ratio and BMI and a negative correlation between the duration of SCI and SCIM III total score ($p<0.05$).

Conclusion: Dyslipidemia was present in the majority of patients with SCI. Dyslipidemia rates were higher in the group of male patients. There was a correlation between lipid levels and BMI, SCI duration, independence levels, and ambulation degrees.

Keywords: Dyslipidemia; lipid profile; spinal cord injury.

ÖZET

Amaç: Bu çalışmanın amacı, omurilik yaralanmalı hastalarda serum lipid seviyelerini değerlendirmek ve lipid seviyelerini etkileyen faktörleri araştırmaktır.

Yöntem: Bu retrospektif çalışmaya Fiziksel Tıp ve Rehabilitasyon Kliniğimizde 2018-2023 yılları arasında takipli olan toplam 96 omurilik yaralanmalı hasta dahil edildi. American Spinal Injury Association Bozukluk Skalası (ABS), Fonksiyonel Ambulasyon Sınıflaması (FAS), Omurilik Yaralanması Spastisite Değerlendirme Ölçeği (SCI-SET) ve Omurilik Bağımsızlık Ölçeği-III (SCIM-III) puanları hasta dosyalarından kaydedildi. Serum total kolesterol (TC), düşük yoğunluklu lipoprotein kolesterol (LDL-c), yüksek yoğunluklu lipoprotein kolesterol (HDL-c), trigliserid (TG) seviyeleri ve TC/HDL-c oranları değerlendirildi.

Bulgular: Hastaların TC seviyeleri 200 mg/dL'nin üzerinde olanlar %41,7, LDL-c 130 mg/dL'nin üzerinde olanlar %32,3, HDL-c 40 mg/dL'nin altında olanlar %47,9, TG 150 mg/dL'nin üzerinde olanlar %41,7 idi. Hastaların %29,2'sinde ise TC/HDL oranı 4,5 ve üzerindeydi. Yetmiş dört hastamızın (%77,1) en az bir lipid profilinde anormallik vardı. Erkek omurilik yaralanmalı hastalarda kadınlara göre HDL-c seviyeleri daha düşük, TG seviyeleri ve TC/HDL-c

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oranları daha yüksekti (p<0,05). TC ve LDL-c ile beden kitle indeksi (BKİ) ve FAS arasında istatistiksel olarak anlamlı bir korelasyon saptandı (p<0,05). HDL-c ile omurilik yaralanması süresi, FAS ve SCIM-III total puanı ile istatistiksel olarak anlamlı korelasyon bulundu (p<0,05). TG seviyeleri ile sadece BKİ arasında anlamlı korelasyon mevcuttu (p<0,05). TC/HDL-c oranı ile BKİ arasında pozitif yönde, omurilik yaralanması süresi ve SCIM-III total skoru ile de negatif yönde istatistiksel olarak anlamlı korelasyon saptandı (p<0,05).

Sonuç: Omurilik yaralanmalı hastaların büyük kısmında dislipidemi görüldü. Erkek hastalarda dislipidemi oranları daha fazlaydı. Lipid seviyeleriyle BKİ, omurilik yaralanması süresi, bağımsızlık seviyeleri ve ambulasyon dereceleri arasında ilişki mevcuttu.

Anahtar sözcükler: Dislipidemi; lipid profili; omurilik yaralanması.

Although medical care after spinal cord injury (SCI) has improved, the mortality rate in this group of patients is reported to be higher than in the general population of the same age group.[1] In addition, data published in recent years show that cardiovascular disease (CVD) has emerged as the leading cause of death in chronic SCI.[2] Therefore, attention to cardio-metabolic risk is becoming increasingly important in the care of individuals with SCI.[3]

Leading contributors to the increased CVD risk in SCI are the relatively higher prevalence of risk factors such as dyslipidemia, obesity, and diabetes in these patients.[3] Dyslipidemia is a major, independent, modifiable risk factor for CVD. It has been shown that cardiovascular morbidity and mortality rates decrease when dyslipidemia is treated effectively.[4]

There are studies reporting increased levels of low-density lipoprotein cholesterol (LDL-c) and total cholesterol (TC) in individuals with SCI compared to healthy individuals, as well as other studies reporting lower serum lipid levels.[5-11] These results suggest that there are different mechanisms involved in lipid metabolism in patients with SCI. In our study, therefore, we aimed to evaluate serum lipid profiles in SCI patients and to investigate the factors affecting lipid levels.

