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PRACA ORYGINALNA
ORIGINAL PAPER

Incidentally detected adrenal tumors – characteristics of patients and incidence of hormonal disorders

Przypadkowo wykryte guzy nadnerczy – charakterystyka pacjentów i częstość występowania zaburzeń hormonalnych

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ABSTRACT

INTRODUCTION: Because of technological development and easier accessibility to diagnostic imaging, incidentally detected adrenal tumors are a frequently diagnosed endocrine disorder. The aim of the paper was to present the characteristics of patients with newly incidentally detected adrenal tumors, with emphasis on the detected hormonal disorders.
MATERIAL AND METHODS: A retrospective, single center study included 96 patients hospitalized due to newly detected adrenal tumor between 2007 and 2014.
RESULTS: Adrenal tumors were detected in 92 patients. The final diagnoses were: incidentaloma – 73 (76%), nodular adrenal hyperplasia – 12 (12.5%), pheochromocytoma – 5 (5.2%), late-onset congenital adrenal hyperplasia – 5 (5.2%), Conn's syndrome – 1 (1.1%). In 94 out of the 96 patients at least one hormonal disorder was detected. The most frequent abnormalities were: incorrect plasma renin activity (67.7% of patients), evening serum cortisol concentration (60.2%, mean level: 8.9 μg%) and morning (48.9%, mean level: 15.4 μg%). A considerable group of patients suffered from comorbidities, such as hypertension (70.8%), impaired glucose tolerance (18.7%) and type 2 diabetes (16.7%). Additionally, the diameter of the tumors was negatively ($p < 0.05$) associated with the serum ACTH level.
CONCLUSIONS: In most of the patients with incidentaloma, despite the lack of characteristic symptoms, it is possible to detect hormonal disorders in laboratory tests. The prevalence of hypertension and diabetes is high in this population of patients.

KEY WORDS

diabetes mellitus, pheochromocytoma, hypertension, Cushing's syndrome, adrenal gland neoplasms, adrenal incidentaloma, hyperaldosteronism

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STRESZCZENIE

WSTĘP: Wraz z gwałtownym postępem technicznym i zwiększoną dostępnością badań obrazowych przypadkowo wykryte guzy nadnerczy stały się częstym problemem endokrynologicznym. Celem pracy była charakterystyka pacjentów z przypadkowo wykrytymi guzami nadnerczy, ze szczególnym uwzględnieniem wykrywanych nieprawidłowości hormonalnych.
MATERIAŁ I METODY: Retrospektywne jednoośrodkowe badanie objęło 96 pacjentów (21 mężczyzn i 75 kobiet w wieku 28–88 lat, mediana 62 lata), hospitalizowanych w latach 2007–2014 z powodu nowo wykrytych guzów nadnerczy.
WYNIKI: Guzy nadnerczy zostały przypadkowo wykryte u 92 pacjentów. Po przeprowadzeniu diagnostyki rozpoznano: gruczolaki nadnercza – incydentaloma – w 73 przypadkach (76%), guzkowy przerost nadnerczy w 12 (12,5%), guzy chromochłonne w 5 (5,2%), późno wykryte wrodzone przerosty nadnerczy w 5 (5,2%) oraz zespół Conna w 1 przypadku (1,1%). Co najmniej jedno zaburzenie hormonalne wykryto u 94 spośród 96 pacjentów. Najczęstszymi zaburzeniami były: nieprawidłowa aktywność reninowa osocza (67,7% pacjentów), nieprawidłowe wieczorne stężenie kortyzolu (60,2%, średnie stężenie: 8,9 μg%) i poranne (48,9%, średnie stężenie: 15,4 μg%). Znaczna grupa pacjentów cierpiała na choroby współistniejące: nadciśnienie tętnicze (70,8%), nieprawidłową tolerancję glukozy (18,7%) i cukrzycę typu 2 (16,7%). Ponadto wykazano odwrotną korelację ($p < 0,05$) największego wymiaru guza ze stężeniem ACTH.
WNIOSKI: U większości pacjentów z przypadkowo wykrytymi guzami nadnerczy, pomimo braku charakterystycznych objawów, można wykryć nieprawidłowości w badaniach hormonalnych. Nadciśnienie i cukrzyca występują u tych pacjentów częściej niż w populacji ogólnej.

