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INTRAOPERATIVE CHARACTERISTICS OF SOMATOTROPINOMAS

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Background. Acromegaly is a rare disease associated with insulin-like growth factor 1 hyperproduction due to the presence of pituitary adenoma in the patient. The first-line treatment of such patients is surgical removal of the formation in order to normalize hormonal status. The main predictors of the ineffectiveness of surgical treatment and relapse of the disease are large tumor size, tumor invasion into the cavernous sinus, and high preoperative levels of growth hormone, as well as Ki-6 % expression. The search for additional risk factors for disease recurrence, which according to various sources is approximately 30 % after primary surgical treatment, is an urgent task for researchers. In our work, we studied the intraoperative characteristics of the tumor, size of pituitary adenomas according to preoperative magnetic resonance imaging of the brain, degree of invasion of the tumor into the cavernous sinus according to the Knosp classification and compared them with disease outcomes after a year of follow-up after surgical treatment.
Aim. To identify new markers of aggressive progression of pituitary tumors.
Materials and methods. A retrospective analysis of medical documentation, protocols of operations of 90 patients aged between 19 and 73 years with the diagnosis of growth hormone-secreting pituitary adenoma was performed. The diagnosis was confirmed based on clinical picture, laboratory and instrumental examination methods. All patients underwent endoscopic transsphenoidal removal of pituitary adenoma by one surgeon in one medical institution between 2017 and 2019.
Results. Intraoperative characteristics of the tumor, such as the color of the solid component, density, degree of vascularization were compared with the results of laboratory and instrumental data, as well as the results of surgical treatment after a year of follow-up.
Conclusion. Such intraoperative characteristics of growth hormone-secreting pituitary adenomas as the purplish-gray color of the solid component, high vascularization, as well as dense-elastic consistency of the tumor, can be considered high risk factors for continued tumor growth in the first 6 months after surgical treatment or relapse of the disease during a year of follow-up.

Keywords: acromegaly, transsphenoidal surgery, recurrence of GH-secreting adenomas

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INTRODUCTION

Acromegaly is a rare disease with incidence of 2.8 to 13.7 cases per 100 000 people and frequency of 0.2 to 1.1 cases per 100 000 people. In most cases, it is associated with development of a pituitary adenoma secreting growth hormone (GH) [1, 2]. Systemic complications in cardiovascular, pulmonary, osteoarticular systems, disruption of carbohydrate and mineral metabolism as well as high risk of neoplasms in the gastrointestinal tract lead to decreased quality of life and cause high mortality among these patients [3, 4]. Currently, acromegaly is treated with the following methods: surgery and medications (somatostatin analogues, growth hormone receptor antagonists, dopamine agonists), while radiotherapy (external beam gamma therapy, radiosurgery) is less common [5]. The effectiveness of these methods varies, but it should be recognized that the majority of clinicians consider surgical treatment using endoscopic and microsurgical techniques the method of choice. Some data show that microsurgical and endoscopic approaches in treatment of acromegaly have similar effectiveness of 68 % [6]. The aim of surgical treatment is normalization of GH and insulin-like growth factor 1 (IGF-1) levels through total tumor removal or, if radical resection is impossible, through a decrease in its mass [7–10]. Patients who do not achieve hormonal remission after surgical treatment are treated with additional methods of conservative therapy, radiotherapy [11, 5].

The main predictors of ineffectiveness of surgical treatment and disease recurrence are large tumor size, its invasion into the cavernous sinus, and high preoperative growth

hormone levels, as well as Ki-67 expression measured during immunohistochemical examination of operative material.

Identification of additional risk factors of disease recurrence which per various sources is observed in 30 % of cases, is necessary for performance of the necessary diagnostic tests (oral glucose tolerance test, dynamic IGF-1 assay) and additional methods of conservative and radiosurgical treatment after surgical removal of the tumor [12–15].

