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Increasing cumulative cabergoline dose in patients with prolactinoma improves metabolic parameters independently of decrease in prolactin levels

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ABSTRACT

Objectives: In prolactinoma patients treated with cabergoline, all of whom achieved normoprolactinemia, longitudinal changes in metabolic parameters and the factors influencing these changes were investigated.

Methods: This retrospective-longitudinal study was conducted at a pituitary disease center. Medical records of newly diagnosed prolactinoma patients between 2013 and 2023 were reviewed. After applying exclusion criteria, 102 prolactinoma patients were included in the final analysis. Clinical and laboratory parameters of prolactinoma patients were recorded. Metabolic parameters assessed were fasting plasma glucose, lipid levels, fasting insulin levels, HbA1c levels, and Homeostatic Model Assessment-Insulin Resistance (HOMA-IR) levels. Subsequently, metabolic parameters assessed at the initial and final visits were compared, and factors influencing these parameters were analyzed.

Results: All prolactinoma patients were treated with cabergoline, and all were in remission at their final visit. The treatment significantly reduced fasting plasma glucose, HbA1c, and LDL cholesterol levels ($P<0.05$). Although there were improvements in other lipid parameters, fasting insulin, BMI, and HOMA-IR compared to baseline, the differences were not statistically significant. A correlation analysis was conducted to identify factors influencing fasting plasma glucose, HbA1c, and LDL cholesterol levels at the final visit in prolactinoma patients. The analysis revealed that only the cumulative dose of cabergoline significantly impacted all three metabolic parameters ($P<0.05$).

Conclusions: Cabergoline not only balances prolactin levels but also directly improves metabolic health. Current and future evidence clearly indicates that dopamine agonists like cabergoline could be an effective treatment not only for patients with prolactinomas but also for individuals affected by metabolic disorders without hyperprolactinemia.

Keywords: Cabergoline, prolactinoma, glucose profile, lipid profile, metabolism

Prolactinomas are the most common pituitary tumors [1]. A high amount of secreted prolactin leads to well-known effects such as gonadal dysfunction and galactorrhea [2]. However, it also leads to many systemic disorders. One of these is its effect on metabolism. Recently, some negative effects

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of hyperprolactinemia on glucose and lipid metabolism have been demonstrated [3]. Furthermore, normalizing prolactin levels through treatment can bring back metabolic disturbances in patients with prolactinoma [4]. Previous studies have reported hyperglycemia, hyperlipidemia, and increased BMI in patients with prolactinoma. Dopamine agonists, particularly cabergoline, one of the primary treatments for prolactinoma, have been shown to have beneficial effects on these metabolic disturbances [3-5]. This metabolic restoration is attributed to prolactin's normalization, gonadal functions' improvement, and the positive metabolic effects of the dopamine agonists used for treatment [5]. Observing the change in metabolic parameters of prolactinoma patients reveals that both the hormone prolactin and the dopamine agonists, which inhibit the release of this hormone in metabolism, will make an essential contribution to our understanding. This study focused on the longitudinal changes in metabolic parameters in a group of prolactinoma patients treated with cabergoline, all of whom achieved normoprolactinemia. Factors influencing the altered metabolic parameters were also investigated.

METHODS

Study Design and Patients

The study adhered to the ethical principles for medical research involving human participants described in the World Medical Association's Declaration of Helsinki. The Ethics Committee of Istanbul University-Cerrahpasa approved the study (Approval Number: 16.10.2023-711105). This retrospective-longitudinal study was conducted at a pituitary disease center. Medical records of patients newly diagnosed with prolactinoma were reviewed between January 2013 and January 2023. The inclusion criteria were: i) adult patients over 18 years of age, ii) patients clearly diagnosed with prolactinoma based on guidelines [6], iii) patients treated with cabergoline, and iv) patients regularly followed up for at least six months. The exclusion criteria were: i) patients with hyperprolactinemia due to causes other than prolactinoma [7], ii) patients followed without treatment (those whose treatment was completed or those in a drug holiday), iii) patients treated with bromocriptine, iv) patients treated with surgery or radiotherapy, v) patients with incomplete metabolic evaluations at diagnosis and during follow-up, vi) patients receiving medical treatment for diabetes, hyperlipidemia, or obesity, vii) patients with hypopituitarism (however, patients with gonadal dysfunction at diagnosis whose gonadal function improved with cabergoline treatment were included), and viii) patients with insufficient follow-up duration.

