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Lipid profiles in spinal cord injury

D Cardús MD, F. Ribas-Cardús MS, W G McTaggart BS

Department of Physical Medicine and Rehabilitation and The Institute for Rehabilitation and Research, Baylor College of Medicine, 1333 Moursund Avenue, Houston, Texas 77030-3405, USA.

Measurement of blood levels of total cholesterol and lipoproteins (HDL and LDL) were conducted on 96 men with spinal cord injury, 46 paraplegics and 50 quadriplegics. All these patients were studied in the stabilized phase of the disease as a follow up to the rehabilitation process. The study was designed to compare results with a normal, able bodied population and to investigate if any abnormal finding could be related to the age at onset of the spinal cord injury, the duration of the disease or the level of the lesion.

Compared to the normal, able bodied population, this study indicates that patients with a spinal cord injury do not have higher levels of cholesterol or LDL, nor lower levels of HDL. Levels of total cholesterol increase with aging, as in the normal population, but have no relation to the duration of the disease or the level of the lesion. Blood levels of HDL and LDL do not seem to be related either to the duration of the disease or to the level of the lesion.

Keywords: lipids; cholesterol; lipoproteins; spinal cord injury.

Introduction

The role of blood cholesterol and lipoprotein fractions in the atherosclerotic process has been unquestionably established. As risk factors of coronary artery disease, blood levels of cholesterol and lipoproteins command the attention of and a considerable share of the current national research effort.

A population considered at risk of coronary artery disease is the one constituted by the patient with a spinal cord injury (SCI), the quadriplegic patient in particular. Recently published papers,[1–6] several coming from the same source, assert that patients with quadriplegia have lower blood levels of high density lipoproteins (HDL). The suspicion that this might be the case arose from the fact that SCI patients, quadriplegics in particular, are subject to extreme physical inactivity and blood levels of HDL are known to be low in sedentary, able bodied individuals. Prospective measurements of blood levels of HDL[7] were also found to be low in individuals who later developed coronary artery disease and myocardial infarction. The corollary is that low blood levels of HDL constitute a risk of coronary artery disease. There are, moreover, several investigators who believe that HDL may play a protective role against atherosclerosis,[7–10] although there is a respected dissenting voice in this regard.[11]

This paper reports the results of the blood lipid profile situation in a spinal cord injury population and compares the findings with those obtained from a normal, non trained, able bodied population.

Methods

Selection of participants was preceded by establishing a cohort of 640 persons with SCI who resided in a 13-county area that includes Houston and Galveston, Texas. Candidates for the community based cohort were solicited by means of widely distributed flyers, articles in area newspapers

and publications for disabled persons, and public service announcements on television and radio. Candidates were also contacted by mail or telephone using lists of names obtained from area hospitals and organizations for persons with disabilities. Opportunities to win prizes in a drawing and a cash bonus were among the incentives offered for becoming enrolled in the cohort. It was explained that the purpose of the cohort was to facilitate studies of the unmet needs of persons with SCI who reside in the community. To be included, an individual was required to have sustained a traumatic SCI at least 9 months prior to enrollment in the cohort, have a residual motor disability at least severe enough to require the use of an assistive device for walking (if the person was ambulatory), and to be at least 18 years of age. One hundred men and 40 women were randomly selected from the cohort to participate in an investigation of the life status and needs of persons with SCI. It is not possible, however, to state at this point whether the population sample of this study is or is not representative of the SCI population of the State of Texas.