In this article, intraoperative characteristics of the tumor, pituitary adenoma size per preoperative magnetic resonance imaging (MRI) of the brain, grade of cavernous sinus invasion per the Knosp classification were studied, and disease outcomes depending on these characteristics were analyzed a year after surgical treatment.

The study objective is to investigate intraoperative characteristics of GH-secreting pituitary adenomas and assess their effect on the outcomes of surgical treatment.

MATERIALS AND METHODS

A retrospective analysis of medical documentation, surgery protocols of 90 patients between the ages of 19 and 73 years with the diagnosis of GH-secreting pituitary adenoma was performed. The diagnosis was confirmed based on clinical picture, laboratory and instrumental examinations. Median age was 53 years (Q_1–Q_3; 42–60 years). The number of women was 67 (74.4 %), men – 23 (25.6 %). All patients underwent endoscopic transsphenoidal resection of pituitary adenoma by one surgeon in one medical facility between 2017 and 2019. Primary surgical treatment was performed in 70 (77.8 %) patients. In 20 (22.2 %) patients, surgical intervention was repeated due to disease recurrence: after a year of biochemical remission consistent increased IGF-1 levels were observed. Pure somatotropinomas were verified through histological examination in 75 (83.3 %) patients, mixed adenomas – in 15 (16.7 %) patients. Various classifications of pituitary adenomas exist, and usually microadenomas (under 10 mm) and macroadenomas (larger than 10 mm) are identified. At the N.N. Burdenko National Medical Research Center of Neurosurgery, adenomas between 35 and 60 mm are considered large, above 60 mm – giant [16].

In the studied sample, there were no patients with giant tumors, therefore all patients were divided into three groups according to the tumor size. In 57 (63.3 %) patients, neuroimaging showed pituitary macroadenoma (between 10 and 35 mm), microadenoma (under 10 mm) was observed in 17 (18.9 %) patients, large adenoma (above 35 mm) in 16 (17.8 %) patients. Treatment outcomes were evaluated a year after surgery. Disease recurrence was diagnosed based on neuroimaging, elevated IGF-1 levels compared to normal range for sex and age a year after surgical treatment. Remission was achieved in 58 (64.4 %) patients, in 32 (35.6 %) patients disease recurrence was diagnosed. Residual tumor tissue after surgical treatment was diagnosed based on brain MRI in the projection of surgical intervention in the form of residual tumor fragment (under 1 cm) accumulating contrast agent. In all patients with residual tumor tissue, signs of biochemical remission (normal IGF-1 level) during 6–12 months after surgical tumor resection were present.

Continued tumor growth was diagnosed per brain MRI after surgical treatment and consistent increased IGF-1 level in the first 6 months after surgery. Residual tumor was observed in 29 (32.2 %) patients, it was absent in 61 (67.8 %) patients; continued growth was diagnosed in 10 (12.5 %) patients, 70 (87.5 %) patients did not have continued growth. In the majority of patients (n = 82, 94.1 %), tumor advanced beyond the Turkish saddle. Suprasellar growth was observed in 47 (49.4 %) patients, retrosellar tumor advancement was observed in 8 (9 %) patients, infrasellar growth was observed in almost all of the cases – in 83 (93.3 %) patients, antesellar tumor advancement was observed in 61 (31.5 %) patients. Almost all patients underwent radical tumor resection per intraoperative imaging (n = 72, 93.5 %), however, total removal was confirmed only in 61 (67.8 %) patients after brain MRI. In a small fraction of patients, tumor resection was subtotal which was noted in the surgical intervention protocol (n = 5, 5.9 %), however, neuroimaging confirmed subtotal removal in 29 (32.2 %) patients.

Analysis of cavernous sinus invasion per preoperative contrast-enhanced MRI showed that tumor did not invade the cavernous sinus (Knosp 0) in 14 (15.6 %) patients, invasion into the cavernous sinus not crossing the medial tangent of the supraclinoid internal carotid artery (ICA) and intracavernous ICA (Knosp 1) was observed in the majority of patients (n = 35, 38.9 %); the tumor was localized between the lateral tangent of the supraclinoid and intracavernous ICA (Knosp 2) in 16 (17.8 %) patients, grade Knosp 3 was observed in 24 (26.7 %) patients. Full encasement of intracavernous ICA by the tumor (Knosp 4) was observed in 1 (1.1 %) patient.