The medical follow-up records obtained the patients' clinical and laboratory data and medication use. Data on medication use, duration, dosage, and intervals were reviewed from a government digital database (https://medeczane.sgk.gov.tr/doktor/login.jsp), which provides information on the history of prescribed medications.

Metabolic parameters evaluated at the initial and final visits were then compared, and factors influencing these metabolic parameters were analyzed.

Patient Management and Definitions

Medical therapy with dopamine agonists (DAs) was recommended as the initial treatment approach for patients diagnosed with prolactinoma. Cabergoline was initiated at 0.25-0.5 mg per week, and the DA dose was gradually increased until prolactin levels normalized. In this study, remission was defined as patients in whom symptoms had resolved, tumor progression was absent, and prolactin levels were below 20 ng/mL. Remission status was monitored every six months by evaluating symptoms and measuring prolactin levels.

Collected Data

The following parameters were examined in prolactinoma patients: age, sex, height, weight, body mass index (BMI), presenting symptoms, disease duration, duration of cabergoline use, cumulative cabergoline doses, comorbid conditions, and data on other medications. At the time of diagnosis and the final visits, the following were recorded: pituitary adenoma size, prolactin levels, anterior pituitary hormone levels, fasting plasma glucose, lipid levels, fasting insulin levels, and HbA1c levels. Homeostatic Model Assessment-Insulin Resistance (HOMA-IR) levels were calculated using the formula: fasting plasma glucose (FPG) (mg/dL) × fasting insulin (μU\mL) / 405 [8].

Biochemical Assays

Fasting blood samples were collected between 8:00 and 9:00 AM. Prolactin levels were measured using an electrochemiluminescence immunoassay (ECLIA). FPG, insulin, total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides were measured using enzymatic colorimetric or immunoturbidimetric methods on Roche/Hitachi Cobas c systems.

Radiological Evaluation

High-resolution magnetic resonance imaging (MRI) of the pituitary gland and hypothalamic region was performed on all patients. Images were obtained using 1.5 Tesla MRI machines until 2018, after which a 3 Tesla MRI machine was used. The presence of a hypointense lesion following the intravenous injection of gadolinium indicated a pituitary adenoma. Lateral-lateral, dorsoventral, and craniocaudal diameters were measured, and the largest adenoma diameter was used for analyses.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software (version 27.0). The data were first analyzed for normality using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean ± standard deviation (SD) and median (interquartile range [IQR]). Student's t-tests or analysis of variance (ANOVA) were used to compare means between groups with a normal data distribution. Medians were compared using the Mann-Whitney U test and the Kruskal-Wallis test. Spearman's rank and Pearson correlation tests were employed to calculate correlation coefficients between continuous variables. Frequencies were compared using Pearson's chi-square test and Fisher's exact test. A paired-sample t-test was used to determine whether the baseline metabolic parameters differed from the final visit values. Results were analyzed with a 95% confidence interval, and a P-value < 0.05 was considered statistically significant.

RESULTS

Characteristics of Patients

The records of 328 newly diagnosed prolactinoma patients were reviewed. After applying the exclusion criteria, 102 patients were included in the final analysis. Table 1 presents the general characteristics of the patients.

Changes in Metabolic Parameters During Treatment

The changes in metabolic parameters evaluated at the time of diagnosis and the final visit in prolactinoma patients are presented in Table 2. Treatment significantly reduced FPG, HbA1c, and LDL cholesterol levels (P<0.05 for all). Although there was an improvement in other lipid parameters, fasting insulin, BMI, and HOMA-IR compared to the baseline, the differences were not statistically significant.

