



Decreased Lipid Serum Level after Pituitary Adenoma Resection

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Abstract

Objective: The aim is to evaluate the relationship between pituitary adenoma and serum lipid by pre- and post-operative.

Methods: A retrospective analysis based on the clinical records of patients with pituitary adenoma was performed. A total of 1095 patients were diagnosed and underwent surgery through the endoscopic transsphenoidal approach at the Shandong Provincial Hospital (Jinan, China) from July 2010 to June 2015. According to the inclusion criteria, 959 patients were included and analyzed. The fasting lipid profile was obtained in the medical records. Pituitary adenomas are classified as different types according to histological diagnoses. The proportion of serum lipid disorders in various pituitary adenomas was analyzed in pre- and post-operative.

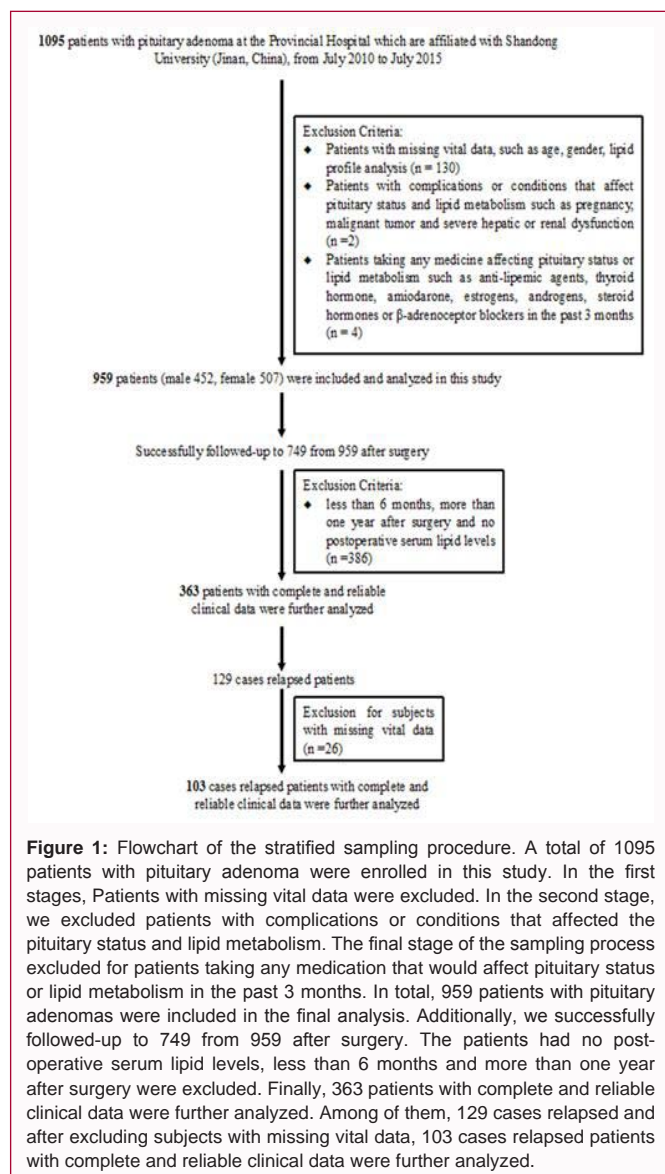
Results: Of all patients with PA, approximately 75.7% of patients exhibited dyslipidemia. Each type of tumor was positive association with the serum lipid level (pure Adrenocorticotrophic Hormone (ACTH)+ adenomas > pure Follicle-Stimulating Hormone (FSH)/Luteinizing Hormone (LH)+ adenomas > chromophobic adenomas > pure prolactin (PRL)+ adenomas > pure Thyroid-Stimulating Hormone (TSH)+ adenomas > mixed pituitary adenomas > pure Growth Hormone (GH)+ adenomas). Additionally, the serum lipid level decreased after the pituitary adenoma resection. Surprisingly, lipid serum level elevated again when pituitary adenoma recurred and the serum lipid level sharp reduced again follow the second operation. Pituitary adenoma accompanied with dyslipidemia was more easily relapsed. The recurrence ratio of pituitary adenoma in the patients with dyslipidemia was high and up to 2-fold that without lipid disorders, especially TSHoma.

Conclusion: There was the relationship between pituitary adenoma and dyslipidemia.