The study here reported was conducted on 96 men with spinal cord injury. Forty-six of these patients had paraplegia and 50 quadriplegia. This population was recruited according to an experimental design that anticipated the formation of four subgroups based on age at the time of the injury, duration of the disease, and level of the spinal lesion. Four of the 100 men did not meet the criteria of the original design and were excluded from the study. At the time of the study these patients were in good health and none had signs suggestive of coronary artery disease. Many of them were taking medications. Medications, nutrition and behavioral aspects such as, for example, smoking could not be taken into consideration in the experimental design. However, statistical analysis comparing the data base of SCI patients with the general population indicates that the men participating in this study did not consume more alcohol than men in the general population (approximately 72% versus 78%), although SCI patients were more likely to require medical treatment for their alcohol problem than men in the general population. More men with SCI were smokers than in the general population (approximately 42% versus 37%). Some of our patients smoked marijuana, but less than in the general population (approximately 17% versus 23%). Factors such as cigarette smoking, arterial blood pressure and diabetes are considered in another paper.[12]

Blood levels of cholesterol and lipoproteins were determined in venous blood samples taken 8 hours at least in the fasting state in the supine position and analyzed for cholesterol, triglycerides, VLDL, LDL and HDL using standardized laboratory techniques.[13]

Two approaches were taken in the analyses of the data. First, the data obtained from SCI patients were compared with data obtained from able bodied men published in the Lipid Research Clinics Data Book.[14] Second, we analyzed whether the age at the time of the spinal cord injury, the duration of the disease, and the level of the spinal cord lesion were associated with any differences observed in blood lipids levels.

The effects of age at onset and duration of the disease were studied by forming four subgroups: G_1 (young and short duration),

Table I Population of SCI patients (paraplegic and quadriplegic) subdivided into 4 groups according to age at onset of injury, current age when study was done, and duration of disease. The figures for age at onset, current age and duration indicate means and standard deviations

Group	N	Age at onset (yrs)	Age current (yrs)	Duration (months)
G_1	25 (26.0%)	21.0 ± 3.2	26.3 ± 3.7	65 ± 27
G_2	30 (31.3%)	19.1 ± 3.5	40.2 ± 8.4	252 ± 96
G_3	29 (30.2%)	44.7 ± 12.0	49.1 ± 11.6	57 ± 21
G_4	12 (12.5%)	37.4 ± 6.6	55.6 ± 9.6	232 ± 122

G_2 (young and long duration) G_3 (old and short duration), and G_4 (old and long duration). The effects of the level of the lesion were studied by subdividing further the previous groups into paraplegic and quadriplegic subgroups. A computer software package was used for the statistical analysis.[15]

Results

The comparisons between the lipid profiles found in the SCI population and those reported by the Lipid Research Clinics (LRC), which comprise a population of 3108 normal men, are presented graphically in Figures 1 to 6. The analysis of data relating to the possible effects of age at onset, duration of the disease, and level of the lesion are presented in Tables II and III.

On those figures the continuous curves indicate the mean and standard error of the LRC data and the dashed curves the data obtained from the SCI population of the present study. Blood lipid levels are represented in the ordinate and the mid point of 5-year age classes on the abscissa.

Figure 1 is a plot of the total cholesterol blood levels versus age. The data obtained from the total SCI (paraplegics and quadriplegics) population of this study are superimposed on the data reported by the Lipid Research Clinics (LRC).

Figure 2 is a plot of the blood total cholesterol levels of quadriplegics only superimposed on the LRC curve. Figure 3 is a plot of HDL of the SCI total population superimposed on the curve of the HDL of the LRC population. Figure 4 is a similar plot but using data from quadriplegics only. Figures 5 and 6 are similar plots for LDL.

The characteristics of the four subgroups of the SCI population considering age at the time of injury, age when the study was done (current age) and duration of the disease are summarized in Table I. The statistical values of plasma total cholesterol, triglyceride, VLDL, LDL and HDL corresponding to the four subgroups are given in Table II. In Table III the same lipid classes are given for the eight groups resulting from further subdividing the previous four groups into paraplegics and quadriplegics.