Initially, 12 patients had impaired fasting glucose. After treatment, FPG returned to normal in six patients (50%). Data on glucose metabolism of these 12 patients are shown in Table 3. FPG, HbA1c, insulin, and HOMA-IR changes in patients with impaired glucose metabolism were statistically significant (P<0.05 for all). Although there was a decrease in all glucose parameters compared to the baseline after treatment in 90 patients with normal glucose metabolism at the beginning, only the reduction in HbA1c was significant (P<0.01, Table 4). Hypoglycemia, defined as FPG < 65 mg/dL [9], was not observed in any patient.

There were 25 patients with LDL cholesterol levels >130 mg/dL at diagnosis. In 10 (40%), LDL cholesterol level decreased to normal after cabergoline treatment. This group's LDL cholesterol change was significant (baseline: 165.6 mg/dL, last visit: 140.6 mg/dL, P=0.002). There were 20 patients with triglyceride levels above 150 mg/dL at diagnosis. After cabergoline treatment, the triglyceride level of seven patients (35%) returned to normal. The triglyceride change in this group was insignificant (baseline: 273.9 mg/dL, last visit: 215.1 mg/dL, P=0.141). There were 12 patients with HDL cholesterol levels <50 mg/dL in women and <40 mg/dL in men at diagnosis. After cabergoline treatment, HDL cholesterol increased to normal in six patients (50%). However, this increase was not statistically significant (baseline: 36.9 mg/dL, last visit: 40.9 mg/dL, P=0.082).

Factors Affecting the Changing Metabolic Parameters

A correlation analysis was performed to identify fac-

Table 1. General characteristics of patients with prolactinoma

Characteristics	Patients with prolactinoma (n=102)
Sex (female), n (%)	64 (62.7%)
Age at diagnosis (years)	32.7±12.5
Largest adenoma diameter at diagnosis (mm)	10 (8-21)
Prolactin at diagnosis (ng/mL)	226 (109-691)
Maximum cabergoline dose (mg/week)	1 (0.5-2)
Cumulative cabergoline dose (mg)	60 (20-150)
Cabergoline usage time (months)	20 (10-50)
Disease duration (months)	36 (18-60)
Largest adenoma diameter at last visit (mm)	5 (3-12)
Prolactin at last visit (ng/mL)	12 (5-30)
Presentation, n (%)	
Galactorrhea	39 (38.2)
Oligomenorrhea	45 (44.1)
Erectile dysfunction	17 (16.7)
Loss of libido	21 (20.6)
Infertility	5 (4.9)
Visual field deficit	15 (14.7)

Data are shown as mean±standard deviation or median (interquartile range) or n (%)

tors influencing the fasting plasma glucose, HbA1c, and LDL cholesterol levels measured at the final visit in prolactinoma patients. The results are presented in Table 5. The analysis showed that only the cumulative dose of cabergoline used significantly affected all three metabolic parameters (P<0.05 for all).

DISCUSSION

In this study, the metabolic changes in a group of prolactinoma patients treated with cabergoline were longitudinally evaluated. After a median follow-up of three years, the patients' fasting plasma glucose,

Table 2. Comparison of metabolic parameters evaluated at diagnosis and last visit in patients with prolactinoma°

Parameters	At diagnosis	At last visit	OR	95% CI	P value
Plasma glucose (mg/dL)	88.7±19.1	83.9±11.8	2.004	1.987–3.654	**0.048**
Insulin (µU/mL)	14.1±9.4	12.2±6.7	1.584	-0.502–4.273	0.119
HbA1c (%)	5.5±0.5	5.2±0.7	4.019	0.172–0.509	**0.001**
HOMA-IR	2.9±1.2	2.6±1.6	1.487	-0.121–0.803	0.144
Total cholesterol (mg/dL)	193.5±41.7	187.9±39.7	1.429	-2.223–13.357	0.158
LDL-cholesterol (mg/dL)	125.4±37.7	113.5±35.4	3.352	4.839–19.095	**0.001**
HDL-cholesterol (mg/dL)	54.9±14.6	55.3±14.5	-0.273	-2.636–2.001	0.786
Triglyceride (mg/dL)	136.9±58.9	128.5±96.4	0.654	-17.421–34.381	0.515
BMI (kg/m^2)	27.1±3.2	26.9±3.4	0.785	-1.527–1.912	0.711