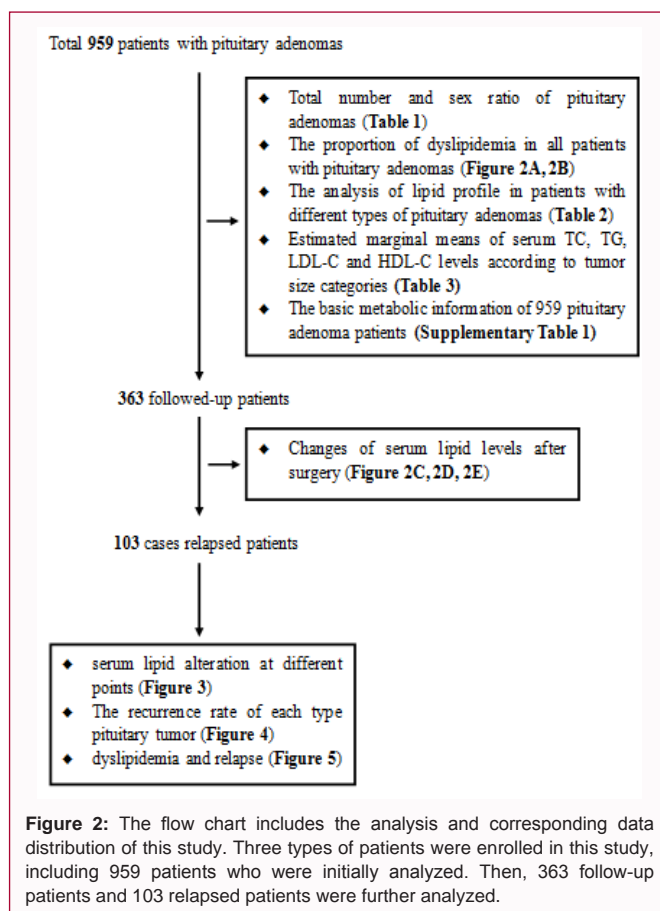
Keywords: Pituitary; Pituitary adenomas; Resection; Recurrence; Serum lipid levels

Introduction

The pituitary gland, a crucial neuroendocrine organ, includes many types of cells. Its main function is to synthesize and secrete different types of hormones. Pituitary adenomas are usually benign monoclonal neoplasms caused by a mixture of pituicyte alterations together with a changed endocrine and paracrine regulatory milieu [1]. Thus, it can cause serious health problems such as abnormal target organ function, pain, disability and even death [2-6]. Pituitary adenomas have a high prevalence in the world, and are the third most frequent tumor type after meningiomas and gliomas in the central nervous system, and account for 15% of all intracranial neoplasms [7-10]. In clinical practice, we found many patients with pituitary adenomas are usually accompanied by hyperlipidemia, which is the main cause of cardiovascular diseases. However, it has been unclear if there is an association between pituitary adenomas and serum lipid profile.



Pituitary adenomas are classified as chromophobic adenomas and chromatophilic cell adenomas, which include pure Prolactin (PRL)+ adenomas, pure Growth Hormone (GH)+ adenomas, pure Adrenocorticotrophic Hormone (ACTH)+ adenomas, pure Follicle-Stimulating Hormone (FSH)/Luteinizing Hormone (LH)+ adenomas, pure Thyroid-Stimulating Hormone (TSH)+ adenomas and mixed pituitary adenomas according to histological diagnoses. Abnormal cell function induced by pituitary adenomas can lead to corresponding hormone level disorder [2,11]. Recently, many studies reported the pituitary hormones have extra-effect besides its target. Our previous study found that pituitary hormone, TSH, could increase cholesterol and Triglyceride (TG) synthesis in the liver and elevate serum levels of lipids independent of other hormones such as thyroid hormones [12-15]. FSH, another kind of pituitary hormones, was correlated with serum cholesterol levels in normal menstruating women and postmenopausal women [16,17]. However, it is unclear whether all pituitary hormones are correlated with lipid serum level. Pituitary adenomas have abnormal serum pituitary hormone levels. Erem C et al., [18] found that 22 patients with pure PRLoma had dyslipidemia. However, the relationship between different endocrine phenotype of adenoma and serum lipid profile remains unclear now.



In the present study, we performed a retrospective analysis focusing on the patients with pituitary adenomas and their lipid profile before and after operation including first occurrence and recurrence. We surprisingly found a strong correlation between pituitary adenomas and dyslipidemia. This study would remind doctors to pay attention to the lipid levels of patients with pituitary adenoma.