SŁOWA KLUCZOWE

cukrzyca, guz chromochłonny, nadciśnienie tętnicze, zespół Cushinga, guz nadnercza, incydentaloma, hiperaldosteronizm

INTRODUCTION

Incidentally detected adrenal tumors – adrenal incidentalomas (AI) – are defined as asymptomatic adrenal tissue mass found upon diagnostic imaging while investigating extra-adrenal disease [1]. Due to technological development and easier accessibility to diagnostic imaging, incidentally detected adrenal tumors are being found increasingly more frequently nowadays. The prevalence of AI is presumably high in the society and ranges from 4% reported in radiological series to 8% in autopsy series [2]. It can be found in almost any age group, however, it is proven that its frequency increases with age [3]. Even though most incidentally discovered adrenal tumors are benign and hormonally inactive adenomas, further examinations are recommended, as some of the tumors may be malignant or hormonally active [1].
According to that, the main aim of further examinations is to diagnose all cases of adenocarcinoma as well as all cases of hormonally active adenomas [4]. In order to define the tumor features, adrenal computed tomography and several hormone tests are performed in each patient with a newly detected adrenal mass. Contrast-enhanced computed tomography is usually enough to decide whether the tumor is a benign adenoma or a malignant adenocarcinoma. The main goal of hormone tests is to exclude pheochromocytoma, hypercortisolism and primary hyperaldosteronism [1]. As evidence shows, the risk of hormonal activity of the tumor is relatively low, with more than 80% of all adrenal tumors being nonfunctioning [5]. Nevertheless, most hormonally active tumors are asymptomatic and due to that, biochemical screening is indicated in every patient, even when there are no symptoms of exceeded hormone levels. The screening consists of multiple hormone tests, but the most important are: urine free cortisol level (UFC), serum cortisol level after an overnight low-dose dexamethasone test and late-night serum cortisol level in order to exclude hypercortisolism, as well as plasma metanephrine and fractionated catecholamines as well as metanephrine in daily urine collection in order to exclude pheochromocytoma [6]. In addition, in patients with hypertension and hypokalaemia, measurement of the plasma aldosterone concentration (PAC) and plasma renin activity (PRA) with calculation of the PAC/PRA ratio is suggested as a screening test for primary aldosteronism [4]. The evaluation of these laboratory tests may be sometimes challenging, considering the number of performed tests and lack of clinical symptoms in most patients. In fact, even in patients with hormonally inactive tumors several slight deviations from the normal values can be found.
The aim of our study was to present the characteristics of patients with incidentally detected adrenal tumors, with special emphasis on the detected hormonal disorders. We focused especially on the results of biochemical evaluation to show which disorders are the most common and what the final diagnoses were in the patients with newly incidentally detected adrenal tumors.

MATERIAL AND METHODS

The study includes the medical records of 96 patients who were hospitalized for the first time in the Department of Internal Medicine and Oncological Chemotherapy in Katowice over the period 2007–2014 with a newly detected adrenal mass. We analyzed the data

from medical histories, such as the auxological parameters (height, weight, body mass index – BMI) and the presence of the diseases of civilization, especially type 2 diabetes (according to fasting plasma glucose levels or oral glucose tolerance test) and hypertension. The most common reasons for referring patients to the diagnostic imaging, which led to accidental detection of adrenal tumors, were determined. Additionally, the size of each tumor was evaluated according to the radiological description. All the patients were thoroughly examined while seeking for hormonal disorders. The laboratory tests included: ACTH, cortisol (morning and evening), aldosterone, ARR, DHEA-S, free testosterone, androstenedione and catecholamines level (patients with suspicion of pheochromocytoma). Urine excretion of cortisol, VMA, metoxycatecholamines were assessed in 24h urine collection. The Synacthen stimulation test was performed among patients in order to measure the levels of 17-OH progesterone.