Data are shown as mean±standard deviation. BMI=body mass index, CI=confidence interval, HDL=high-density lipoprotein, HOMA-IR=Homeostatic model assessment-insulin resistance, LDL=low-density lipoprotein, OR=odds ratio

Table 3. Changes in glucose metabolism with treatment in patients with impaired glucose metabolism at baseline

Parameters (n=12)	At diagnosis	At last visit	OR	95% CI	P value
Plasma glucose (mg/dL)	117.6±29.2	104.8±18.5	3.114	0.487–0.554	**0.003**
Insulin (µU/mL)	19.9±9.8	16.1±8.7	5.584	0.102–0.273	**0.001**
HbA1c (%)	6.1±0.5	5.8±0.7	1.011	-0.163–0.487	0.140
HOMA-IR	4.6±1.8	3.5±1.7	1.487	0.213–0.312	**0.001**

Data are shown as mean±standard deviation. CI=confidence interval, HOMA-IR=Homeostatic model assessment-insulin resistance, OR=odds ratio

HbA1c, and LDL cholesterol levels significantly decreased compared to baseline. In patients with initially impaired glucose metabolism, glucose metabolism returned to normal in 50% of patients with treatment. In addition, 40% of patients with high LDL cholesterol levels achieved normal LDL levels with cabergoline treatment. Moreover, a significant relationship was found between these parameters and the cumulative dose of cabergoline used. It was observed that as the cumulative cabergoline dose increased, the reductions in these metabolic parameters were more pronounced. It is well-established that elevated prolactin levels in prolactinoma patients are associated with metabolic disorders [3]. Previous studies have reported hyperglycemia, hyperlipidemia, and increased BMI in patients with prolactinoma [10-37]. Dopamine agonists, particularly cabergoline, one of the primary treatments for prolactinoma, have been shown to have beneficial effects on these metabolic disturbances. In patients who achieve normoprolactinemia with treatment, improvements in metabolic abnormalities are observed [24-28]. These improvements are attributed to normalization of prolactin levels and the positive metabolic effects of cabergoline [31-33]. The beneficial effects of dopamine agonists on metabolic disorders have been demonstrated even in patients without hyperprolactinemia [24].

Prolactin receptors have been identified in insulin-secreting pancreatic beta cells [16]. Elevated prolactin levels lead to an increase in both beta cell mass and insulin secretion [17]. Additionally, dopamine receptors (D2DR) are also present in beta cells, and the administration of dopamine agonists, such as cabergoline, reduces insulin secretion from the pancreas [38]. Glucose profile and insulin resistance improvements have been reported in prolactinoma patients following cabergoline treatment [26, 27]. Long-term cabergoline therapy has been shown to reduce fasting insulin and HOMA-IR levels, correlating with the cumulative dose of cabergoline [33]. In our study, fasting plasma glucose and HbA1c levels significantly decreased with treatment. However, although insulin and HOMA-IR levels decreased compared to baseline, the changes did not reach statistical significance. The improvement in glucose profiles observed in our study was strongly correlated

Table 4. Changes in glucose metabolism with treatment in patients with normal glucose metabolism at baseline

Parameters (n=90)	At diagnosis	At last visit	OR	95% CI	P value
Plasma glucose (mg/dL)	85.5±18.1	84.6±16.3	2.025	-0.564–0.162	0.052
Insulin (µU/mL)	13.4±6.4	10.6±7.6	4.357	-0.814–0.581	0.140
HbA1c (%)	5.4±0.6	5.2±0.5	1.011	0.175–0.339	**0.001**
HOMA-IR	2.4±1.0	2.3±1.1	3.245	-0.314–0.124	0.120

Data are shown as mean±standard deviation. CI=confidence interval, HOMA-IR=Homeostatic model assessment-insulin resistance, OR=odds ratio

Table 5. Evaluation of factors affecting metabolic parameters that showed significant changes during follow-up using correlation analysis

