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Analysis of correlation of liver, kidney and thyroid functions with hyperlipidemia in senile patients

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Abstract: **The objective of this study is to analyze the correlation of liver, kidney and thyroid functions with hyperlipidemia in senile patients, and provide objective clinical data for designing effective treatment plan in clinical work. According to the principle of informed consent form, a number of 1289 senile dyslipidemia patients who did physical examination in the health examination center in our hospital were enrolled in the study. Questionnaire of blood lipid was used to investigate general information of senile patients with dyslipidemia; indicators related to blood lipid, liver function, renal function and thyroid function were tested and factors related to dyslipidemia were analyzed. Statistical analysis demonstrated that the morbidity rate of high level of total cholesterol (TC) and low density lipoprotein cholesterol (LDL-C) in female was higher than that in male and the prevalence rate of low level of high density lipoprotein cholesterol (HDL-C) in male was higher than that in female, which were all statistically significant; there was no significant difference of triglyceride (TG) levels between male and female. High TC, TG and LDL-C was mainly concentrated in the 66-70 years of age; while, there was no obvious difference of the prevalence rate of low HDL-C among different ages.TC was positively correlated with ALT, GGT and UA; TG was positively associated with age, ALT, GGT and UA; HDL-C was negatively correlated with sex and UA; LDL-C was positively associated with Cr and UA, and negatively correlated with sex and ALT. Therefore, the morbidity of dyslipidemia could be effectively decreased by improving liver function, renal function and thyroid function.**

Keywords: Senile patients; Hyperlipidemia; Correlation

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1. Introduction

Senile dyslipidemia refers to the blood lipid disorder in the elderly with age over 60 years old as well as a series of clinical syndromes caused by this. Blood lipid disorder can cause different degrees of damages to the inner, middle and outer vascular membranes, which severely influences vasodilation. The commonly used clinical indicators of blood lipid include serum triglyceride (TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) and so forth. High TC and TG, low HDL-C and mixed types are commonly seen.

At present, coronary atherosclerotic heart disease was one of main diseases causing death in our country, and dyslipidemia was the independent risk factor of coronary heart disease [1,2]. Researches demonstrated that increase of every 1% of TC level would increase 2-3% of morbidity rate of coronary heart disease; each add of 15mg/dl of HDL-C could decrease 2-3% of morbidity rate of coronary heart disease [3]. For TG, researches done by Miller [4] and other scholars discovered that after correction of LDL-C, non-HDL-C and other factors, cardiovascular death incidents---myocardial infarction (MI) and acute coronary syndrome (ACS) could drop 1.6% and 1.4% respectively when TG decreased 10mg/dl. Therefore, effective improvement of blood lipid level was very significant for the prevention of cardiovascular and cerebrovascular diseases.

So far, our country had carried out several large-scale epidemiologic researches of blood lipid (see Table 1). Results [5-10] demonstrated that: (1) levels of TC, LDL-C and TG were increased with age; (2) obvious regional differences of serum lipid level and abnormal rate were found. However, since the upper age limits of the above research subjects (patients with cardiovascular disease or high-risk patients) were mostly below 70 years old, the research data of the elderly, especially the advanced ages, were not enough. Therefore, the distribution of dyslipidemia in senile people was studied and analysis of the influencing factors of blood lipid disorder was made for the sake of filling blanks of clinical data concerning the blood lipid disorder in the elderly, which would provide the foundation for giving health guidance for patients accordingly in clinical work and designing effective prevention programs.

2. Methods

2.1. Study subjects

A total of 1997 senile people (≥60 years old), who were Qingdao residents (living in Qingdao for at least 2 years) and did physical examinations in the affiliated Hospital of Qingdao University from September, 2015 to July, 2016, were enrolled in the study. There were 1029 males and 968 females. The average age was 67.06±6.61 years of age. This study was approved by the Ethics Committee of Qingdao Centers for Disease Control and Prevention and written informed consents were obtained from all studies subjects.

Table 1 List of large-scale domestic epidemiologic researches of blood lipid

Research project	Year of the study	Age (years old)
MONICA	1984-1993	25-64
Chinese-American cooperative epidemiologic research of cardiovascular disease	1981-2001	35-54
Cohort studies of risk factors of cardiovascular diseases in 11 provinces and cities	1992	24-64
Comparative study of the risk factors and epidemic trends of cardiovascular and cerebrovascular diseases in high-incidence and low-incidence areas	1992-1994	35-59
Epidemiologic research of cerebrovascular disease in China	1993	Above 40
Cooperative research of cardiovascular disease in Asia	2000-2001	35-75
The 4th nationwide nutritional survey	2002	Above 18
The 2nd multi-center cooperative study of blood lipid control in clinic in China	2006	23-91
Blood lipid level and distribution features of Chinese adult in 2010	2010	Above 18

2.2. Design of questionnaire form

All information in the questionnaire form was acquired through consultation with subjects by investigators, including patient's name, sex, age, native place, residence and smoking history. The questionnaire form was only used for this study and any usage for other purpose was forbidden.