Biochemical status of the patient prior to surgery, on day 1 after surgery and one year after surgery is presented in the form of descriptive statistics as categorial and quantitative variables (Tables 1, 2). Surgical material was examined for presence or absence of Ki-67 expression. Immunohistochemical analysis was performed using the standard streptavidin-biotin-peroxidase staining technique in paraffin sections. Reaction was performed using OmniTaqs Universal Streptavidin/Biotin Immunoperoxidase Detection System (Thermo Shandon). In immunohistochemical staining monoclonal murine antibodies (DakoCytomation) against Ki-67 (MIB-1) were used. Immunohistochemical assay showed Ki-67 expression in 54 (60 %) patients, its absence – in 36 (40 %) patients.

Analysis of surgical intervention protocols allowed to identify 3 types of tumors with varying density which was evaluated by the operating surgeon based on subjective intraoperative data during tumor resection. The first group had soft-elastic texture (number of patients n = 6, 6.7 %), the second group had dense-elastic texture (n = 60, 66.7 %),

Table 1. *Descriptive statistics of the patients' biochemical status before and after surgical treatment*

Indicator	Median, Me	Interquartile range, Q_1–Q_3	Number of patients, abs.	Maximum value	Minimum value
Preoperative GH, ng/mL	10	5–26	67	2	170
Change in preoperative GH compared to sex/age normal value, ng/mL	8.80	3.53–27.76	49	0.01	164.7
GH on day 1 after surgery, ng/mL	2.50	1.57–5.01	58	0.03	31.3
Change in GH on day 1 after surgery compared to normal value, ng/mL	2.15	0.89–11.12	15	0.04	26.3
Preoperative IGF-1, ng/mL	601	450.25–823.75	68	186	1283
Change in preoperative IGF-1 compared to sex/age normal value, ng/mL	359	228–605	65	0	1096
IGF-1 one year after surgery, ng/mL	232	178.75–513.00	68	145	1043
Change in IGF-1 compared to sex/age normal value one year after surgery, ng/mL	338	212–456	29	115	856

Note. *Here and in Tales 2, 4, 5, 9: GH – growth hormone; IGF-1 – insulin-like growth factor 1.*

Table 2. *Descriptive statistics of categorical variables*

Indicator	Characteristic	Number of patients. abs. (%)
1	2	3
Sex	Female	67 (74.4)
	Male	23 (25.6)
Preoperative GH level	Elevated	49 (73.1)
	Normal	18 (26.9)
GH level on day 1 after surgery	Elevated	15 (25.9)
	Normal	43 (74.1)
Further changes in GH level compared to baseline on day 1 after surgery	Increase	3 (9.4)
	Decrease	29 (90.6)
Adenomas	GH-adenomas	75 (83.3)
	Mixed	15 (16.7)
Adenoma size	Microadenoma	17 (18.9)
	Macroadenoma	57 (63.3)
	Large adenoma	16 (17.8)
Cavernous sinus invasion grade	Knosp 0	14 (15.6)
	Knosp 1	35 (38.9)
	Knosp 2	16 (17.8)
	Knosp 3	24 (26.7)
	Knosp 4	1 (1.1)
Tumor advancement		
endosellar	Present	82 (91.1)
	Absent	8 (8.9)
retrosellar	Present	81 (91)
	Absent	8 (9)
antesellar	Present	82 (92.1)
	Absent	7 (7.9)
suprasellar	Present	42 (47.2)
	Absent	47 (52.8)
infrasellar	Present	6 (6.7)
	Absent	83 (93.3)
parasellar	Present	28 (31.5)
	Absent	61 (68.5)
Surgery type	Primary, endoscopic transsphenoidal technique	70 (77.8)
	Repeat	20 (22.2)
The degree of radicality of tumor removal (per medical documentation)	Total	72 (93.5)
	Subtotal	5 (6.5)
IGF-1 level one year after surgery	Elevated	32 (35.6)
	Normal	58 (64.4)
Condition one year after surgery	Remission	58 (64.4)
	Recurrence	32 (35.6)
Residual tumor tissue (brain MRI after surgery)	Present	61 (67.8)
	Absent	29 (32.2)
Continued tumor growth in 6 months after surgery	Present	70 (87.5)
	Absent	10 (12.5)