Methods

In the current study, patients who were followed up in our hospital's Physical Medicine and Rehabilitation Clinic between 2018 and 2023 were retrospectively examined. SCI patients aged ≥18 years with an injury duration of at least 1 year were included in the study. Those with malignant or other diseases affecting nutrition or lipid profile, and those with neurologic diseases other than SCI causing motor deficits or gait disturbances were excluded from the study. Demographic data, American Spinal Injury Association Impairment Scale (AIS), Functional Ambulation Categories (FAC), SCI Spasticity Evaluation Tool (SCI-SET) and Spinal Cord Independence Measure, version III (SCIM III) scores were recorded from the patients' files. TC, low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c), and triglyceride (TG) levels were recorded from the tests performed in the last 6 months. TC/HDL-c ratios were calculated. The ratio of serum TC to HDL-c (TC/HDL-c) has been reported to be a strong indicator of CVD risk.[12,13] The patients were examined for the presence of dyslipidemia using guidelines from the National Cholesterol Education Project Adult Treatment Panel III (ATP III). TC ≥200 mg/dl, HDL-c <40 mg/dL, LDL-c ≥130 mg/dL, and TGs ≥150 mg/dL were defined as dyslipidemia.[14] AIS is the most widely accepted scale used to assess the severity of injury in patients with SCI, classifying from A to E. AIS A: complete lesion. No sensory or motor function is preserved in sacral segments S4–S5. AIS B: sensory but no motor function is preserved below the neurological level and includes the sacral segments S4–S5, and no motor function is preserved more than three levels below the motor level on either side of the body. AIS C: motor function is preserved below the neurological level, and more than half of the key muscle functions below the single neurological level of injury have muscle grades 0–2. AIS D: motor function is preserved below the neurological level, and at least half or more of the key muscle functions below the neurological level of injury have a muscle grade >3. AIS E: sensation and motor function are recorded as normal in all segments.[15]

FAC is a scale that assesses the ambulation ability of patients. Its classification consists of six categories from 0 to 5. Category 0 refers to non-functional ambulation and category 5 refers to complete independence in ambulation.[16]

SCI-SET was developed by Adams et al.[17] to measure the effect of spasticity on daily life in patients with SCI. It consists of 35 questions and assesses both the positive and negative effects of spasticity on daily activities that patients perform. Reliability and cross-cultural adaptation of the Turkish version were performed by Akpinar et al.[18]

SCIM III is an independent scale developed for patients with SCI. It is a 17-item scale with three subscales: self-care, respiratory and sphincter control, and mobilization. Higher scores indicating a higher level of independence.[19] The validity and reliability study of its Turkish version was conducted by Kesiktas et al.[20]

All procedures were conducted in accordance with the Helsinki Declaration and the study protocol was approved by the institutional Ethics Committee of our hospital Fatih Sultan Mehmet Training and Research Hospital (FSMEAH-KAEK, 2023/89).

Statistical Analysis

IBM SPSS Statistics 22 (IBM SPSS, Türkiye) program was used for statistical analyses while assessing the findings obtained in the study. The conformity of the parameters to normal distribution was evaluated by Shapiro Wilks test. Student's t-test was used for the comparison of normally distributed parameters between the two groups and Mann–Whitney U test was used for the comparison of non-normally distributed parameters. Pearson correlation test was used for normally distributed parameters and Spearman correlation test was used for non-normally distributed parameters. For multivariate analysis, linear regression analysis was performed using the Backward stepwise method. P<0.05 was considered statistically significant.