2.3. Laboratory data

Laboratory data: Enzymatic method was adopted to test the composition of blood lipid, including serum TC, TG, HDL-C and LDL-C. Liver function test: sensitive indicators of liver function damage, including ALT, AST and GGT, were observed; velocity method was adopted to determine the content of ALT and AST in patient's serum; serum GGT was tested by γ -glutamy-p-nitroaniline method. Renal function test: 24 hours observation of patient's MAU, BUN and Cr was performed; MAU was tested by immunoturbidimetry; BUN was tested by enzyme coupling rate method; Cr was tested by enzymic method. Thyroid function test: sensitive indicators of thyroid function damage, including FT4 and TSH, were observed and tested by ECLIA. Blood should be drawn from the median cubital vein of in the morning in resting state with over 10 hours fasting during night.

2.4. Statistical analysis

The SPSS19.0 software was adopted for statistical analysis. All measurement data were presented as mean ± standard difference (X±S). T test was used for comparison between two groups of measurement data. As for the comparisons among multiple groups, One-Way ANOVA was applied. Comparisons of the qualitative data (MAU) were made by χ^2 test. Multi-factor Logistic regression analysis was applied for the comparison of relative factors analysis. $P<0.05$ was considered as statistical significant.

3. Results

3.1. General data of study subjects

A total of 1289 senile people (age≥60) were tested with dyslipidemia among the initial 1997 participants, so the dyslipidemia rate was 64.5%. 670 were male and 619 were female; the average age was 67.06±6.61 years of age. All the subjects with dyslipidemia were divided into 5 groups according to their age: group I: 60-65 years of age (353 males and 346 females); group II: 66-70 years of age (124 males and 142 females); group III: 71-75 years of age (89 males and 64 females); group IV: 76-80 years of age (61 males and 42 females); group V: > 80 years of age (47 males and 21females).

3.2. Sex and age difference of patients with dyslipidemia

According to Table 2, the morbidity of high TC and LDL-C in female was higher than that in male and the prevalence rate of low HDL-C in male was higher than that in female, which were all statistically significant; there was no significant difference of TG levels between male and female. Prevalence of high TC, TG and LDL-C was mainly concentrated in the 66-70 years of age; while, there was no obvious difference between the morbidity of low HDL-C and the years of age.

Table 2 Dyslipidemia rates for patients with different sex and age (%, n)

Clinical features	n	Rate of high TC		Rate of high TG		Rate of low HDL-C		Rate of high LDL-C	
Sex									
Male	670	84.2	564	37.5	251	4.9	33	54.3	364
Female	619	92.9	575	39.4	244	0.6	4	57	353
P		<0.001**		0.123		<0.001**		<0.001**	
Age (years of age)									
60-65	699	88.9	622	39.2	274	2.1	15	57.2	400
66-70	266	90.6	241	40.6	108	2.3	6	57.5	153
71-75	153	87.6	134	36.6	56	5.2	8	54.2	83
76-80	103	86.4	89	35.9	37	7.8	8	47.6	49
＞80	68	85.3	58	36.7	25	7.4	5	54.4	37
P		<0.001**		<0.001**		0.384		0.003*	

*P<0.05, ** P<0.001

3.3. Analysis of factors correlated with dyslipidemia

Analysis of factors correlated with dyslipidemia (see Table 3A, B and Table 4) was made and the results demonstrated that the Cr and UA levels in patients with normal TC was obviously different from that in patients with abnormal TC, and ALT, GGT, UA and FT4 levels in patients with normal TG was evidently different from that in patients with abnormal TG, which were all statistically significant; there were obvious differences of ALT, GGT, Cr, UA and FT4 levels between patients with normal and abnormal HDL-C, and the levels of ALT and UA in patients with normal LDL-C was evidently different from that in patients with abnormal LDL-C, which were all statistically significant. Results of the multi-factor Logistic regression analysis of senile dyslipidemia after correction of confounding factors (see Table 5) showed that TC was positively correlated with ALT, GGT and UA; TG was positively associated with age, ALT, GGT and UA; HDL-C was positively correlated with FT4 and negatively correlated with sex and UA; LDL-C was positively associated with Cr and UA, but negatively associated with sex and ALT.