Continuation of table 2

End of table 2

1	2	3
Tumor texture	Dense elastic	60 (66.7)
	Soft elastic	6 (6.7)
	Gelatinous	24 (26.7)
Intraoperative color of solid tumor component	Purplish-gray	27 (30.0)
	Whitish-pink	20 (22.2)
	Whitish-gray	43 (47.8)
Intraoperative tumor vascularization	High	53 (58.9)
	Low	37 (41.1)

Note. *Here and in Table 10: MRI – magnetic resonance imaging.*

the third group had gelatinous texture ($n = 24$, 26.7 %). We have accumulated data on tumor color which was noted in the medical documentation by the operating surgeon based on subjective intraoperative visualization. The majority of tumors had whitish-grey ($n = 43$, 47.8 %) and purplish-grey ($n = 27$, 30 %) colors, whitish-pink tumors were more rare ($n = 20$, 22.2 %).

Tumor vascularization was evaluated and noted by the operating surgeon in the surgical intervention protocol based on subjective intraoperative data obtained during tumor resection. Our group estimated tumor vascularization degree as high ($n = 53$, 58.9 %) if it had abundant blood supply, venous or arterial bleeding during tumor resection requiring constant draining in the surgical field projection. Low tumor vascularization ($n = 37$; 41.1 %) was noted in the medical documentation as tumor tissue with low blood supply and signs of capillary bleeding requiring episodic use of surgical aspirator every 5–10 s.

Statistical analysis was performed using StatTech v. 2.8.1 software (Stattech LLC, Russia). Quantitative characteristics were evaluated for compliance with normal distribution per the Shapiro–Wilk test (if the number of patients was below 50) or Kolmogorov–Smirnov test (if the number of patients was above 50). Quantitative characteristics with normal distribution were described using arithmetic means (M) and standard deviations (SD), confidence interval 95 % range (95 % CI). In the absence of normal distribution, quantitative data were described using median (Me) and lower and upper quartiles (Q_1–Q_3). Categorical data was described using absolute values and percentages. Comparison of 2 groups per a quantitative characteristic with normal distribution in case of equal variances was performed using Student's t-test. Comparison of 3 or more groups per a quantitative characteristic with normal distribution was performed using one factor analysis of variance, post hoc comparisons were performed using Tukey's test (in case of equal variances). Comparison of 2 groups per a quantitative characteristic with non-normal distribution was performed using Mann–Whitney U-test; comparison of 3 groups per a quantitative characteristic with non-normal distribution using Kruskal–Wallis test, post hoc comparisons using Dunn's test with Holm–Bonferroni correction. Comparison of percentages in analysis of 4-way contingency tables was performed using Pearson's chi-squared test (for expected values above 10), Fisher's exact test (for expected values under 10), and in analysis of multi-way contingency tables using Pearson's chi-squared test.

RESULTS

Analysis of tumor color and vascularization degree depending on GH level on day 1 after surgical intervention was performed (Table 3). Significant differences in the compared groups were found (methods used: Kruskal–Wallis test, Mann–Whitney U-test).

Comparative analysis of intraoperative tumor color depending on the presence or absence of Ki-67 expression (Table 4) showed statistically significant differences (Pearson's chi-squared test).