Subjects and Methods

Patient demographics

A total of 1095 patients diagnosed with pituitary adenomas using an endoscopic transsphenoidal approach at the Shandong Provincial Hospital affiliated with Shandong University (Jinan, China), July 2010 to June 2015 were included in this retrospective study. As described in a study by Shao S et al., [9], all adenomas were resected by transsphenoidal surgery and identified by histological diagnoses. Information on the medication and a history of surgical diseases in each patient was obtained. The fasting lipid profile, fasting plasma glucose level and blood pressure (examined for the first time on admission) were obtained from the medical records. Adenoma sizes were calculated by the MRI results in the medical records.

The following criteria were used for patient exclusion: (1) Missing vital data, such as age, gender, serum lipid profile, pathology reports; (2) Complications or conditions that affect pituitary status and lipid metabolism, such as pregnancy, malignant adenomas or severe hepatic or renal dysfunction and (3) Use of any medication that affects the pituitary or lipid metabolism, including statins, fibrates, thyroid hormones, anti-thyroid drugs, iodine, amiodarone, alemtuzumab, lithium, tyrosine kinase inhibitors, interferon, estrogens, androgens,

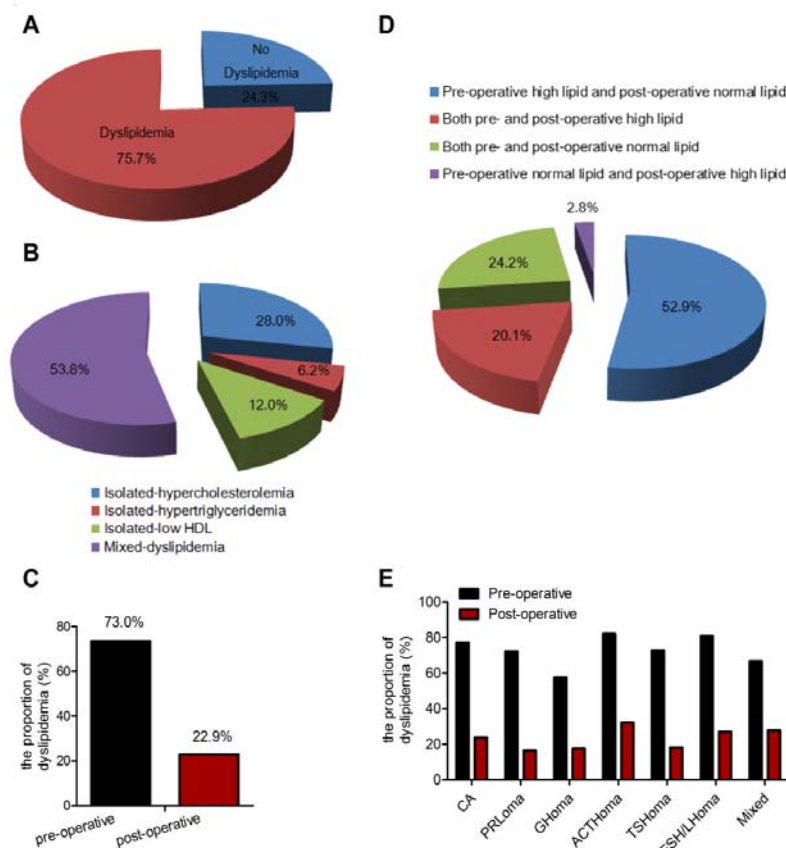


Figure 3: (A) The frequencies of patients with and without dyslipidemia among all patients with pituitary adenomas (n=959). (B) The frequencies of isolated hypercholesterolemia, isolated hypertriglyceridemia, isolated low HDL and mixed dyslipidemia in dyslipidemia patients with pituitary adenomas (n=726). (C) The frequencies of dyslipidemia in all follow-up patients at the pre- and post-operative periods (n=363). (D) The frequencies of pre-operative high lipid and post-operative normal lipid, both pre- and post-operative high lipid, both pre- and post-operative normal lipid and pre-operative normal lipid and post-operative high lipid (n=363). (E) The prevalence of dyslipidemia in every subtype at the pre- and post-operative periods (n=363). Data are expressed as percentages (%).

glucocorticoids, nonsteroidal anti-inflammatory drugs, antiepileptic drugs, rifampicin, furosemide, heparin or β -adrenoceptor blockers in the past 3 months [12]. Generally, the patients were clinically stable at the time of hospitalization, and those with serious conditions or who were in the intensive care unit were excluded. Ultimately, 959 patients (452 males and 507 females) were selected and initially analyzed in the present study.

