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***Ocena możliwości posturalnych u pacjentów z pierwotną, wtórną
i trzeciorzędową nadczynnością przytarczyc***

**Rozprawa na stopień doktora nauk medycznych i nauk o zdrowiu
w dyscyplinie nauki medyczne**

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11. Abstract

Assessment of Postural Capabilities in Subjects with Primary, Secondary and Tertiary Hyperparathyroidism

Introduction: Hyperparathyroidism is an endocrine disorder that is caused by excessive production of parathyroid hormone (PTH) by the parathyroid glands and can lead to the development of osteoporosis. In recent years, the disease has aroused more and more interest, and the cause of this condition is seen in the epidemiological situation of osteoporosis in the world. Current reports indicate that abnormal PTH levels observed in subjects may also be one of the factors increasing the risk of uncontrolled falls. Therefore, it should be suspected that subjects with hyperparathyroidism constitute a group of increased risk in terms of the occurrence of disorders within the mechanisms responsible for the control of body posture.

Aim: Assessment of the influence of various functional states of primary, secondary and tertiary hyperparathyroidism on the quality of the process of maintaining balance based on posturographic examination before and after surgery.

Material and Methods: The study was conducted on a group of subjects diagnosed with primary, secondary, tertiary hyperparathyroidism, referred for parathyroidectomy at the Department of General, Endocrine and Vascular Surgery, Independent Central Clinical Hospital in Warsaw (SP CSK), in a randomly selected group of subjects aged 32-77 years (mean age: 57.33 ± 11.68 years). The study was conducted in three stages: pre-operative, immediately post-operative, and six months after parathyroidectomy. During the preoperative period and six months after parathyroidectomy, the subjects underwent the following assessments: posturographic evaluation using the PEL 38 pedobarograph, assessment of the subject's clinical condition based on an original questionnaire, assessment of functional capabilities using the modified WOMAC questionnaire, assessment of pain intensity using the VAS scale. Moreover, in the immediate postoperative period, the subjects underwent a posturographic evaluation. The obtained results were statistically analysed using the IBM SPSS Statistics 25 software package. Basic descriptive statistics were analysed with Shapiro-Wilk tests, Mann-Whitney U tests, Friedman tests, two-way analyses of variance in an intra-group scheme, one-factor variance analyses in an

intra-group regimen, correlation analyses with Pearson's r coefficient, Spearman's rank correlation ρ analysis, Fisher's exact tests. The classical threshold $\alpha = 0.05$ was considered the level of significance, however, the test statistic probability results at the level of $0.05 < p < 0.1$ were interpreted as significant at the statistical trend level.

Results:

1. Subjects with primary, secondary and tertiary hyperparathyroidism in the period preceding parathyroidectomy had significantly worse results in terms of the length parameter and the average rate of COG sways in the conditions of disabled visual control, compared to the results obtained in the postoperative period.
2. There was no correlation between the sex of the examined subjects with hyperparathyroidism and the values of the parameters of the posturographic examination.
3. There was a correlation between age, BMI and the values of selected posturographic parameters in the examined subjects with hyperparathyroidism. The age of the subjects correlated positively with the value of the parameters of length and the average rate of COG sways with maintained visual control in measurement I preceding the parathyroidectomy. There was also one relationship at the level of the statistical trend, in which the area of COG sways under the conditions of maintained visual control in the preoperative period positively correlated with the age of the subjects. In terms of sex of the subjects, statistically significant changes were recorded only in the subgroup of female subjects. A positive correlation was also shown between BMI and the values of the examined posturographic parameters with maintained visual control (the length and the average speed of COG sways) in the first measurement preceding the surgery.
4. Significant changes in the tested biochemical parameters were demonstrated before and after surgery. There was a significant difference between the values of the tested biochemical parameters, calcium concentration, PTH and phosphate in the period preceding the parathyroidectomy, and the results obtained after the surgical treatment. For the Ca parameter, all the observed concentration changes between measurements were statistically significant. The highest result was obtained in the preoperative period and the lowest in the period immediately after the

parathyroidectomy. Two statistically significant changes were found for the PTH and phosphate parameters, where the results obtained in the preoperative measurement I differed significantly from the immediate postoperative measurement and the results obtained six months after the surgical treatment.