Results

The present study included 96 SCI patients. Of the patients, 34 (35.4%) were female and 62 (64.6%) were male. The mean age was 49.6±14.1 years. Table 1 shows the demographic data, AIS, FAC, SCI-SET, and SCIM III levels of the patients.

Among the patients, 41.7% had TC over 200 mg/dL, 32.3% had LDL-c over 130 mg/dL, 47.9% had HDL below 40 mg/dL, 41.7% had a level of TGs above 150 mg/dL, and 29.2% had TC to HDL-c ratio of 4.5 and above (Table 2). There were 74 patients (77.1%) with at least one lipid profile abnormality.

When patients with SCI were evaluated in terms of gender, HDL-c levels were statistically significantly lower in men than in women, while TG levels and TC/HDL-c ratios were statistically significantly higher in men (p<0.05) (Table 3).

When the patients were divided into 2 groups as motor complete (AIS A and B) and motor incomplete (AIS C and D), no statistically significant difference was found between the groups in terms of TC, LDL-c, HDL-c, TG, and TC/HDL-c ratio (p>0.05) (Table 4). When the patients were compared dividing them into two groups of paraplegia and tetraplegia, no statistically significant difference was found in terms of lipid profiles between the groups (p>0.05) (Table 5).

Table 1. Demographic data and general characteristics of the patients

Sex, n (%)	
Female	34 (35.4)
Male	62 (64.6)
Age (year)	
Mean±SD	49.6±14.1
Min-Max	23-78
BMI (kg/m^2)	
Mean±SD	25.6±4.0
DM (n) (%)	15 (15.6)
Hypertension (n) (%)	14 (14.6)
Hyperlipidemia (n) (%)	11 (11.6)
Duration of spinal cord injury (year)	
Mean±SD	8.5±7.3
Median (Min-Max)	6 (1-32)
Spinal cord injury levels n (%)	
Cervical	24 (25)
Thoracal	63 (65.6)
Lumbosacral	9 (9.4)
Paraplegia/Tetraplegia n (%)	
Paraplegia	72 (75)
Tetraplegia	24 (25)
AIS n (%)	
A	23 (24)
B	20 (20.8)
C	18 (18.8)
D	35 (36.5)
Motor completeness (n) (%)	
Motor complete (AIS A,B)	43 (44.8)
Motor incomplete (AIS C,D)	53 (55.2)
FAC	
Mean±SD	1.8±1.9
Median (Min-Max)	1 (0–5)
SCIM III (Mean±SD)	
Self-care	13.7±6.3
Respiration and sphincter	27.7±9.6
Mobility	18.5±11.9
Total score	59.6±24.7
SCI-SET (Mean±SD)	−0.64±0.69

AIS: ASIA (American Spinal Cord Injury Association) Impairment Scale; BMI: Body mass index; DM: Diabetes mellitus; FAC: Functional Ambulation Categories; SCI-SET: Spinal Cord Injury Spasticity Evaluation Tool; SCIM III: Spinal Cord Independence Measure, version III.

Table 2. The incidence of dyslipidemia in patients

	n (%)
TC ≥ 200 mg/dL	40 (41.7)
LDL-c ≥130 mg/dL	31 (32.3)
HDL-c <40 mg/dL	46 (47.9)
TG ≥150 mg/dL	40 (41.7)
TC/HDL-c ≥4.5	28 (29.2)

HDL-c: High density lipoprotein cholesterol; LDL-c: Low-density lipoprotein cholesterol; TC: Total cholesterol; TG: Triglyceride.