We successfully followed-up to 749 from 959 after surgery. Additionally, those patients lacking of post-operative serum lipid levels, less than 6 months and more than one year after surgery were excluded. Finally, 363 patients with complete and reliable clinical data were further analyzed. Among of them, 129 cases relapsed and after excluding subjects with missing vital data, 103 cases relapsed patients with complete and reliable clinical data were further analyzed, including 50 males and 53 females. The selection process is illustrated in the supporting information (Figure 1).

The local ethics committee approved the retrospective review of the patients' medical records and licensed the records for research purposes only.

Definition of dyslipidemia with pituitary adenoma

According to the National Cholesterol Education Program Adult Treatment Panel III criteria, isolated hypertriglyceridemia was defined as triglycerides ≥ 1.70 mmol/L (150 mg/dL) and isolated

hypercholesterolemia was defined as total cholesterol (TC) ≥ 5.18 mmol/L (200 mg/dL) and/or low-density lipoprotein cholesterol (LDL-C) ≥ 3.37 mmol/L (130 mg/dL) [19]. Isolated low high-density lipoprotein cholesterol (HDL-C) was defined as HDL-C <1.04 mmol/L (40 mg/dL). Mixed dyslipidemia was defined as more than one abnormal lipid component.

Statistical analysis

Statistical tests were performed using SPSS version 18.0 for Windows (Chicago, IL, USA). Data are expressed as the means \pm standard deviation or numbers (percentages). Differences were compared using ANOVA. We investigated the effects of adenoma size on lipid parameters using a general linear model. The relationships between adenoma size and serum lipid parameters of different subtypes were evaluated using partial correlation analysis after adjustment for confounding factors (age, sex, BMI, FPG and SBP). All calculated values were two-sided, and P values less than 0.05 were considered statistically significant.

Results

General characteristics of pituitary adenoma patients

The 959 patients with pituitary adenomas included 452 males (47.1%) and 507 females (52.9%) with a gender ratio (male: female) of 1:1.1. The age of these patients at the time of initial diagnosis ranged from 1 year to 76 years (median, 46 years). The median age was 48

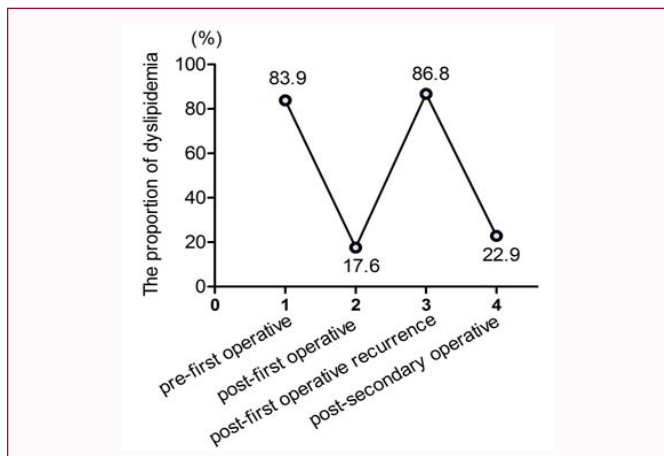


Figure 4: The proportion of patients with dyslipidemia at pre-first operative, post-first operative, post-first operative recurrence and post-secondary operative examinations among patients with pituitary adenomas (n=103). Data are expressed as percentages (%).

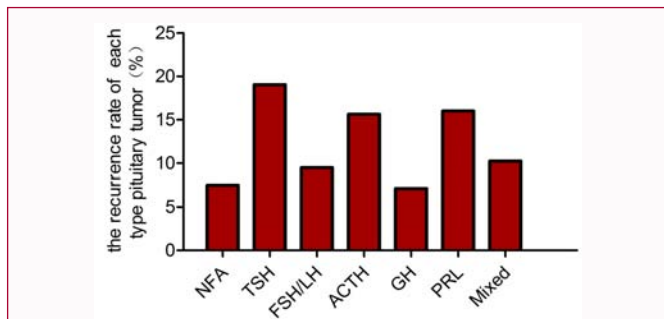


Figure 5: The recurrence rate of each subtype. The percentage is expressed as the ratio of recurrent patients to the corresponding total number of each type of pituitary tumor. Data are expressed as percentages (%).