Metabolic parameters	Cumulative cabergoline dose		Disease duration		Prolactin at last visit	
	P value	r-value*	P value	r-value*	P value	r-value*
Fasting plasma glucose	**0.038**	-0.211	0.097	-0.047	0.226	-0.017
HbA1c	**0.012**	-0.316	0.091	-0.036	0.317	-0.046
LDL-cholesterol	**0.006**	-0.418	0.076	-0.012	0.199	-0.032

*The r value expresses the direction and coefficient of correlation.
LDL: low-density lipoprotein

with the cumulative cabergoline dose. Our findings support the hypothesis that, in addition to prolactin normalization, cabergoline has a beneficial effect on glucose metabolism regulation.

Dyslipidemia has been frequently reported in prolactinoma patients and is characterized by increased total cholesterol, LDL, triglycerides, and decreased HDL levels [35, 36, 39]. Hyperprolactinemia is thought to be responsible for this unfavorable lipid profile by inhibiting apolipoprotein biosynthesis [37]. In our study, improvements in lipid metabolism were observed after treatment compared to baseline. Notably, there was a significant reduction in LDL levels following treatment. Although positive changes were also noted in other lipid parameters, these did not reach statistical significance. Additionally, the improvement in the lipid profile was correlated with the cumulative dose of cabergoline used.

Hyperprolactinemia can lead to increased appetite, weight gain, and obesity [10-14]. Prolactinoma patients have been reported to have higher body fat mass than healthy controls [39]. Moreover, elevated prolactin levels may result from metabolic risk factors such as waist circumference and visceral fat accumulation. It is believed that long-term treatment with cabergoline may improve waist circumference and body composition. Notably, in hypogonadal male prolactinoma patients, the addition of testosterone replacement therapy to cabergoline treatment has been associated with more pronounced improvements in body composition [40]. In our study, although a decrease in BMI was observed after treatment in prolactinoma patients, it did not reach statistical significance. This may be due to excluding hypogonadal patients receiving replacement therapy, in whom improvements are likely more pronounced. Additionally, our study did not perform waist circumference and visceral fat measurements, which may explain the lack of significant changes observed.

This study confirmed that metabolic improvements were observed in prolactinoma patients when disease control was achieved through treatment. Our results suggest that these improvements may be attributed not only to the achievement of normoprolactinemia but also to the beneficial metabolic effects of cabergoline. However, our study has some limitations. First, the causal relationship at the molecular level between metabolic parameters, prolactin, and cabergoline was not established. Nevertheless, the metabolic improvements observed in a relatively large cohort with long-term follow-up are likely attributable to prolactin normalization and cabergoline treatment. Additionally, only patients without gonadal dysfunction were included in the study, meaning that the results are independent of gonadal replacement therapy. Since all patients achieved normoprolactinemia, the findings likely reflect the positive metabolic effects of cabergoline. Another limitation is that patients treated with other modalities, such as surgery, were excluded. However, surgery in our center is typically reserved for more challenging prolactinoma cases [41, 42], which often present with additional hormonal disturbances that could affect the outcomes [43]. A further limitation is the lack of advanced metabolic assessments. Due to the study's retrospective nature, more detailed evaluations, such as oral glucose tolerance tests, apolipoprotein measurements, waist circumference, and body composition analyses, were unavailable. Future prospective, large-scale, and molecular-level studies could provide stronger evi-

dence and highlight metabolic restoration as a therapeutic goal in prolactinoma patients.

CONCLUSION

Prolactin is a hormone with widespread metabolic effects, and elevated prolactin levels have been clearly shown to negatively impact metabolism in prolactinoma patients. Achieving normoprolactinemia through appropriate treatment is critical in restoring these patients' metabolic balance. However, cabergoline provides direct metabolic benefits beyond normalizing prolactin levels. Current and future research suggests that dopamine agonists like cabergoline may represent a powerful therapeutic option not only for prolactinoma patients but also for individuals suffering from metabolic disorders who do not have hyperprolactinemia. This opens up a new and promising treatment avenue for managing metabolic disorders in broader patient populations with dopamine agonists.