Table 3A Each factor associated with dyslipidemia

	TC			TG		
	Formal	Noformal	P	Formal	Noformal	P
ALT	27.98±14.272	22.551±11.400	0.069	21.285±10.576	26.22±24.532	<0.001**
AST	21.49±13.933	20.682±11.174	0.233	20.574±12.050	21.090±10.627	0.463
GGT	27.57±23.410	25.059±19.238	0.798	23.176±18.836	28.843±20.742	<0.001**
BUN	5.787±1.699	5.587±2.301	0.81	5.604±2.017	5.620±2.559	0.429
Cr	82.60±14.839	77.559±13.938	<0.001**	77.506±13.535	79.175±14.997	0.586
UA	366.8±89.425	325.98±80.690	<0.001*	321.68±78.443	345.22±87.394	<0.001**
FT4	15.985±2.232	16.398±4.634	0.693	16.702±5.370	15.820±2.296	0.0168*
TSH	3.065±5.235	2.595±3.715	0.427	2.546±3.860	2.801±3.994	0.679

Table 3B Each factor associated with dyslipidemia

	HDL-C			LDL-C		
	Formal	Noformal	P	Formal	Noformal	P
ALT	22.75±11.522	37.622±18.077	<0.001**	24.453±23.349	22.171±10.603	0.004*
AST	20.59±18.979	27.235±25.721	0.739	21.737±14.844	20.013±7.889	0.069
GGT	25.20±18.979	30.243±38.053	0.004*	26.075±23.133	24.773±16.603	0.149
BUN	5.600±2.249	5.966±1.892	0.524	5.602±2.466	5.617±2.043	0.604
Cr	78.00±14.065	78.838±15.756	<0.001**	78.187±13.917	78.115±14.312	0.19

UA	330.1±82.627	350.73±85.961	<0.001**	335.41±82.563	326.99±82.789	<0.001**
FT4	16.344±4.484	16.64±2.099	0.020*	16.120±2.986	16.542±5.599	0.062
TSH	2.666±3.964	2.004±1.009	0.062	2.563±2.931	2.716±4.533	0.893

*P<0.05 ,** P<0.001. ALT: alanine aminotransferase, AST: aspartate aminotransferase, GGT: gamma glutamyl transpertidase, BUN: blood urea nitrogen, Cr：creatinine, UA:uric acid, FT4: free thyroxine, TSH: thyroid stimulating hormone.

4. Discussion

With aggravation of the aging of population in our country, the proportion of the aged in total population is increased. The population of the aged had surpassed 200 million in 2013 and will reach 300 million in 2025 and China will become a super aging country at that time. Atherosclerotic cardiovascular disease (ASCVD) was the main disease causing death and influencing living quality of the aged [11]. Meanwhile, the morbidity and mortality of ASCVD was increased with age. Dyslipidemia was a changeable risk factor of ASCVD [12]. Therefore, prevention and treatment of dyslipidemia was very significant in extending life-span and improving the living quality of the aged. It was reported that the morbidity of hyperlipidemia in developed country was 23.2%~65.7% [13-14]. In this study, the prevalence rate of hyperlipidemia in the aged reached 64.5%, which was basically in accord with the report. The Chinese prevention guideline of dyslipidemia for adult pointed out that TC and LDL-C would be increased with age both in male and female, and would reach peak in the 50~69 years of age, and then were slightly decreased after 70 years of age [15]. This study further concluded that the increasing rates of TC, TG and LDL-C levels in senile female were higher than that in male and reached peaks in the 66~70 years of age, and then slightly went down after 70 years of age. The morbidity of hyperlipidemia in senile female was obviously higher than that in male, which gave us a hint that the prevention and treatment of dyslipidemia should be focused on menopausal women. It was mainly because that female would lose the protection of estrogen hormone for blood lipid metabolism after menopause.

Table 4 Other factors associated with dyslipidemia

	TC		TG		HDL-C		LDL-C	
	X^2	P	X^2	P	X^2	P	X^2	P
MAU	0.011	0.916	0.039	0.844	1.225	0.190	0.092	0.762

*P<0.05, ** P<0.001，MAU: albuminuria

Table 5 Multivariate logistic regression analysis of factors associated with dyslipidemia

	TC		TG		HDL-C		LDL-C	
	P	r	P	r	P	r	P	r
Age	0.276	0.014	0.043*	0.010	0.743	0.001	0.606	-0.002
Gende	0.274	0.173	0.065	0.119	<0.001**	-0.203	<0.001**	-0.156
ALT	0.005*	0.005	0.024*	0.005	0.080	-0.004	0.010*	-0.003
AST	0.290	0.007	0.185	-0.008	0.169	0.002	0.793	-0.001
GGT	0.034*	0.008	0.014*	0.007	0.301	0.001	0.423	0.001
BUN	0.435	0.014	0.557	-0.012	0.393	0.005	0.572	0.005
Cr	0.281	0.006	0.809	0.002	0.824	-0.004	0.044*	0.004
UA	0.002*	0.003	0.031*	0.001	0.031*	-0.001	0.006*	0.001
MAU	0.613	-0.152	0.073	0.208	0.854	0.016	0.94	-0.005
FT4	0.481	-0.024	0.090	-0.020	0.005*	-0.010	0.073	0.011
TSH	0.624	0.005	0.303	-0.165	0.142	-0.007	0.874	0.001

*P<0.05, **P<0.01, r express correlation.ALT: alanine aminotransferase, AST: aspartate aminotransferase, GGT: gamma glutamyl transpertidase, BUN: blood urea nitrogen, Cr: creatinine, UA:uric acid, MAU: albuminuria, FT4: free thyroxine, TSH: thyroid stimulating hormone.