Statistical analysis

The results were presented using the basic parameters of descriptive statistics such as mean value and standard deviation (SD). The correlations were estimated with Pearson's correlation coefficient for parametric variables and Spearman's rank correlation coefficient for non-parametric variables; $p < 0.05$ was considered as statistically significant. STATISTICA software was used for the calculations.

RESULTS

Due to newly detected adrenal tumors, 21 males and 75 females at the age of 28–88 (median 61.5) were hospitalized. The demographic characteristics of the groups are listed in Table I. The presence of pheochromocytoma symptoms was considered as exclusion criteria for incidental detection of adrenal mass.

In the study group the reasons for conducting diagnostic imaging were pulmonary indications and lumbar spinal disc herniation. Adrenal tumors were revealed in a CT scan in 77 cases (80.2%), sonography in 10 (10.4%) or MRI in 4 (4.2%). The tumors were bilateral in 25% of the cases.

The final diagnoses of adrenal pathology were: adrenal adenoma – incidentaloma – 73 (76%), nodular adrenal hyperplasia – 12 (12.5%), pheochromocytoma – 5 (5.2%), late-onset congenital adrenal hyperplasia – 5 (5.2%), and Conn's syndrome – 1 (1.1%). At the moment of detection the size of the tumors varied significantly. The smallest one was 6 mm in diameter. Few giant adenomas were noted with the largest one 137 x 85 x 95 mm in size.

An increased BMI (> 25) was found in 69 of 96 patients (71.9%), including 36 with obesity (40.4%). A considerable proportion of patients suffered from other diseases of civilization including: hypertension (70.8% of patients), impaired glucose tolerance (18.7%) and type 2 diabetes (16.7%) – Table II.

Table I. Demographic characteristics of groups (patient with Conn's syndrome is omitted)
Tabela I. Charakterystyka demograficzna grup pacjentów (pacjenta z zespołem Conna pominięto)

Data	All patients (n = 96)	Adrenal adenoma (n = 73)	Pheochromocytoma (n = 5)	Late-onset CAH (n = 5)	Nodular adrenal hyperplasia (n = 12)
Gender (M:F)	21:75	16:57	2:3	2:3	1:11
Age (years)	61.5 (28–88)	61.5 (28–88)	63 (30–80)	65 (56–78)	58.5 (52–71)
BMI (kg/m^2)	29.68 ± 5.57	30.14 ± 5.71	28.07 ± 7.39	29.98 ± 4.69	28.68 ± 4.33

Mean ± standard deviation, median (minimum–maximum); CAH – congenital adrenal hyperplasia

Table II. Frequency of diseases of civilization among each group of patients (patient with Conn's syndrome is omitted)
Tabela II. Częstość występowania chorób cywilizacyjnych w poszczególnych grupach pacjentów (pacjenta z zespołem Conna pominięto)

Data	Hypertension	IGT	DM2
All patients (n = 96)	70.8%	18.7%	16.7%
Adrenal adenoma (n = 73)	68.1%	15.3%	16.7%
Pheochromocytoma (n = 5)	80.0%	0.0%	0.0%
Late-onset CAH (n = 5)	80.0%	20.0%	40.0%
Nodular adrenal hyperplasia (n = 12)	83.3%	41.7%	8.3%

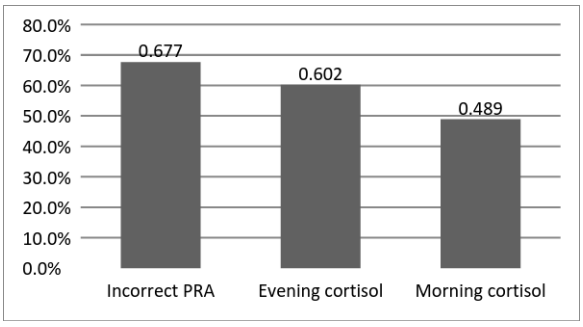
IGT – impaired glucose tolerance; DM2 – diabetes mellitus type 2