Ethics Committee Approval
The study adhered to the ethical principles for medical research involving human participants described in the World Medical Association's Declaration of Helsinki. The Ethics Committee of Istanbul University-Cerrahpasa approved the study (Approval Number: 16.10.2023-711105).

Authors' Contribution
Study Conception: AND, AB, DÖ, SŞ, PK; Study Design: AND, AB, DÖ, SŞ, PK; Supervision: AND, AB, DÖ, SŞ, PK; Funding: N/A; Materials: AND, AB, DÖ, SŞ, PK; Data Collection and/or Processing: AND, AB, DÖ, SŞ, PK; Statistical Analysis and/or Data Interpretation: AND, AB, DÖ, SŞ, PK; Literature Review: AND, AB, DÖ, SŞ, PK; Manuscript Preparation: AND, AB, DÖ, SŞ, PK and Critical Review: AND, AB, DÖ, SŞ, PK.

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REFERENCES

1. Ciccarelli A, Daly AF, Beckers A. The epidemiology of prolactinomas. Pituitary. 2005;8(1):3-6. doi: 10.1007/s11102-005-5079-0.
2. Schlechte JA. Clinical practice. Prolactinoma. N Engl J Med. 2003;349(21):2035-2041. doi: 10.1056/NEJMcp025334.
3. Pirchio R, Graziadio C, Colao A, Pivonello R, Auriemma RS. Metabolic effects of prolactin. Front Endocrinol (Lausanne). 2022;13:1015520. doi: 10.3389/fendo.2022.1015520.
4. Ben-Jonathan N, Hugo ER, Brandebourg TD, LaPensee CR. Focus on prolactin as a metabolic hormone. Trends Endocrinol Metab. 2006;17(3):110-116. doi: 10.1016/j.tem.2006.02.005.
5. Auriemma RS, De Alcubierre D, Pirchio R, Pivonello R, Colao A. The effects of hyperprolactinemia and its control on metabolic diseases. Expert Rev Endocrinol Metab. 2018;13(2):99-106. doi: 10.1080/17446651.2018.1434412.
6. Petersenn S, Fleseriu M, Casanueva FF, et al. Diagnosis and management of prolactin-secreting pituitary adenomas: a Pituitary Society international Consensus Statement. Nat Rev Endocrinol. 2023;19(12):722-740. doi: 10.1038/s41574-023-00886-5.
7. Verhelst J, Abs R. Hyperprolactinemia: pathophysiology and management. Treat Endocrinol. 2003;2(1):23-32. doi: 10.2165/00024677-200302010-00003.
8. Abbasi F, Okeke Q, Reaven GM. Evaluation of fasting plasma insulin concentration as an estimate of insulin action in nondiabetic individuals: comparison with the homeostasis model assessment of insulin resistance (HOMA-IR). Acta Diabetol. 2014;51(2):193-197. doi: 10.1007/s00592-013-0461-2.
9. Morales J, Schneider D. Hypoglycemia. Am J Med. 2014;127(10 Suppl):S17-S24. doi: 10.1016/j.amjmed.2014.07.004.
10. Baptista T, Lacruz A, de Mendoza S, et al. Body weight gain after administration of antipsychotic drugs: correlation with leptin, insulin and reproductive hormones. Pharmacopsychiatry. 2000;33(3):81-88. doi: 10.1055/s-2000-8451.
11. Doknic M, Pekic S, Zarkovic M, et al. Dopaminergic tone and obesity: an insight from prolactinomas treated with bromocriptine. Eur J Endocrinol. 2002;147(1):77-84. doi: 10.1530/eje.0.1470077.
12. Greenman Y, Tordjman K, Stern N. Increased body weight associated with prolactin secreting pituitary adenomas: weight loss with normalization of prolactin levels. Clin Endocrinol (Oxf). 1998;48(5):547-553. doi: 10.1046/j.1365-2265.1998.00403.x.
13. Brandebourg T, Hugo E, Ben-Jonathan N. Adipocyte prolactin: regulation of release and putative functions. Diabetes Obes Metab. 2007;9(4):464-476. doi: 10.1111/j.1463-1326.2006.00671.x.
14. Bina KG, Cincotta AH. Dopaminergic agonists normalize elevated hypothalamic neuropeptide Y and corticotropin-releasing hormone, body weight gain, and hyperglycemia in ob/ob mice. Neuroendocrinology. 2000;71(1):68-78. doi: 10.1159/000054522.
15. Macotela Y, Triebel J, Clapp C. Time for a New Perspective on Prolactin in Metabolism. Trends Endocrinol Metab. 2020;31(4):276-286. doi: 10.1016/j.tem.2020.01.004.
16. Sorenson RL, Brelje TC. Adaptation of islets of Langerhans to pregnancy: beta-cell growth, enhanced insulin secretion and the role of lactogenic hormones. Horm Metab Res. 1997;29(6):301-307. doi: 10.1055/s-2007-979040.