Table 3. Comparison of lipid profiles according to gender of patients

	Female (n=34) (Mean±SD)	Male (n=62) (Mean±SD)	p
TC mg/dL	181.8±49.8	189.0±43.5	0.481
LDL-c mg/dL	108.3±39.3	114.9±34.2	0.410
HDL-c mg/dL	47.7±16.2	39.2±9.2	0.014*
TG mg/dL	136.3±85.6	167.5±78.6	0.015*
TC/HDL-c	3.2±2.0	4.6±2.6	0.006*

HDL-c: High density lipoprotein cholesterol; LDL-c: Low-density lipoprotein cholesterol; TC: Total cholesterol; TG: Triglyceride. *p<0.05.

Table 4. Comparison of lipid profiles of patients with motor complete and motor incomplete SCI

	Motor complete (n=43) (Mean±SD)	Motor incomplete (n=53) (Mean±SD)	p
TC mg/dL	184.4±45.7	191.3±45.6	0.249
LDL-c mg/dL	111.4±36.3	113.6±36.1	0.768
HDL-c mg/dL	39.3±10.1	44.6±14.2	0.103
TG mg/dL	149.6±77.9	162.0±85.6	0.593
TC/HDL-c	4.2±2.3	4.1±2.6	0.578

HDL-c: High density lipoprotein cholesterol; LDL-c: Low-density lipoprotein cholesterol; TC: Total cholesterol; TG: Triglyceride. *p<0.05.

Table 5. Comparison of lipid profiles of paraplegic and tetraplegic patients

	Paraplegia (n=72) (Mean±SD)	Tetraplegia (n=24) (Mean±SD)	p
TC mg/dL	190.7±46.2	173.4±42.6	0.108
LDL-c mg/dL	115.4±36.7	104.1±33.1	0.185
HDL-c mg/dL	43.6±13.5	38.1±9.1	0.108
TG mg/dL	155.0±81.5	160.8±85.4	0.899
TC/HDL-c	4.1±2.4	4.3±2.6	0.122

HDL-c: High density lipoprotein cholesterol; LDL-c: Low-density lipoprotein cholesterol; TC: Total cholesterol; TG: Triglyceride. *p<0.05.

When the relationship between serum lipid levels and age, body mass index (BMI), injury duration, AIS, injury level, FAC, SCIM III total score, and SCI-SET was analyzed a statistically significant positive correlation was found between TC and LDL-c with BMI and FAC ($p<0.05$). There was a statistically significant positive correlation between HDL-c and duration of SCI, FAC, and SCIM III total score ($p<0.05$). There was a significant correlation between TG levels and BMI only ($p<0.05$). There was a statistically significant positive correlation between TC/HDL-c and BMI and a negative correlation between the duration of SCI and SCIM III total score ($p<0.05$) (Table 6).

When evaluated by linear regression analysis, the effect of BMI and FAC on TC was found to be of statistical significance ($p<0.05$). In the regression analysis for LDL-c, the effect of BMI was statistically significant, but the effect of FAC was not statistically significant. The effect of SCI duration and FAC on HDL-c level and the effect of BMI and SCIM III total score on TC/HDL-c ratio was statistically significant ($p<0.05$) (Table 7).

Discussion

In this study investigating lipid levels in patients with SCI, dyslipidemia was present in 77.1% of the patients. Male SCI patients had lower HDL-c levels and higher TG levels and TC/HDL-c ratios than female SCI patients. In addition, we found that BMI, duration of SCI, level of independence, and degree of ambulation were found to affect lipid levels.

Vichiansiri et al.[21] found at least one lipid profile abnormality in 76.7% of patients with SCI. Similarly, in our study, 77.1% of our patients had at least 1 lipid profile abnormality. In a meta-analysis, it was reported that 29.1% had LDL-c elevation, 46.1% had low HDL-c levels, and 36.5% had TG elevation in Türkiye.[4] In this study, 32.3% had LDL-c elevation, 47.9% had low HDL-c levels, and 41.7% had TG elevation. Rates were slightly higher than in the general population. Catecholamines are the main regulators of lipolysis plasma hormones in humans. As a result of the interruption of the sympathetic nervous system in patients with SCI, changes in catecholamine concentrations may occur during rest and exercise depending on the level of injury. There may be a decrease in lipolysis and an increase in dyslipidemia due to decreased activity of the sympathetic nervous system. Consequently, this contributes to cardiovascular and metabolic changes.[22,23]