Senile hyperlipidemia was closely related to the damage of liver function [16]. Recent research results demonstrated that age-related change of liver sinusoidal endothelial cell was one of the main reasons for senile dyslipidemia [17]. This study showed that TC and TG levels were positively associated with ALT and GGT. Researches [18-19] discovered that increase of blood lipid was influenced by abnormal liver

function and damage of liver cells. Liver damage was usually presented as rupture of liver cells in the early stage; abnormal liver function made the deposition speed of blood lipid faster than the degradation speed; then the lipid composition in blood was difficult to be metabolized and cleaned immediately, which further caused excessive deposition of lipid in liver cells; then lipid oxidation and oxidative stress were occurred, which easily caused inflammatory medium and

Dyslipidemia was a common complication of chronic kidney disease (CKD). This study results showed that dyslipidemia was closely related with renal function. Patient with chronic renal failure (CRF) usually had abnormal lipid metabolism. The main reasons [21] were that (1) middle molecular toxic substances, especially the parathyrin, could decrease the activity of HL and LPL, and influence the degradation of TG in VLDL and LDL, which caused increase of TG content; (2) slow elimination of APO-B was possibly related to abnormal number or function of APO-B receptors, which further influenced the metabolism of lipoprotein; (3) liver cell had difficulty in taking in fatty acid; (4) L-carnitine was insufficient, which led to incomplete oxidation of β-free fatty acid and caused utilization difficulty. Moreover, due to the geographical location and dietary habit of Qingdao, clam with beer became the local diet features. However, drinking large amount of beer during eating seafood would produce excessive uric acid. Therefore, the blood acid level of Qingdao people was generally high. The analysis of correlation of uric acid with blood lipid in this study showed that TG, TC and LDL-C were positively correlated with uric acid, and HDL-C was negatively associated with uric acid. Researches abroad also reported that TG and TC were positivelyassociated with uric acid [22], and TG was an independent risk factor of causing increase of uric acid level. There were several explanations of the mechanism between hyperlipidemia and hyperuricemia. It was possible that increase of blood lipid could cause deposition of lipid; then kidney was damaged, which caused difficulty in lipid excretion and further led to obstacles in clearing blood uric acid and finally resulted in the increase of uric acid. Fatty acid produced by TG would increase ATP and accelerate its utilization, which caused increase of UA concentration in blood [23]. Some other scholars thought that the increasing demands of reduced coenzyme II during the synthesis of free fatty acid could enhance the synthesis of uric acid. Increase of uric acid could decrease the activity of lipoprotein lipase, reduce decomposition of TG and improve level of TG in blood [24].

Thyroid hormone (TH) was one of body's most important hormones. TH had significant physiological effect, including influences on substance metabolism and growth and development. Researches [20] discovered that TH had significant influence on the synthesis, mobilization and metabolism of lipid. Mechanism I was to eliminate neutral sterol and bile acid, and reduce the absorption of cholesterol in intestines; mechanism II was to enhance the activity of hepatic lipase and decrease serum TC; mechanism III was to inhibit the expression of the gene of liver cholesterol 7α-hydroxylase [25-28].

mitochondrial function disorder; it activated the hepatic stellate cell, which further led to the fibrosis and inflammatory necrosis of liver cells. Moreover, excessive deposition of lipid in liver cells could influence intrahepatic bile excretion and induce liver cells to produce massive GGT. Once liver cells were damaged, and GGT and ALT were overflown from liver cell, activities of GGT and ALT in blood serum would be increased [20].

Free thyroxine (FT4) in serum was a sensitive indicator of in vitro thyroid function test. FT4 could accurately reflect thyroid function even under physiological or pathological conditions when the binding force and concentration of plasma thyroxine-binding protein were changed. This study showed that FT4 was positively associated with HDL-C. Researches demonstrated that HDL was positively correlated with FT4 in female and high FT4 was an independent risk factor of low HDL [29]. Considering that female was influenced by sex hormone and HDL was closely related to oxidative stress and adipocytokines, FT4 in female was more closely related to HDL [30]. This study didn't make gender classification of HDL compared with FT4, so whether there was gender difference or not for the positive correlation of HDL-C with FT4 still need further investigation.

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