17. Weinhaus AJ, Stout LE, Bhagroo NV, Brelje TC, Sorenson RL. Regulation of glucokinase in pancreatic islets by prolactin: a mechanism for increasing glucose-stimulated insulin secretion during pregnancy. J Endocrinol. 2007;193(3):367-381. doi: 10.1677/JOE-07-0043.
18. Landgraf R, Landraf-Leurs MM, Weissmann A, Hörl R, von Werder K, Scriba PC. Prolactin: a diabetogenic hormone. Diabetologia. 1977;13(2):99-104. doi: 10.1007/BF00745135.
19. Johnston DG, Alberti KG, Nattrass M, et al. Hyperinsulinaemia in hyperprolactinaemic women. Clin Endocrinol (Oxf). 1980;13(4):361-368. doi: 10.1111/j.1365-2265.1980.tb03397.x.
20. Schernthaner G, Prager R, Punzengruber C, Luger A. Severe hyperprolactinaemia is associated with decreased insulin binding in vitro and insulin resistance in vivo. Diabetologia. 1985;28(3):138-142. doi: 10.1007/BF00273860.
21. Atmaca A, Bilgici B, Ecemis GC, Tuncel OK. Evaluation of body weight, insulin resistance, leptin and adiponectin levels in premenopausal women with hyperprolactinemia. Endocrine. 2013;44(3):756-761. doi: 10.1007/s12020-013-9931-0.
22. Wang GJ, Volkow ND, Logan J, et al. Brain dopamine and obesity. Lancet. 2001;357(9253):354-357. doi: 10.1016/s0140-6736(00)03643-6.
23. Kok P, Roelfsema F, Frölich M, Meinders AE, Pijl H. Prolactin release is enhanced in proportion to excess visceral fat in obese women. J Clin Endocrinol Metab. 2004;89(9):4445-4449. doi: 10.1210/jc.2003-032184.
24. Pijl H, Ohashi S, Matsuda M, et al. Bromocriptine: a novel approach to the treatment of type 2 diabetes. Diabetes Care. 2000;23(8):1154-1161. doi: 10.2337/diacare.23.8.1154.
25. Holt RI, Barnett AH, Bailey CJ. Bromocriptine: old drug, new formulation and new indication. Diabetes Obes Metab. 2010;12(12):1048-1057. doi: 10.1111/j.1463-1326.2010.01304.x.
26. Bahar A, Kashi Z, Daneshpour E, Akha O, Ala S. Effects of cabergoline on blood glucose levels in type 2 diabetic patients: A double-blind controlled clinical trial. Medicine (Baltimore). 2016;95(40):e4818. doi: 10.1097/MD.0000000000004818.
27. Pala NA, Laway BA, Misgar RA, Dar RA. Metabolic abnormalities in patients with prolactinoma: response to treatment with cabergoline. Diabetol Metab Syndr. 2015;7:99. Published 2015 Nov 14. doi: 10.1186/s13098-015-0094-4.
28. Berinder K, Nyström T, Höybye C, Hall K, Hulting AL. Insulin sensitivity and lipid profile in prolactinoma patients before and after normalization of prolactin by dopamine agonist therapy. Pituitary. 2011;14(3):199-207. doi: 10.1007/s11102-010-0277-9.
29. Naliato EC, Violante AH, Gaccione M, et al. Body fat in men with prolactinoma. J Endocrinol Invest. 2008;31(11):985-990. doi: 10.1007/BF03345636.
30. Naliato EC, Violante AH, Caldas D, et al. Body fat in nonobese women with prolactinoma treated with dopamine agonists. Clin Endocrinol (Oxf). 2007;67(6):845-852. doi: 10.1111/j.1365-2265.2007.02973.x.