5. In the preoperative period, the analysis of the entire study group showed the existence of a positive correlation between PTH concentration and all three posturographic parameters analysed with disabled visual control in the preoperative measurement. Moreover, a certain statistical tendency was observed, in which the concentration of PTH and phosphates positively correlated with the selected posturographic parameters in the examination with open eyes. The analysis taking into account sex of the subjects showed that in the preoperative period, the correlation between the values of the selected posturographic parameters and the concentration of the assessed parameters of calcium-phosphate metabolism was observed only in the subgroup of male subjects.

When analysing the results of the whole group in the immediate postoperative period, only the relationships at the level of statistical tendency were observed between the values of the length and the area of COG sways in the variant with open eyes and PTH concentration. Meanwhile, taking into account sex of the subjects, only in the group of male subjects there was a correlation at the level of statistical tendency between the concentrations of PTH and phosphates and the values of the selected posturographic parameters in the study with maintained visual control.

Six months after the parathyroidectomy, a positive correlation was observed in the study cohort between the concentration of phosphates and the selected posturographic parameters in the conditions of disabled visual control. Moreover, a certain tendency was revealed regarding the relationship between the concentrations of Ca and phosphates and the values of certain posturographic parameters with maintained visual control. Taking into account sex of the subjects, statistically significant correlations were observed only in the subgroup of male subjects.

6. There was a significant reduction in the declared pain intensity in the final measurement six months after the parathyroidectomy. The sex difference was not significant, however, the strength of the observed effect was clearly higher in the group of female subjects.

7. There was no evidence of a relationship between pain intensity reported by subjects and the values of the assessed posturographic parameters, both in the period preceding the surgical procedure and six months after the implementation of treatment.
8. Functional abilities of the study subjects assessed on the basis of the modified WOMAC questionnaire improved significantly in the final measurement, six months after the parathyroidectomy. Sex difference was not significant, however, the strength of the observed effect was clearly higher in the group of female subjects.
9. The functional status of subjects in the preoperative period, assessed with the modified WOMAC, has not been shown to affect the analysed posturographic parameters, both in the analysis of the whole group analysis and in sex subgroups of subjects. Meanwhile, six months after parathyroidectomy, two relationships were noticed at the level of statistical trend in the group of female subjects, in which the values of the parameters of length and average speed of COG sways with disabled visual control correlated negatively with the result obtained in the modified WOMAC questionnaire.
10. It has not been demonstrated that the subjects who experienced a fall within the last year achieved different results in terms of the examined posturographic parameters compared to those who had not experienced them. Meanwhile, when analysing the relationship between a past fracture and the postural stability in the group of subjects with hyperparathyroidism, two results were observed at the level of statistical tendency, in which subjects who had experienced fractures presented higher parameters of length and average speed of COG sways with eyes open in the immediate postoperative period. When analysing the results, taking into account sex division, changes were observed only in the group of female subjects. The analysis of the entire study group showed that the subjects declaring muscle weakness in the lower extremities obtained significantly higher values of the parameter of COG sways area with eyes open in the immediately postoperative measurement II, compared to those who had not been experiencing it. However, no significant correlations were observed, taking into account the subgroups of female and male subjects.

It was not been shown that the subjective experiences of balance disorders reported by subjects had been affecting the values of the assessed parameters of the posturographic examination.