Analysis of the patient group in which GH levels decreased compared to the preoperative value depending on tumor color (Table 5) showed significant differences (Pearson's chi-squared test).

Differences were found in comparative analysis of adenoma sizes depending on tumor density and color (Table 6).

Table 3. *Analysis of growth hormone (GH) levels on the first day after surgical treatment, depending on the color of the tumor and degree of its vascularization*

Intraoperative indicator	Characteristic	GH level on day 1 after surgical treatment, ng/mL		Number of patients, abs. (%)	Statistical significance p
		Median, ng/mL	Q_1–Q_3, ng/mL		
Color of solid tumor component	Purplish-gray	11.71	5.46–18.74	11	<0.05
	Whitish-pink	1.74	1.19–3.04	15	
	Whitish-gray	2.07	1.57–2.79	32	
Tumor vascularization	High	2.91	1.83–5.93	33	
	Low	2.01	1.46–2.88	25	

Table 4. *Analysis of tumor color depending on the presence or absence of Ki-67 expression*

Intraoperative color of solid tumor component	Number of patients, abs. (%)		Statistical significance *p*
	without Ki-67 expression	with Ki-67 expression	
Purplish-gray	11 (21)	16 (44)	<0.05
Whitish-pink	12 (22)	8 (23)	
Whitish-gray	31 (57)	12 (33)	

Table 5. *Tumor color depending on the dynamics of growth hormone (GH) on the first day after surgical treatment*

Intraoperative color of solid tumor component	Number of patients, abs. (%)		Statistical significance *p*
	with increase in GH	with decrease in GH	
Purplish-gray	3 (10)	4 (14)	<0.05
Whitish-pink	0 (0)	8 (27)	
Whitish-gray	0 (0)	17 (59)	

Table 6. *Color and density of the tumor depending on adenoma size*

Indicator	Characteristic	Number of patients, abs. (%)			Statistical significance *p*
		with microadenoma (<10 mm)	with macroadenoma (10–35 mm)	with large adenoma (>35 mm)	
Tumor consistency	Dense elastic	9 (53)	36 (63)	15 (94)	<0.05
	Soft elastic	0 (0)	5 (9)	1 (6)	
	Gelatinous	8 (47)	16 (28)	0 (0)	
Intraoperative color of solid tumor component	Purplish-gray	2 (12)	14 (25)	11 (69)	
	Whitish-pink	5 (29)	14 (24)	1 (6)	
	Whitish-gray	10 (59)	29 (51)	4 (25)	

Table 7. *Analysis of the degree of tumor vascularization depending on the cavernous sinus invasion grade*

Intraoperative tumor vascularization	Distribution of patients according to the degree of tumor invasion into the cavernous sinus, abs. (%)					Statistical significance *p*
	Knosp 0	Knosp 1	Knosp 2	Knosp 3	Knosp 4	
High	7 (50)	15 (43)	13 (81)	17 (71)	1 (100)	<0.05
Low	7 (50)	20 (57)	3 (19)	7 (29)	0 (0)	

Significant differences in tumor density were observed only in the patient groups with microadenomas (under 1 cm) and large adenomas (above 35 cm) (Pearson's chi-squared test).

Analysis of cavernous sinus invasion depending on vascularization degree (Table 7, see Figure) showed significant differences between the studied groups (Pearson»s chi-squared test).

Comparison of intraoperative tumor characteristics depending on first or repeat surgery (Table 8) showed significant differences in the color of the solid component and tumor vascularization degree (Pearson's chi-squared test).

Additionally, the odds ratio (OR) of low vascularization in the primary surgery group were 20 times higher than in the repeat surgery group, and the difference is statistically significant (95 % CI: 2.552–158.599).