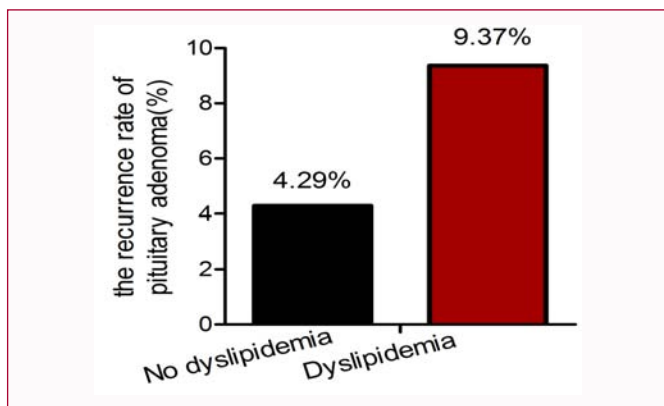


Figure 6: The recurrence rate of pituitary adenoma with or without dyslipidemia at pre-first operative. Data are expressed as percentages.

years for males (range, 1 year to 76 years) and 45 years for females (range, 8 years to 73 years). The flow chart includes the analysis and corresponding data distribution of this study was shown in Figure 2.

All patients in our study underwent transsphenoidal surgery, and the excised tissue was subjected to hematoxylin and eosin and immunohistochemical staining. Immunohistochemical staining of PRL, GH, ACTH, TSH, FSH and LH were performed for adenoma histology after surgery. The clinicopathologic features of the patients and their adenomas are summarized in Table 1. Among the tumors, only a small percentage was chromophobic adenomas (29.2%).

Most were chromatophilic cell adenomas (70.8%), including PRL+ (20.9%), mixed adenomas (17.3%), FSH/LH+ (12.1%), GH+ (11.7%), ACTH+ (6.7%) and TSH+ is the rarest form of pituitary adenomas (2.2%), as the study of Tjörnstrand A et al., [20] said. ACTH+, GH+ and PRL+ adenomas were occurred mostly in females, and FSH/LH+, TSH+ and chromophobic adenomas were occurred mostly in males. No obvious gender difference was observed for mixed adenoma.

In clinical practice, we found that many patients with pituitary adenomas also had dyslipidemia. To determine whether a correlation existed between pituitary adenomas and dyslipidemia, we performed a retrospective study.

First, the proportion of dyslipidemia in all enrolled patients with pituitary adenomas (n=959) was analyzed in Figure 3A,3B. The proportion of dyslipidemia was much higher than that reported previously epidemiological investigation in the general Chinese adult population [21-23].

As shown in Table 2, presenting a scan analysis of lipid profile in patients with different types of pituitary adenomas. We noted that the prevalence of dyslipidemia was over 65% for either type of adenoma. 85.94% (n=55) ACTHoma patients owned dyslipidemia, followed by FSH/LHoma (n=94, 81.03%), chromophobic adenoma (n=226, 80.71%), PRLoma (n=151, 75.5%), TSHoma (n=15, 71.43%), mixed adenoma (n=112, 67.47%) and GHoma (n=73, 65.18%). The major type of dyslipidemia in these patients was mixed dyslipidemia and most of them have high serum TC/LDL-C levels. The basic metabolic information of 959 pituitary adenoma patients was shown in Table 3.

In 959 patients, 774 patients had the data of adenoma size, which was determined based on radiographic data. The sizes of 734 adenomas were >1 cm (median, 2.81 cm, 95%), and 40 were ≤ 1 cm (median, 0.73 cm, 5%). We further explored the relationship between adenoma size and serum lipid profile. As shown in Table 4, the serum TC, TG and LDL-C levels showed a significantly positive association with the adenoma size, whereas the HDL-C levels showed a significantly negative association with the adenoma size, independent of confounding factors. It suggested that there was a close correlation between adenoma size and serum lipid profile.

Serum lipid levels decrease after surgery

To clearly observe serum lipid levels in post-first operative pituitary adenomas, we performed the follow-up of 959 patients post-operatively. A total of 363 patients with complete and reliable clinical data were further analyzed. When analyzing their pre- and post-operative data, we found that the proportion of patients with dyslipidemia was significantly decreased after surgery, from a pre-operative value of 73.0% to a post-operative value of 22.9% (Figure 3C). As presented in Figure 3D, the percentage of patients, who were pre-operative high lipid levels and post-operative normal lipid levels, was greater than 50%.

We also observed the change of serum lipid levels in post-first operative for every subtype of pituitary adenomas (Figure 3E). The prevalence of dyslipidemia decreased 39% to 56% in all pituitary tumor subtype after surgery. These results suggested a correlation between pituitary adenomas and abnormal serum lipid levels.

Serum lipid levels were dependent on pituitary tumor existing in relapsed patients

To further conform the correlation between pituitary adenomas and dyslipidemia, we focused on the serum lipid levels at four check

Table 1: Total number and sex ratio of pituitary adenomas.