11. A statistically significant change in the level of physical activity declared by subjects in the preoperative period and six months after the parathyroidectomy was observed. In the baseline measurement, sex difference was not significant, whereas in the final measurement, a higher level of declared physical activity was achieved by male subjects. In the entire study group, improvement was observed in nine subjects, and deterioration in one subject. Meanwhile, when analysing sex division, changes in the declared level of physical activity were significant; there were five cases of improvement and no cases of deterioration.
12. In the period preceding the parathyroidectomy, the level of physical activity in subjects with hyperparathyroidism negatively correlated with the values of the parameters of length and average speed of COG sways in examination with visual control. Meanwhile, in the analysis taking into account sex division, in the subgroup of male subjects, a negative correlation was found between the level of physical activity and the values of COG sway area with maintained visual control. However, no relationship was found between the level of physical activity declared by subjects and the values of the analysed posturographic parameters in the immediate postoperative period and six months after the surgical treatment.
13. A significant change in the subjective assessment of health condition was demonstrated in the group of subjects with hyperparathyroidism, measured before and six months after parathyroidectomy. In the whole study group, improvement was observed in twenty subjects, whereas deterioration in two subjects, and significant changes were observed in both the female and male groups. Whereas in the period preceding the parathyroidectomy in the subgroup of male subjects, there was a negative correlation between the declared health condition and the value of the parameter of COG sway area in the test with eyes open, no correlation was observed in the immediate postoperative period, even at the level of statistical trend. In the examination performed 6 months after the parathyroidectomy, a positive correlation was found in the group of female subjects between the declared health condition and the values of the parameters of length and average COG sways in the variant with closed eyes. Moreover, a similar positive correlation at the level of statistical trend was observed for the entire study group, without taking into account

sex division.

14. A detailed analysis of clinical symptoms reported by subjects with hyperparathyroidism in the preoperative period showed a significant sex difference in the incidence of two symptoms. Nephrolithiasis was more common in the female group, and more frequent urination was observed in the male group. Two relationships were also revealed at the level of statistical tendency for the next two symptoms, in which female subjects more often declared irritability, while male subjects reported pancreatitis. Meanwhile, the final study performed six months after the parathyroidectomy showed two significant differences, in which female subjects more often experienced muscle weakness and problems with concentration compared to the group of male subjects. Additionally, as in the preoperative period, a tendency of increased incidence of pancreatitis was observed in male subjects. It has also been shown that in the case of problems with concentration and irritability, there are significant changes taking place in the reported clinical symptoms between the first and the final examinations.

Conclusions:

1. Parathyroidectomy can positively influence the improvement of body stability in the group of subjects with hyperparathyroidism.
2. In the examined group of subjects, sex had no effect on the stability of body posture assessed in static conditions, which was confirmed by the lack of significant differences between the values of the selected posturographic parameters determining COG sways.
3. Age and BMI may have a significant impact on the selected posturographic parameters characterising body stability in the group of subjects with hyperparathyroidism.
4. The parathyroidectomy procedure influences the normalization of calcium – phosphate metabolism.
5. High concentration of PTH observed in subjects with hyperparathyroidism before parathyroidectomy may contribute to the deterioration of postural body control.
6. Parathyroidectomy significantly reduces the intensity of perceived pain (VAS) and improves the functional state (mod. WOMAC) in the group of subjects with

hyperparathyroidism. However, it has not been shown that these changes are significantly related to the values of the assessed posturographic parameters.

7. There is a moderate suspicion that higher values of the selected posturographic parameters characterising COG uptake in subjects with hyperparathyroidism may lead to an increased risk of fractures in this group of subjects.
8. The history of falls reported by subjects over the last year did not deteriorate the stability of their body posture compared to people who had not experienced them.
9. The subjective self-assessment of body stability in subjects with hyperparathyroidism does not correlate with the objective results of posturographic examination in the early period after parathyroidectomy.
10. The presented results encourage further observation of a larger group of subjects with reference to a control group, as well as recording a posturographic examination at a point in time later after the parathyroidectomy.

Keywords: primary hyperparathyroidism, secondary hyperparathyroidism, tertiary hyperparathyroidism, parathyroidectomy, pedobarography, stability.