Table 6. Correlation between serum lipid levels and age, BMI, injury duration, AIS, injury level, FAC, SCIM III total score and SCI-SET

	TC	LDL-c	HDL-c	TG	TC/HDL-c
Age					
r (p)	NS	NS	NS	NS	NS
BMI	0.262	0.231	NS	0.262	0.257
r (p)	(0.010)*	(0.024)*		(0.010)*	(0.012)*
Duration of SCI	NS	NS	0.229	NS	-0.296
r (p)			(0.025)*		(0.003)*
AIS	NS	NS	NS	NS	NS
Level of injury	NS	NS	NS	NS	NS
FAC	0.238	0.206	0.202	NS	NS
r (p)	(0.020)*	(0.44)*	(0.049)*		
SCIM-III total	NS	NS	0.214	NS	-0.274
r (p)			(0.036)*		(0.007)*
SCI-SET					
r (p)	NS	NS	NS	NS	NS

AIS: ASIA (American Spinal Cord Injury Association) Impairment Scale; BMI: Body mass index; FAC: Functional Ambulation Categories; SCI-SET: Spinal Cord Injury Spasticity Evaluation Tool; SCIM III: Spinal Cord Independence Measure, version III, NS: Nonsignificant correlation; *p<0.05.

In this study, male SCI patients had lower HDL-c levels, higher TG levels, and higher TC/HDL-c ratios compared to female patients with SCI. In this study, male SCI patients had lower HDL-c levels, higher TG levels, and higher TC/HDL-c ratios compared to female patients with SCI. Gardner et al.[24] examined lipid profiles in 1037 individuals aged 25–54 years without disability. The researchers found higher HDL-c levels in women than in men. They even reported that HDL-c levels were higher in women using oral contraceptives or receiving estrogen replacement therapy. As a result, they suggested that serum lipid levels were affected by estrogen. Schmid et al.[25] showed that there were gender-related differences in the lipoprotein profiles of patients with SCI in their study. Regardless of physical activity, premenopausal women with SCI did not have the unfavorable lipoprotein profiles observed in men with SCI. They suggested that this difference may be related to the effect of sex hormones, independent of the lesion level.

There are studies that found higher serum lipid levels in individuals with SCI than in the general population, and there are also other studies reporting that serum lipid levels, es-

Table 7. Linear regression analysis of clinical and demographic charecteristics that can be related with dyslipidemia

	Unstandardized coefficients		Standardized coefficients		p
	B	Std. Error	Beta	t	
TC					
(Constant)	111.057	29.231		3.799	0.001*
BMI	2.607	1.147	0.227	2. .272	0.025*
FAC	4.685	2.379	0.196	1.970	0.045*
LDL-c					
(Constant)	60.279	23.367		2.580	0.011*
BMI	1.914	0.917	0.200	1.977	0.050*
FAC	3.185	1.901	0.169	1.675	0.097
HDL-c					
(Constant)	35.263	2.345		15.036	0.001*
Duration of SCI	0.355	0.171	0.203	2.077	0.041*
FAC	2.130	0.649	0.320	3.284	0.001*
TC/ HDL-c					
(Constant)	2.156	1.658		1.301	0.197
BMI	0.146	0.063	0.236	2.328	0.022*
Duration of SCI	−0.063	0.034	−0.187	−1.852	0.067
SCIM-III Total	−0.021	0.010	−0.205	−2.025	0.046*

BMI: Body mass index; FAC: Functional Ambulation Categories; SCIM III: Spinal Cord Independence Measure, version III HDL-c: high density lipoprotein cholesterol; LDL-c: low-density lipoprotein cholesterol; TC: total cholesterol; TG: Triglyceride *p<0.05.