31. dos Santos Silva CM, Barbosa FR, Lima GA, et al. BMI and metabolic profile in patients with prolactinoma before and after treatment with dopamine agonists. Obesity (Silver Spring). 2011;19(4):800-805. doi: 10.1038/oby.2010.150.
32. Korner J, Lo J, Freda PU, Wardlaw SL. Treatment with cabergoline is associated with weight loss in patients with hyperprolactinemia. Obes Res. 2003;11(2):311-312. doi: 10.1038/oby.2003.46.
33. Ciresi A, Amato MC, Guarnotta V, Lo Castro F, Giordano C. Higher doses of cabergoline further improve metabolic parameters in patients with prolactinoma regardless of the degree of reduction in prolactin levels. Clin Endocrinol (Oxf). 2013;79(6):845-852. doi: 10.1111/cen.12204.
34. Pelkonen R, Nikkilä EA, Grahne B. Serum lipids, postheparin plasma lipase activities and glucose tolerance in patients with prolactinoma. Clin Endocrinol (Oxf). 1982;16(4):383-390. doi: 10.1111/j.1365-2265.1982.tb00731.x.
35. Medic-Stojanoska M, Icin T, Pletikosic I, et al. Risk factors for accelerated atherosclerosis in young women with hyperprolactinemia. Med Hypotheses. 2015;84(4):321-326. doi: 10.1016/j.mehy.2015.01.024.
36. Heshmati HM, Turpin G, de Gennes JL. Chronic hyperprolactinemia and plasma lipids in women. Klin Wochenschr. 1987;65(11):516-519. doi: 10.1007/BF01721038.
37. Schwetz V, Librizzi R, Trummer C, et al. Treatment of hyperprolactinaemia reduces total cholesterol and LDL in patients with prolactinomas. Metab Brain Dis. 2017;32(1):155-161. doi: 10.1007/s11011-016-9882-2.
38. Contreras F, Foullioux C, Pacheco B, et al. Effect of drugs interacting with the dopaminergic receptors on glucose levels and insulin release in healthy and type 2 diabetic subjects. Am J Ther. 2008;15(4):397-402. doi: 10.1097/MJT.0b013e318160c353.
39. Posawetz AS, Trummer C, Pandis M, et al. Adverse body composition and lipid parameters in patients with prolactinoma: a case-control study. BMC Endocr Disord. 2021;21(1):81. doi: 10.1186/s12902-021-00733-6.
40. Auriemma RS, Galdiero M, Vitale P, et al. Effect of chronic cabergoline treatment and testosterone replacement on metabolism in male patients with prolactinomas. Neuroendocrinology. 2015;101(1):66-81. doi: 10.1159/000371851.
41. Demir D, Demir AN, Sulu C, et al. The Combination of Dopamine Agonist Treatment and Surgery May Be the Best Option in Challenging Prolactinoma Cases: A Single-Centre Experience. World Neurosurg. 2023;175:e1166-e1174. doi: 10.1016/j.wneu.2023.04.089.
42. Zulfaliyeva G, Demir AN, Cetintas SC, Ozaydin D, Tanriover N, Kadioglu P. Role of Medical and Surgical Treatment in Management of the Patients With Prolactinoma: A Single-Center Experience. Exp Clin Endocrinol Diabetes. 2024 Oct;132(10):570-580. doi: 10.1055/a-2364-6027
43. Ozaydin D, Demir AN, Tanriover N. Evaluation of the gender effect in operated prolactinomas. Eur Res J. 2023;9(5):1135-1141. doi: 10.18621/eurj.1340508.