	CA	PRLoma	GHoma	ACTHoma	TSHoma	FSH/LHoma	Mixed
Total	280	200	112	64	21	116	166
Percentage (%)	29.2	20.9	11.7	6.7	2.2	12.1	17.3
Male/Female							
Total number	150/130	84/116	39/73	16/48	13-Aug	75/41	75/91
Percentage (%)*	33.2/25.6	18.6/22.9	8.6/14.4	3.5/9.5	2.9/1.6	16.6/8.1	16.6/17.9
Ratio†	1.3:1	01:01.2	01:01.7	01:02.7	1.8:1	2:01	01:01.1

*Percentage is expressed as the ratio to total number of male (N=452) or females (N=507) respectively.

†The gender ratio is expressed as the quotient of percentage of men and women.

Abbreviations: CA: Chromophobe Adenoma; PRLoma: PRL+ Adenoma; GHoma: GH+ Adenoma; ACTHoma: ACTH+ Adenoma; TSHoma: TSH+ Adenoma; FSH/LHoma: FSH/LH+Adenoma; Mixed: ≥ 2 Pituitary Hormones+ Adenoma

Table 2: The analysis of lipid profile in patients with different types of pituitary adenomas.

	CA (n=280)	PRLoma (n=200)	GHoma (n=112)	ACTHoma (n=64)	TSHoma (n=21)	FSH/LHoma (n=116)	Mixed (n=166)	P Value
Age (yr), mean (SD)	50.12 (11.91)	42.16 (13.89)	44.54 (11.49)	44.69 (14.26)	45.81 (15.08)	50.98 (13.50)	43.48 (13.11)	<0.001
BMI, mean (SD)	25.74 (3.99)	25.70 (3.89)	27.66 (6.59)	25.25 (3.50)	24.40 (2.98)	25.31 (2.73)	25.84 (3.88)	0.011
Tumor size (cm), mean (SD)	2.88 (0.97)	2.61 (1.23)	2.38 (1.02)	2.63 (1.37)	2.91 (0.80)	3.02 (0.96)	2.50 (1.37)	<0.001
No Dyslipidemia, No. (%)	54 (19.29)	49 (24.50)	39 (34.82)	9 (14.06)	6 (28.57)	22 (18.97)	54 (32.53)	..
Dyslipidemia, No. (%)	226 (80.71)	151(75.50)	73 (65.18)	55 (85.94)	15 (71.43)	94 (81.03)	112 (67.47)	..
Isolated-hypercholesterolemia, No. (%)	67 (29.65)	43 (28.48)	15 (20.55)	18 (32.73)	4 (26.67)	22 (23.40)	34 (30.36)	..
Isolated-hypertriglyceridemia, No. (%)	12 (5.31)	10 (6.62)	6 (8.22)	5 (9.09)	2 (13.33)	3 (3.19)	7 (6.25)	..
Isolated-low HDL, No. (%)	21 (9.29)	19 (12.58)	15 (20.55)	4 (7.27)	2 (13.33)	10 (10.64)	16 (14.29)	..
Mixed-dyslipidemia, No. (%)	126 (55.75)	79 (52.32)	37 (50.68)	28 (50.91)	7 (46.67)	59 (62.77)	55 (49.11)	..
High TC/LDL-C, No. (%)	99 (78.60)	59 (74.68)	25 (67.57)	20 (71.43)	6 (85.71)	48 (81.36)	42 (76.36)	..
Normal TC/LDL-C, No. (%)	27 (21.40)	20 (25.32)	12 (32.43)	8 (28.57)	1 (14.29)	11 (18.64)	13 (23.64)	..

Continuous variables were compared by using the ANOVA test. $P < 0.05$ was considered significant.

Abbreviations: CA: Chromophobe Adenoma; PRLoma: PRL+Adenoma; GHoma: GH+Adenoma; ACTHoma: ACTH+Adenoma; TSHoma: TSH+Adenoma; FSH/LHoma: FSH/LH+Adenoma; Mixed: ≥ 2 Pituitary Hormones+Adenoma; FPG: Fasting Plasma Glucose; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; TC: Total Cholesterol; LDL-C: Low-Density Lipoprotein Cholesterol; HDL-C: High-Density Lipoprotein Cholesterol; TG: Triglyceride

points (pre-first operative, post-first operative, post-first operative recurrence and post-secondary operative) of all relapsed patients, who undergone two surgeries. A total of 103 relapsed patients had complete and reliable clinical data. Figure 4 shows significant changes in the proportion of pituitary adenoma patients with dyslipidemia during the above four points. The prevalence of patients with dyslipidemia decreased from 83.9% (pre-operation) to 17.6% (post-operation). However, the proportion of dyslipidemia increased again in the patients with recurred pituitary adenomas. The increased lipid levels in the recurred patients reduced again follow the second operation, which fully established that the levels of serum lipid were dependent on pituitary tumor existing, and there was a close correlation between pituitary adenomas and dyslipidemia.