All the patients were thoroughly examined in the search for hormonal disorders. The results of the laboratory tests are presented in Table III. Additionally, the comparison of hormone test results concerning the patients with impaired glucose metabolism (diabetes mellitus, impaired glucose tolerance and impaired fasting glucose) and the rest of the patients was conducted. The first group of patients presented a significantly ($p < 0.05$) higher evening serum cortisol level than those with correct glucose metabolism (9.9 µg/dl vs 8.3 µg/dl). The laboratory investigations demonstrated that in 94 out of the 96 patients (98%) at least one hormonal disorder was detected. The most frequent abnormalities were: incorrect plasma renin activity (67.7% of patients), evening serum cortisol concentration (60.2%) and morning (48.9%) – Figure 1.

Table III. Hormone levels of each group of patients (patient with Conn's syndrome is omitted)
Tabela III. Wyniki badań hormonalnych w poszczególnych grupach pacjentów (pacjenta z zespołem Conna pominięto)

Data	All patients (n = 96)		Adrenal adenoma (n = 45)		NAH (n = 12)		PHC (n = 5)		Late-onset CAH (n = 5)		P
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
ACTH (10–60 pg/ml)	22.03	17.84	20.35	14.18	17.77	10.33	21.50	11.73	51.00	45.85	0.43
DHEA-S (μg%)	80.85	68.95	83.93	74.76	50.30	18.08	72.78	48.78	115.78	66.79	0.45
Free Testosterone (< 4.1 pg/ml)	2.83	5.01	2.45	4.16	4.18	8.92	2.26	1.72	6.81	6.61	0.28
Noradrenaline (< 600 pg/ml)	847.94	1655.77	830.00	1864.85	602.33	13.65	1212.50	573.84	783.50	669.63	0.13
Adrenaline (< 100 pg/ml)	35.14	33.31	32.73	21.85	7.67	4.73	47.48	35.24	104.00	140.01	0.20
Cortisol M (5–15 μg%)	15.43	5.11	15.79	5.22	14.47	5.65	12.66	4.28	15.22	4.01	0.62
Cortisol E (2.5–7.5 μg%)	8.87	3.65	8.70	3.94	10.46	2.93	7.32	1.88	8.22	1.88	0.17
Aldosterone (1–16 ng%)	14.04	8.56	14.29	7.93	11.30	5.00	10.68	8.68	10.88	2.50	0.26
Androstenedione (0.4–3.4 ng/ml)	1.11	1.01	1.12	1.01	0.67	0.28	0.88	0.56	2.66	1.94	0.39
PRA (0.5–1.9 ng/ml/h)	0.95	2.25	0.60	0.92	2.81	5.43	0.54	0.51	1.88	2.51	0.34
Cortisol Urine (28–276 μg/24h)	212.14	69.04	207.64	62.67	245.20	103.32	194.40	60.02	218.25	80.45	0.42
Aldosterone Urine (2.3–21.4 μg/24h)	9.43	13.74	7.62	4.60	9.59	4.84	7.93	5.12	30.16	51.35	0.31
Metanephrine (0–1.0 mg/24h)	0.87	0.48	0.82	0.39	0.82	0.44	1.35	1.08	0.99	0.58	0.66
VMA (< 60 μmol/24h)	45.46	18.16	44.81	17.10	48.08	26.80	43.70	9.98	55.37	29.98	0.99

Aldosterone Urine (μg/24) – 24h urine secretion of aldosterone, Cortisol M – morning serum cortisol concentration, Cortisol E – evening serum cortisol concentration, Cortisol Urine – 24h urine secretion of cortisol, Metanephrine – 24h urine secretion of metanephrine, NAH – nodular adrenal hyperplasia, VMA – 24h urine secretion of vanillylmandelic acid, PRA – plasma renin activity, SD – standard deviation, PHC – pheochromocytoma



PRA – plasma renin activity

Fig. 1. Most frequent hormonal abnormalities.
Ryc. 1. Najczęstsze nieprawidłowości hormonalne.