Table II Plasma lipid and lipoprotein concentrations (mg/dl) in the SCI population divided into 4 subgroups. The figures indicate means ± standard error

SCI class	N	Age (current)	TC	TG	VLDL	HDL	LDL
G_1	25	26.3 ± 0.7	179 ± 6.6	110 ± 18.8	21 ± 3.8	43 ± 2.1	116 ± 6.4
G_2	30	40.2 ± 1.5	181 ± 8.1	101 ± 10.0	20 ± 2.1	43 ± 2.0	117 ± 8.0
G_3	29	49.2 ± 2.1	213 ± 6.8	170 ± 22.5	34 ± 4.5	44 ± 2.4	135 ± 6.5
G_4	12	55.6 ± 2.8	205 ± 13.4	143 ± 19.1	29 ± 3.8	44 ± 3.2	134 ± 12.4

Table III Plasma lipid and lipoprotein concentrations (mg/dl) as in Table II but separating each G group into paraplegics and quadriplegics. The figures indicate means ± standard errors

	N	Age (current)	TC	TRIG	VLDL	HDL	LDL
G_1P	9	26.2 ± 1.3	163 ± 8.3	131 ± 46.3	23 ± 9.6	44 ± 1.8	95 ± 8.1
G_2P	16	38.6 ± 2.4	190 ± 11.9	104 ± 15.7	21 ± 3.4	46 ± 2.4	124 ± 12.6
G_3P	14	47.3 ± 2.7	213 ± 10.9	219 ± 37.5	44 ± 7.5	46 ± 3.9	124 ± 8.8
G_4P	12	58.7 ± 3.7	209 ± 14.2	163 ± 23.3	33 ± 4.7	41 ± 4.3	139 ± 13.0
G_1Q	16	26.3 ± 0.9	189 ± 8.5	99 ± 14.6	20 ± 2.9	42 ± 3.1	128 ± 7.4
G_2Q	14	41.9 ± 1.8	171 ± 10.8	98 ± 12.4	20 ± 2.5	41 ± 3.3	111 ± 9.7
G_3Q	15	51.1 ± 3.3	213 ± 8.8	124 ± 20.5	25 ± 4.2	42 ± 3.0	145 ± 8.9
G_4Q	5	51.2 ± 3.6	199 ± 27.4	116 ± 30.8	23 ± 6.1	48 ± 4.8	127 ± 25.4

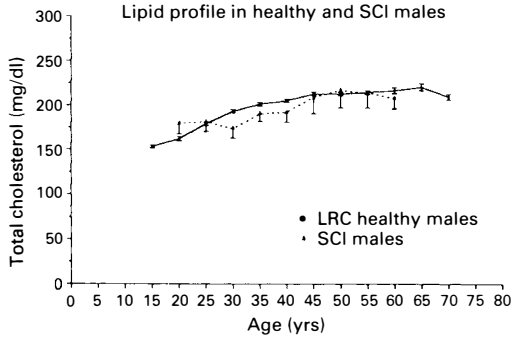

Figure 1 Cholesterol vs age. Comparison between normal (able bodied) and total SCI population.

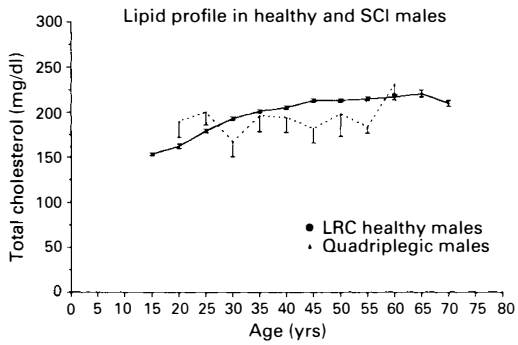

Figure 2 Cholesterol vs age. Comparison between normal (able bodied) and quadriplegic patients.

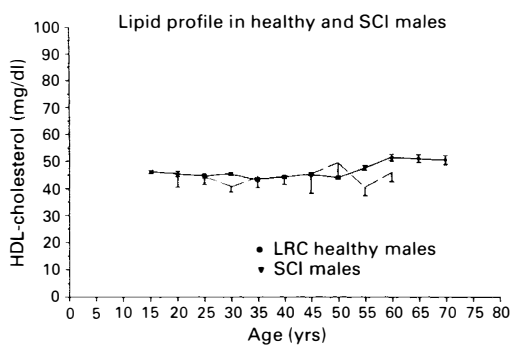

Figure 3 HDL vs age. Comparison between normal (able bodied) and total SCI population.