We further studied the recurrence rate of different tumor subtypes among 103 relapsed patients. Among them, 21 of these relapsed cases were chromophobic adenoma, comprising 7.5% of 280 chromophobic adenoma. Other relapsed cases included GH+ (n=8, 7.14% of subjects with pure GH+ adenomas), TSH+ (n=4, 19.05%), ACTH+ (n=10, 15.63%), FSH/LH+ (n=11, 9.48%), PRL+ (n=32, 16%) and mixed adenomas (n=17, 10.24%) (Figure 5). Our results suggested that TSHoma most commonly relapsed, followed by PRLoma. The results revealed that recurrence was associated with the pathological types of tumors.

As shown in Figure 6, the recurrence rate of pituitary adenoma was 9.37% in the patients with dyslipidemia at pre-first operative, and

only 4.29% in the patients without dyslipidemia. Thus, the patients with dyslipidemia at pre-operative made relapsed more common than those patients without dyslipidemia. The results in this section were consistent with our above findings.

Discussion

In this retrospective study, we found that there was strong correlation between pituitary adenomas and serum lipid profile. The evidence was as follows. (1) The proportion of dyslipidemia was very high in the pituitary adenomas either first occurrence or recurrence and (2) The abnormal elevated lipid levels were sharp decreased accompanying the resection of tumor. Additionally, this study further demonstrated that pituitary hormones, except for their traditional target organ effects, also play an important role in other pathophysiological functions of the body.

Chughtai M et al., [24] reported that dyslipidemia is accompanied by obesity. We also noted that the most of the observed patients in this study had body fatness (i.e. overweight and obesity). Acharya R et al., [25] present a rare case of Diabetic Ketoacidosis (DKA) as an initial manifestation of Cushing's disease secondary to ACTH-producing pituitary adenoma. Hypercortisolism caused by Cushing's disease leads to diabetes mellitus, hypertension and obesity [26]. In pituitary adenoma patients, an increased incidence of stroke was observed compared with the general population [27]. Feelders RA et al., [28] reported that GH-producing pituitary adenoma is accompanied by

Table 3: The basic metabolic information of 959 pituitary adenoma patients.

	CA (n=280)	PRLoma (n=200)	GHoma (n=112)	ACTHoma (n=64)	TSHoma (n=21)	FSH/LHoma (n=116)	Mixed (n=166)	P Value
FPG (mmol/L), mean (SD)	5.61 (1.58)	5.39 (1.56)	7.14 (3.87)	5.36 (1.16)	5.11 (0.66)	5.43 (1.58)	6.00 (2.57)	<0.001
SBP (mmHg), mean (SD)	132.25 (18.89)	126.84 (17.25)	134.02 (17.00)	130.44 (16.29)	131.24 (12.34)	132.72 (18.41)	131.22 (20.61)	0.016
DBP (mmHg), mean (SD)	84.10 (12.64)	81.58 (11.16)	84.11 (12.39)	86.32 (14.33)	84.43 (10.43)	84.13 (11.77)	83.75 (13.96)	0.172
TC (mmol/L), mean (SD)	5.33 (1.30)	5.06 (1.19)	4.80 (1.21)	5.53 (1.08)	5.03 (1.26)	5.44 (1.21)	4.97 (1.22)	<0.001
TG (mmol/L), mean (SD)	2.09 (1.77)	1.86 (1.56)	1.73 (1.31)	1.92 (1.02)	2.89 (5.84)	2.15 (1.78)	1.83 (1.60)	0.069
LDL-C (mmol/L), mean (SD)	3.18 (1.00)	3.07 (0.91)	2.92 (0.95)	3.43 (0.89)	2.95 (0.69)	3.33 (0.95)	3.02 (0.87)	0.001
HDL-C (mmol/L), mean (SD)	1.19 (0.32)	1.17 (0.33)	1.21 (0.31)	1.27 (0.43)	1.10 (0.29)	1.15 (0.30)	1.19 (0.27)	0.206
apoA (g/L), mean (SD)	1.22 (0.19)	1.18 (0.20)	1.19 (0.22)	1.25 (0.24)	1.13 (0.18)	1.21 (0.18)	1.18 (0.21)	0.059
apoB (g/L), mean (SD)	1.08 (0.39)	0.99 (0.29)	0.92 (0.27)	1.08 (0.25)	0.93 (0.22)	1.07 (0.31)	0.90 (0.24)	<0.001

Continuous variables were compared by using the ANOVA test. $P < 0.05$ was considered significant.