Abnormal cortisol secretion was also frequent among the patients who were finally diagnosed with non-secreting incidentaloma, presented no Cushing's syndrome symptoms and had a correct urine cortisol level: the evening serum cortisol concentration was raised in 55.4% of the patients (mean level 11.1 μg%) and morning in 50% (mean 19.8 μg%). Additionally, the largest diameter of tumors was negatively ($p < 0.05$) associated with ACTH, DHEA-S, adrenaline and androstenedione levels (Table IV, Figure 2).

Table IV. Statistically significant correlations between largest diameter of tumor and hormone levels during first hospitalization
Tabela IV. Statystycznie istotne korelacje między największym wymiarem guza i wynikami badań hormonalnych w czasie pierwszej hospitalizacji

Data	Valid N	R	p-value
Largest diameter of tumor & ACTH (pg/ml)	73	-0.380488	**0.000898**
Largest diameter of tumor & DHEA-S (μg%)	76	-0.329298	**0.003677**
Largest diameter of tumor & Adrenaline (pg/ml)	44	-0.327312	**0.030100**
Largest diameter of tumor & Androstenedione (ng/ml)	69	-0.386372	**0.001041**
Largest diameter of tumor & Morning cortisol (μg%)	82	0.015991	0.886616
Largest diameter of tumor & Evening cortisol (μg%)	79	0.155941	**0.169955**

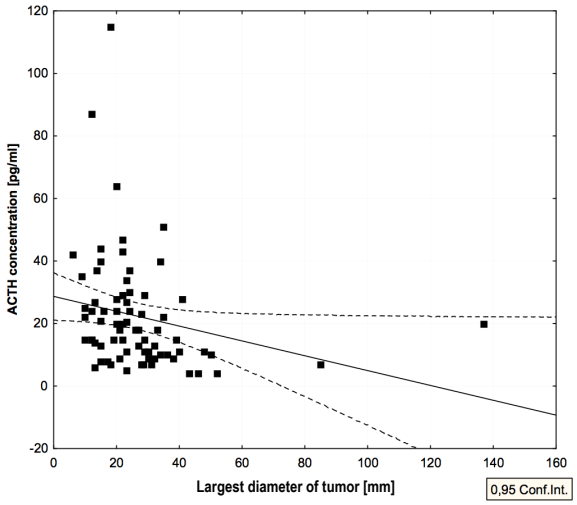


Fig. 2. Correlation between largest diameter of tumor and ACTH concentration.
Ryc. 2. Korelacja między największym wymiarem guza i stężeniem ACTH.

DISCUSSION

In our study, we analyzed the characteristics of patients with a newly detected adrenal mass. As was mentioned before, the age of the patients ranged between 28 and 88 years old with a median of 62. It is consistent with the data from the literature suggesting that incidentally detected adrenal tumors may occur across all age groups of adults, however, they are more often detected in older patients [3]. 78.5% of the patients were females and 21.5% males. This gender disproportion is higher than reported in most studies where it was almost equal, with only a slight preponderance either of females [5,7] or males [8]. According to the literature, unlike adrenocortical carcinoma, which is found more often in females, the prevalence of nonfunctioning tumors is believed to be slightly higher in males [9]. Due to that, the disproportion in our study may be a result of coincidence or may stem from the fact that women make far greater use of health care services, which is often reported in other studies [10]. Many of the analyzed patients suffered from comorbidities and the most frequent was arterial hypertension, which was present in 70.8% of the patients. Type 2 diabetes mellitus was found in 16.7%, while an additional 18.7% suffered from impaired glucose tolerance (IGT). These numbers are high in comparison to the general population, as the prevalence of hypertension in the Polish population reported in large epidemiological studies ranges from 29% (NATPOL PLUS study) [11] to 60.3% (PURE study) [12]. At the same time, the prevalence of diabetes according to the NATPOL study performed on a representative sample of Polish adults was 6.7% [13].