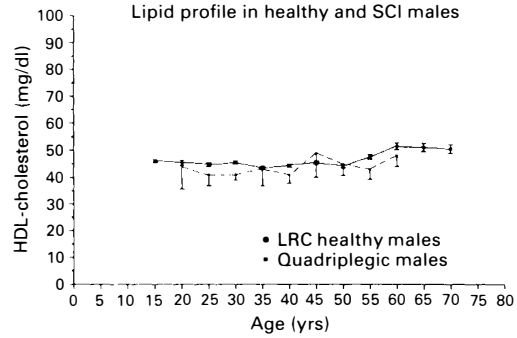

Figure 4 HDL vs age. Comparison between normal (able bodied) and quadriplegic patients.

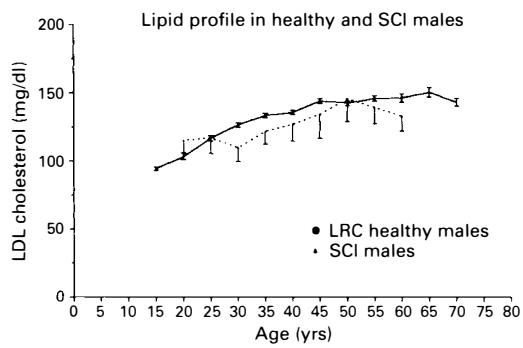

Figure 5 LDL vs age. Comparison between normal (able bodied) and total SCI population.

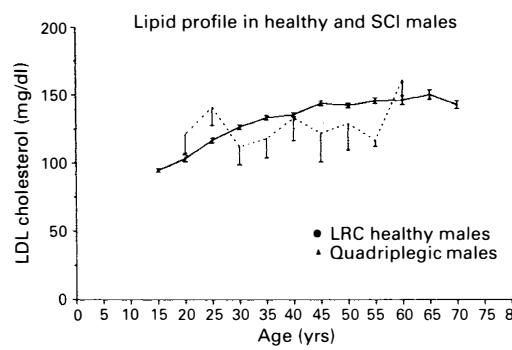

Figure 6 LDL vs age. Comparison between normal (able bodied) and quadriplegic patients.

Discussion

Blood cholesterol levels

The LRC curve shows that blood levels of total cholesterol in the normal population increase from age 15 to 65. There is a decrease in the 70 year class. Patients with SCI exhibit a curve with the same pattern as the LRC curve. The LRC curve shows standard error values of the mean which are much smaller than those of the SCI curve. This is due, of course, to the fact that the number of subjects in each age class is much larger in the LRC study than in our SCI population. The graphs do not show points at the ends of the SCI curves because there were one or two cases only in the age classes corresponding to both ends of the curves. Discrepancies between these two curves are not statistically significant. An analysis of variance showed that the differences in cholesterol between the points of the LRC curve and the points of the SCI curve are statistically not significant ($p < 0.01$ level). The figure shows, however, that patients with SCI do not have elevated blood levels of total cholesterol. When quadriplegic patients are separated from the total SCI population (Fig 2) there is no evidence either that levels of total cholesterol are higher in quadriplegics.

Blood HDL levels

The LRC data shows that HDL blood levels are almost invariable up to the age of 50. There is a small increase after 50. The superimposed curve from SCI patient data (Fig 4) is practically the same. When only quadriplegic data are plotted, no significant differences are found (Fig 5). This is clear up to the 60 year age class. We think, however, that the similarity of the two curves probably extends beyond 60. Thus, our data does not seem to support the notion that quadriplegic patients' HDL levels are lower than those observed in the normal population. The reason for the disagreement between our findings and those of previous reports may be that the number of SCI cases studied in previous reports is generally small and the average values are computed over ages that spread over relatively large ranges. Also, some of these studies were done in the early state of the disease and on patients who had severe associated clinical complications.