Abbreviations: FPG: Fasting Plasma Glucose; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; TC: Total Cholesterol; TG: Triglyceride; LDL-C: Low-Density Lipoprotein Cholesterol; HDL-C: High-Density Lipoprotein Cholesterol

Table 4: Estimated marginal means of serum TC, TG, LDL-C and HDL-C levels according to tumor size categories.

	TC			TG			LDL-C			HDL-C		
	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI
Tumor size quartile												
Quartile 1 (<2.0 cm)	4.86	0.08	4.70-5.02	1.51	0.07	1.37-1.66	2.93	0.06	2.80-3.05	1.24	0.02	1.20-1.28
Quartile 2 (2.0 cm-2.6 cm)	5.12	0.09	4.94-5.30	1.94	0.12	1.71-2.18	3.1	0.07	2.96-3.24	1.2	0.02	1.15-1.24
Quartile 3 (2.6 cm-3.4 cm)	5.33	0.08	5.17-5.50	2.08	0.1	1.88-2.27	3.25	0.06	3.12-3.37	1.19	0.02	1.15-1.23
Quartile 4 (≥ 3.4 cm)	5.46	0.1	5.23-5.66	2.48	0.21	2.08-2.89	3.25	0.07	3.11-3.39	1.14	0.03	1.08-1.19
Linear coefficient	0.148			0.166			0.106			-0.124		
P value for linear trend	<0.001			<0.001			0.003			0.001		

Data are estimated marginal mean (mean), corresponding Standard Error (SE) and 95% Confidence Interval (CI).

Abbreviations: TC: Total Cholesterol; TG: Triglycerides; LDL-C: Low-Density Lipoprotein Cholesterol; HDL-C: High-Density Lipoprotein Cholesterol

Values shown were adjusted for age, sex, BMI, FPG and SBP.

A value of $p < 0.05$ was considered statistically significant.

atherosclerosis. These studies fully clarified that there are correlations between pituitary adenoma and obesity, diabetes mellitus, stroke or atherosclerosis. In this study, we did not analyze the correlation between serum lipid profile and diabetes mellitus, coronary heart disease or stroke, because the duration of disease varied before and after surgery. We are not enough to obtain accurate information related to the prevalence of lipid-related cardiovascular and cerebrovascular diseases. However, among 959 patients with pituitary adenoma, we have observed 112 patients owned diabetes mellitus, coronary heart disease or stroke at first pre-operation and found 76% of these patients owned dyslipidemia (data not shown). Additionally, considering the half-life of cholesterol metabolism is 75 days, the serum lipid levels recorded in our study were at least 6 months after surgery [29]. This made us to get credible data.

Pituitary hormone receptors, once thought to be limited to target gland cells, have been detected in numerous extra-target gland tissues. For example, the expression of the TSH receptor has been detected in the liver and adipose tissues [30-32]. Our previous study reported that TSH promoted the activity of HMGCR, a rate-limiting enzyme in cholesterol synthesis, by acting on the TSH receptor in hepatocyte membranes and stimulating the Cyclic Adenosine Monophosphate/Protein Kinase A/Cyclic Adenosine Monophosphate-Responsive Element Binding Protein (cAMP/PKA/CREB) signaling system [13]. We had also reported that TSH increases hepatic triglyceride content through the upregulation of SREBP-1c activity, and increases adipose triglyceride content through glycerol-3-phosphate acyltransferase 3 [14,15]. Additionally, our previous study reported that elevated

TSH triggers mitochondrial ROS, and Babula D et al., [34] reported decreased nitric oxide serum level after pituitary adenoma resection [33]. Although no direct evidence, the aforementioned studies raise the possibility that pituitary adenomas by regulate triglyceride or cholesterol contents in adipose or hepatic tissue, affecting serum lipid levels, and this process may be related to mitochondrial ROS.

Conclusion

This study reports retrospective study data for pituitary adenomas in China and systematically summarizes the relevant lipid profile features. The decrease of serum lipid level after the pituitary adenoma resection and increased of serum lipid level after pituitary adenoma recurrence indicates the relationship between serum lipid level and PA occurrence.

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