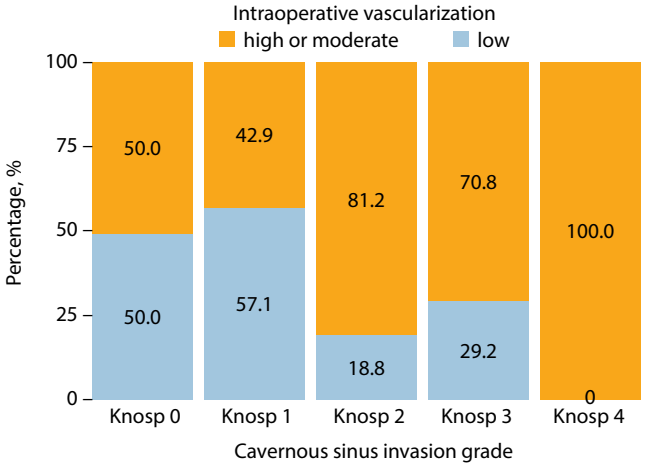
Additionally, analysis of density, color and vascularization degree depending on IGF-1 level and presence of disease recurrence one year after surgical treatment (Table 9) showed statistically significant differences (Pearson's chi-squared test).

Table 8. *Analysis of intraoperative characteristics of the tumor depending on the primary/re-operated operation*

Characteristics of the tumor	Number of operated patients with tumor, abs. (%)		Statistical significance *p*
	primary	repeat	
Consistency:			
Dense elastic	41 (59)	19 (95)	
Soft elastic	6 (8)	0 (0)	
Gelatinous	23 (33)	1 (5)	
Intraoperative color of solid component:			
Purplish-gray	8 (12)	19 (95)	<0.05
Whitish-pink	20 (28)	0 (0)	
Whitish-gray	42 (60)	1 (5)	
Intraoperative vascularization			
High	34 (49)	19 (95)	
Low	36 (51)	1 (5)	

Table 9. *Analysis of intraoperative characteristics of the tumor depending on the level of IGF-1 and presence/absence of disease recurrence after one year of follow-up*

Characteristics of the tumor	Number of operated patients, abs. (%)				Statistical significance *p*
	IGF-1 level within the limits of sexual and age norm 1 year after surgery		Disease remission 1 year after surgery		
	No	Yes	No	Yes	
Consistency:					
Dense elastic	27 (84)	33 (57)	33 (57)	27 (84)	
Soft elastic	0	6 (10)	6 (10)	0	
Gelatinous	5 (16)	19 (33)	19 (33)	5 (16)	
Intraoperative color of solid component:					
Purplish-gray	22 (69)	5 (8)	5 (10)	22 (69)	<0.05
Whitish-pink	4 (12)	16 (28)	16 (27)	4 (12)	
Whitish-gray	6 (19)	37 (64)	37 (64)	6 (19)	
Intraoperative vascularization					
High or moderate	27 (85)	26 (45)	26 (45)	27 (85)	
Low	5 (15)	32 (55)	32 (55)	5 (15)	



Analysis of intraoperative tumor vascularization depending on its cavernous sinus invasion grade

Odds ratio of low vascularization in the recurrence group were 6.646 times lower than in the remission group, the differences are statistically significant (OR = 0.150; 95 % CI: 0.051–0.446).

Odds ratio of low vascularization in the normal IGF-1 group were 6.646 times higher than in the elevated IGF-1 group, the differences are statistically significant (95 % CI: 2.245–19.679).

Differences in analysis of intraoperative tumor characteristic depending on presence of continued tumor growth in the first 6 months after surgical treatment and presence of residual tumor one year after surgical treatment were found (Table 10).

DISCUSSION

In the study, such intraoperative data as tumor color, vascularization level and density were cross-referenced with outcomes of surgical treatment of patients with acromegaly.