The hypothesis that quadriplegic patients might have lower values of HDL is based on the fact that the immobilization and physical inactivity of these patients are generally severe and on epidemiological studies that show that physical inactivity is associated with low HDL values in sedentary able bodied populations. The relationship between low HDL levels and coronary heart disease has been studied in many different ways[7–9,16–22] but research demonstrating the relevance of those studies to the quadriplegic population is not available. Blood levels of HDL seem to be related to a variety of factors[23–31] which could not be taken into consideration in the experimental design of this study because it would have been unmanageable and many of these factors were not available in the population used for comparison. On the other hand, the notion that mortality by coronary heart disease is high in spinal cord injury should be reconsidered because it is based on questionable methodology and insufficient evidence.[32–44] Only in one paper[45] it was found that the prevalence of cardiovascular disease was high in the SCI population. It is possible that the psychosocial stress of that population played an important role in that finding.

Blood LDL levels

Whereas the metabolic mechanism and protective role of HDL remains, to a large extent, to be established, the experimental background of the biosynthesis and control of LDL and the physiological findings that show the relevance of LDL to human atherogenesis are much better established.[46–52] Present knowledge of the homeostatic mechanisms that regulate intracellular cholesterol allows us to better understand the relationship between cholesterol, atherosclerosis and coronary artery disease. If the inactivity of the quadriplegic is of concern as a risk of coronary artery disease it would seem appropriate to investigate LDL also, an aspect not critically considered in the cited literature concerning

the spinal cord injury population. Knowing that LDL is seemingly the most important factor in the atherogenetic process, the investigation of LDL perhaps should even have priority. Our data, summarized in Figure 5, shows, however, that the SCI population does not have levels of LDL cholesterol significantly higher than those of the normal (LRC) population. This remains true even when quadriplegics are considered separately (Fig 6), ie when the LRC curve is compared with the curve obtained with data from quadriplegics only.

Effect of age, duration and level of the lesion

The possible influence of the age at which the injury was sustained, the duration of the disease, and the level of the spinal cord lesion on blood lipid levels was investigated by comparing lipid measurements in the subgroups G_1, G_2, G_3 and G_4. The results are summarized in Tables II and III.

An analysis of variance of the four subgroups of Table II indicates that only some differences in cholesterol level were significant ($p < 0.01$). None of the differences in HDL or LDL were significant. The significant differences in cholesterol were between G_1 and G_3 and between G_2 and G_3. This clearly suggests that the differences were due to aging. The comparison between G_3 and G_4, whose age difference was not significant whereas the difference in the duration of the disease was, shows that the cholesterol level difference between these two groups was not significant. This suggests that blood levels of cholesterol or lipoprotein fractions are not independently related to the duration of the disease per se.

The effect of the level of the lesion was assessed by comparing corresponding groups (G_{1P}-G_{1Q}, G_{2P}-G_2Q, G_{3P}-G_{3Q} and G_{4P}-G_{4Q}). The subscripts indicate paraplegic (P) and quadriplegic (Q). Differences in total cholesterol and HDL between the groups were not significant. They were significant for LDL between G_{1P} and G_{1Q}, and for VLDL between G_{3P} and G_{3Q}. There is no logical explanation for the significance of those differences except that one of the subjects in group G_{3P} had very high triglycerides as compared to the others and this suggests that that subject was probably an outlier. There were differences among some of the other groups, for example between G_{1P} and G_{2P}, G_{3P}, G_{4P} in cholesterol and LDL, but not HDL. Those differences must be attributed, principally, to age, except for those between G_{1P} and G_{1Q}.

Conclusion

The results of this study indicate that blood levels of total cholesterol, HDL and LDL in the stabilized spinal cord injury population of the present study were not statistically different from those found in a non trained, able bodied population. As in the normal population blood levels of total cholesterol in the SCI population increased with aging. The duration and the level of the spinal lesion did not seem to have per se an effect on the blood levels of total cholesterol and lipoproteins.

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