In the study group the reasons for conducting diagnostic imaging varied. The most frequent were pulmonary indications and lumbar spinal disc herniation. The most frequent radiological procedure, which located 77 (80.2%) adrenal tumors, was CT scan. Tumors were found incidentally in 90 patients. The size of the tumors varied. Although some of them were significantly large, they were all asymptomatic. In the final diagnosis all the tumors were characterized as benign, however, after biochemical evaluation several of those non-symptomatic tumors turned out to be hormonally active. There were 3 cases of pheochromocytoma (3.3%) and 1 of primary hyperaldosteronism (1.1%). An additional 4 patients (4.4%), after performing an ACTH-stimulation test, were diagnosed as late-onset (non-classic) congenital adrenal hyperplasia (CAH). The rest of the patients had either inactive adrenal adenoma (uni or bilateral) or adrenal cortical hyperplasia, 71 (78.9%) and 10 (11.1%) respectively. No case of Cushing's syndrome was diagnosed. Similar results with domination of benign hormonally-inactive tumors were obtained in other studies [5,8,14,15,16,17]. Out of 6 patients with non-incidentally detected adrenal tumors (there had been a suspicion of adrenal pathology prior to diagnostic imaging) 2 had pheochromocytoma, 1 – late-onset CAH, 2 – adrenal cortical hyperplasia and 1 – benign adenoma.

During analysis of the results of the hormone laboratory tests we found out that in almost all the patients with complete hormonal evaluation (97.9%) at least one incorrect hormone level was detected. The most common was incorrect plasma renin activity (PRA). However, PRA is very variable and hence non-specific. Only in one patient, also after calculating the aldosterone/renin ratio (PAC/PRA), it enabled us to diagnose Conn's syndrome. More interesting were the cortisol results. The serum cortisol concentration was elevated in the evening in 60.2% of the patients, whereas in the morning in 48.9%. Interestingly, cortisol concentration abnormalities were also common when only the cases that were finally diagnosed as non-secreting adenoma had been analyzed. In this group, the serum cortisol concentration in the morning was raised in 50% and in the evening in 55.4%. At the same time, these patients did not present clear signs of Cushing's syndrome (CS), nor raised 24h urinary free cortisol concentration. Owing to that, CS could not be diagnosed in any of the patients. We need to point out, that some other studies reported the presence of CS among patients with incidentalomas, however, its prevalence was rather low, usually < 5% [8]. Patients are more often diagnosed with subclinical Cushing's syndrome (SCS) or subclinical hypercortisolism (SH). It is defined as ACTH-independent cortisol hypersecretion without clinical features of CS [18]. Its prevalence in studies varies, partly because of the fact that there is no clear consensus on the diagnostic criteria [19]. In fact, the new European Society of Endocrinology guidelines avoid the term SCS and use 'autonomous cortisol secretion' instead [1]. Loh et al. [20] in a large meta-analysis study assessed the SCS prevalence at 6.3% of adrenal incidentalomas. In our study no patients were diagnosed with SCS, as there were no abnormalities in the 24h urinary free cortisol concentration, and therefore dexamethasone suppression test (DST), which is now recommended to assess autonomous cortisol hypersecretion, had not been per-

formed. On the other hand, our analysis of the correlation between the tumor size (tumor largest diameter) and hormone levels shows a moderate negative correlation with the serum ACTH concentration and positive, but statistically insignificant with the evening serum cortisol concentration. Such a correlation was not observed between the BMI and cortisol concentration, as obesity, which was present in 40.4% of the patients, may be a confounding factor. These results may suggest that in some patients with adrenal incidentalomas slight autonomous cortisol hypersecretion can be found. Our findings were consistent with the conclusions of the scientists from the Medical University of Gdansk, who described a positive correlation between the tumor size and urinary cortisol excretion as well as serum cortisol concentration after DST [21].