Purplish-grey tumor color was more common in tumors expressing proliferative index Ki-67 (n = 16; 44 %) (see Table 4), as well as in patients after repeat surgery (n = 19; 95 %) (see Table 8). Additionally, patients with purplish-grey tumor color had high GH level on day 1 after surgical intervention (median 11.71 ng/ml, Q_1–Q_3; 5.46–18.74 ng/ml), and in 100 % of cases (n = 3) GH

Table 10. *Analysis of intraoperative characteristics of the tumor depending on the continued tumor growth and presence of residual tumor tissue (brain magnetic resonance imaging data)*

Characteristics of the tumor	Number of patients with residual tumor tissue after 1 year of follow-up (brain MRI data), abs. (%)		Number of patients with continued tumor growth in the 6 months after treatment, abs. (%)	
	No	Yes	No	Yes
Consistency:				
Dense elastic	35 (57)	25 (86)	45 (64)	9 (90)
Soft elastic	5 (8)	1 (4)	6 (9)	0
Gelatinous	21 (35)	3 (10)	19 (27)	1 (10)
Intraoperative color of solid component:				
Purplish-gray	6 (10)	21 (72)	18 (26)	8 (80)
Whitish-pink	17 (28)	3 (10)	16 (23)	1 (10)
Whitish-gray	38 (62)	5 (18)	36 (51)	1 (10)
Intraoperative vascularization				
High	28 (46)	25 (86)	40 (57)	8 (80)
Low	33 (54)	4 (14)	30 (43)	2 (20)

Note: *p >0.05 – continued tumor growth; p <0.05 – residual tumor tissue.*

level was elevated compared to preoperative value. GH decrease was observed for whitish-grey tumors (n = 17; 59 %) (see Tables 3, 5). Purplish-grey color was more common in large adenomas (n = 11; 69 %); whitish-pink (n = 5; 29 %) and whitish-grey colors (n = 10; 59 %) were commonly observed in microadenomas (see Table 6). Tumors of purplish-grey color were resected subtotally in 100 % of cases (n = 5). Purplish-grey tumor color in most cases was associated with high IGF-1 level (n = 22; 69 %) and disease recurrence one year after surgical treatment. Moreover, purplish-grey color was associated with continued tumor growth in the first 6 months after surgery (n = 8; 80 %) and verified residual tumor tissue (n = 21; 72 %) (see Tables 9, 10). For whitish-grey tumors (n = 37; 64 %) positive outcomes of surgical treatment were more common.

Higher GH level on day 1 after surgery was observed in patients with high tumor vascularization (median 2.91 ng/ml, Q_1–Q_3 1.83–5.93 ng/ml) (see Table 3). High tumor vascularization was frequent in adenomas with cavernous sinus invasion, as well as in patients undergoing repat surgery (n = 19; 95 %) (see Tables 7, 9, see Figure). Additionally, OR of low vascularization degree in the primary surgery group were 20 times higher than in the repeat surgery group (95 % CI: 2.552–158.599). Odds ratio of low vascularization in the recurrence group were 6.646 times lower than in remission group (OR = 0.150; 95 % CI: 0.051–0.446). Moreover, OR of low vascularization in the patient group with normal IGF-1 one year after surgical intervention was 6.646 times higher than in elevated IGF-1 group (95 % CI: 2.245–19.679).

It was shown that dense-elastic texture was characteristic of large adenomas (n = 15; 94 %), gelatinous texture was characteristic of microadenomas (n = 15; 94 %) (see Table 6). Moreover, dense-elastic texture was more common in repeat surgery group (n = 19; 95 %), patients after primary surgery has soft-elastic (n = 6; 8 %) or gelatinous (n = 23; 33 %) tumors. Elevated IGF-1 (n = 27; 84 %) level and diagnosed tumor recurrence one year after surgery (n = 27; 84 %) were more frequent in patients with dense-elastic tumor texture. In most cases of patients with intraoperative dense-elastic tumor texture (n = 35; 57.4 %), residual tumor tissue was observed during control examinations (see Tables 6, 8–10).

CONCLUSION

Such intraoperative characteristics of GH-secreting pituitary adenomas as purplish-grey color of the solid component, high vascularization and dense-elastic tumor texture can be considered high risk factors for continued tumor growth in the first 6 months after surgery and disease recurrence 1 year after surgery.

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