pecially HDL-c, are lower in SCI patients.[7-11] It has been suggested that the decrease in serum lipid levels is probably associated with the inflammation in SCI patients.[11]

In the present study, no significant difference was found in serum lipid levels between the groups of patients with motor complete and motor incomplete injuries and between the groups of paraplegic and tetraplegic patients. Koyuncu et al.[26] found that HDL-c levels were significantly lower in patients with motor complete injury than in those with motor incomplete injury. No significant difference was found between the serum lipid levels of the paraplegic and tetraplegic patients. In a meta-analysis, similar to our study, no difference was found between paraplegic and tetraplegic patients in terms of LDL-c, HDL-c and TG levels.[10] Laclaustra et al.[8] found higher TC, HDL-c, LDL-c levels in paraplegic patients compared to tetraplegic patients. As a result, they suggested that paraplegic patients had higher HDL-c levels due to their ability to use their upper extremities for exercise. In another study where patients with SCI were grouped as low-risk and medium-high-risk patients according to the Framingham risk score, no significant difference was found between the groups in the rates of tetraplegia, ambulation status, and duration of injury.[21] However, Matos-Souza et al.[27] investigated the common carotid artery intima-media thickness in patients with SCI and showed that subclinical atherosclerosis was more prominent in tetraplegic patients than in paraplegic patients. These results suggest that factors other than lipid levels may be involved in the development of atherosclerosis in patients with SCI.

In this study, SCI duration and FAC were found to affect HDL-c levels. Dallmeijer et al.[28] suggested that lipid profiles improved during the first 2 years after injury in SCI patients and that improving physical capacity or being physically active may have a positive effect on lipid profiles of patients. Koyuncu et al.[26] found that the incidence of dyslipidemia was increased in those with a disease duration of 0–12 months. They found a positive correlation between HDL-c level and duration of injury and a negative correlation between TG level and TC/HDL-c ratio and duration of injury.

In the present study, it was determined that BMI had an effect on TC, LDL-c levels and TC /HDL ratio. Bauman et al.[29] found that serum HDL-c values were inversely correlated with BMI in patients with SCI. de Groot et al.[30] found that an increase in BMI had a negative effect on all lipid profiles and suggested that BMI is the most important indicator of lipid profile. They also found a significant decrease in TG and TC/HDL-c ratio during inpatient rehabilitation and a significant increase in HDL-c levels during and after inpatient rehabilitation in patients with SCI. These results support that increasing physical activity and decreasing BMI with an appropriate diet may positively affect lipid levels. The mechanisms underlying lipid profiles in patients with SCI appear to be quite complex. Further studies on diet, lifestyle, frequency, and intensity of exercise are needed to further investigate lipid changes in these patients. In addition, since cardiovascular and metabolic diseases are more likely to be overlooked in these patients, special preventive measures are needed and it is very important that we are more vigilant and make sure that patients are followed up regularly.

Limitations of this study were that there was no healthy control group, so comparison with the normal population could not be made. In addition, since this study was retrospective, the exercise and nutrition levels of the patients could not be evaluated.

Conclusion

Consequently, in this study, HDL-c levels were lower, TG levels and TC/HDL-c ratios were higher in male patients with SCI than in female. There were no significant differences between the lipid profiles of patients with motor complete SCI and patients with motor incomplete SCI and between paraplegic patients and tetraplegic patients. Lipid levels were found to be affected by BMI, duration of SCI, level of independence and degree of ambulation. Preventing an increase in BMI by regulating patients' diet and exercise, and improving their independence and ambulation levels through rehabilitation may also have a positive impact on their lipid profile. This may contribute to a reduction in cardiovascular.

Disclosures

Ethics Committee Approval: All procedures were conducted in accordance with the Helsinki Declaration and the study protocol was approved by the institutional Ethics Committee of our hospital Fatih Sultan Mehmet Training and Research Hospital (FSMEAH-KAEK, 2023/89).

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