The role of subtle subclinical cortisol hypersecretion still needs to be studied. Although it causes no symptoms of Cushing's syndrome, it may result in a higher prevalence of arterial hypertension and diabetes mellitus [22,23]. New evidence has shown that even physiological cortisol concentration levels may be correlated with a risk of diabetes. A Japanese study, performed on a group of patients without diabetes or steroid treatment proved that higher physiological cortisol levels are associated with decreased secretion of insulin [24]. This may explain the results of another prospective research that showed an increased risk of diabetes in patients with nonfunctional adrenal tumors in comparison to those without adrenal tumors (adjusted risk ratio 1.87) [25]. In our study we observed a significantly higher evening serum cortisol concentration in the patients with impaired glucose metabolism than in the rest of the study group (9.9 μg/dl vs 8.3 μg/dl). It should be mentioned, that not only a higher cortisol concentration may be a risk factor for diabetes, but also patients with poor glycemic control present subtle abnormalities in the hypothalamus-pituitary-adrenal glands (HPA) axis [26].

The fact that autonomous cortisol secretion (or SCS) is more often detected in patients with bilateral adrenal adenoma may constitute another piece of evidence that cortisol concentration is positively correlated with the tumor volume [27]. In addition, studies have shown that unilateral adrenalectomies may be beneficial in patients with autonomous cortisol secretion and comorbidities that are potentially related to cortisol excess [28]. The impact of subclinical cortisol hypersecretion may be another argument for the hormonal follow-up of patients with adrenal incidentalomas. However, despite the fact that the European Society of Endocrinology suggests that there is no need to repeat the follow-up in patients with non-secreting incidentalomas [1], studies have shown that over the 4-year follow-up period even 12% of patients with nonfunctioning adenomas may present intermittent subclinical hypercortisolism. That is the reason why Morelli et al. [29] suggest a 5-year control period in all patients with AI.

All of the facts presented above point out that in patients with incidentally detected adrenal tumors, despite the lack of characteristic symptoms, some hormonal disorders could be detected in laboratory tests. Moreover, in almost all the cases (98% of the patients) basic endocrinology laboratory assays, which can be conducted in any department of internal medicine, are sufficient to discover hormonal abnormalities. It is relevant to highlight the issue of hypertension and diabetes, which are other diseases that may suggest hypercortisolism and are more frequently found among patients with adrenal tumors than in the general population. Our data confirms a negative correlation between the largest size of tumor and serum ACTH, which could be explained by potential subtle cortisol hypersecretion by tumors, as even among patients with relatively small adrenal neoplasms, hormonal disorders (including elevated cortisol concentration) are detectable.

What makes our study noteworthy is the fact that it comprises an entire group of hospitalized patients with a newly detected adrenal mass in one department during an eight-year study period. In addition, by means of careful descriptive and statistical analysis of all the performed laboratory tests, we focused on the process of diagnosis and clinical evaluation of newly incidentally detected tumors. We also presented the reasons for performing diagnostic imaging and the employed radiological techniques. However, the weakness of this study lies in the fact that because of the lack of a control group, we were not able to compare the hormone levels and prevalence of comorbidities to the general population.

CONCLUSIONS

Our study shows that adrenal tumors can be detected in different age groups upon diagnostic imaging performed for reasons unrelated to adrenal or even abdominal pathology. Careful biochemical evaluation is crucial in this kind of findings, as even when there are no symptoms, some potentially life-threatening diseases, such as pheochromocytoma, can be found among clinically silent tumors. In addition, a prevalent proportion of patients with incidentally detected adrenal tumors, despite the lack of characteristic symptoms, is likely to have hormonal disorders detected in laboratory tests. Our results suggest that some tumors may present subtle cortisol hypersecretion that may be associated with the higher prevalence of civilization diseases in this group of patients in comparison to the general population.

Author's contribution

Study design – I. Grochoła, M. Winder, K. Kocot, T. Menżyk
Data collection – M. Winder, K. Kocot, T. Menżyk
Data interpretation – I. Grochoła, K. Kocot, T. Menżyk
Statistical analysis – K. Kocot, T. Menżyk
Manuscript preparation – I. Grochoła, M. Winder, K. Kocot, T. Menżyk
Literature research – K. Kocot, T. Menżyk, J. Wojnar

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