# Analysis of Biochemical, Hormonal and Radiological Morphological Measurement Values in Patients with Empty Sella: A Clinical Study

## *Análise de valores de medidas morfológicas bioquímicas, hormonais e radiológicas em pacientes com Sela Vazia: Um estudo clínico*

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**Abstract**

**Objective** This study investigated the relationship between radiological morphological findings and hormone levels in patients with empty sella.

**Methods** Patients (32 female, 3 male) with empty sella detected on radiological images were grouped as "partial empty sella (PBS) group" (subarachnoid space volume $< 70\%$) and "total empty sella (TBS) group" (subarachnoid space volume $> 70\%$). Age, gender, sella volume, pituitary gland thickness, the ratio of subarachnoid space height to pituitary gland height, and diaphragm sellae diameter were measured on radiological images. All patients' blood count results, biochemistry results, and serum hormone values were recorded.

**Results** Age, complete blood count, serum biochemistry parameters, and hormone levels were not different between PBS and TBS groups. Correlation analysis revealed a negative correlation between gender and subarachnoid space invasion volume, between gender and sagittal width of the sella turcica (ST), between cortisol level and ST axial diameter, between progesterone level and ST axial diameter, between testosterone level and ST axial diameter, between adrenocorticotropic hormone level

**Keywords**
- Empty Sella
- radiology
- morphology
- hormone
- biochemistry

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and ST axial diameter, between TSH level and subarachnoid space invasion rate, between free T4 level and diaphragm sellae sagittal width, and between free T4 level and ST sagittal width.

**Conclusion** This study showed that some serum hormone values may decrease when the sella tursica dimensions or the volume of subarachnoid space invading the sella tursica increase in patients with empty sella, and therefore, periodic follow-up of hormone levels and radiological images of these patients would be appropriate.

## Resumo

**Objetivo** Este estudo investigou a relação entre achados morfológicos radiológicos e níveis hormonais em pacientes com sela vazia.

**Métodos** Pacientes (32 mulheres 3 homens) com sela vazia detectada em imagens radiológicas foram agrupados como "grupo sela parcialmente vazia (PBS)" (volume do espaço subaracnóideo $< 70\%$) e "grupo sela totalmente vazia (TBS)" (volume do espaço subaracnóideo $> 70\%$). Idade sexo volume da sela espessura da glândula pituitária a razão entre a altura do espaço subaracnóideo e a altura da glândula pituitária e o diâmetro do diafragma da sela foram medidos em imagens radiológicas. Os resultados do hemograma bioquímica e valores hormonais séricos de todos os pacientes foram registrados.

**Resultados** Idade hemograma completo parâmetros bioquímicos séricos e níveis hormonais não foram diferentes entre os grupos PBS e TBS. A análise de correlação revelou uma correlação negativa entre gênero e volume de invasão do espaço subaracnóideo entre gênero e largura sagital da sela túrcica (ST) entre nível de cortisol e diâmetro axial do ST entre nível de progesterona e diâmetro axial do ST entre nível de testosterona e diâmetro axial do ST entre nível de hormônio adrenocorticotrófico e diâmetro axial do ST entre nível de TSH e taxa de invasão do espaço subaracnóideo entre nível de T4 livre e largura sagital do diafragma da sela e entre nível de T4 livre e largura sagital do ST.

**Conclusão** Este estudo mostrou que alguns valores hormonais séricos podem diminuir quando as dimensões da sela túrsica ou o volume do espaço subaracnóideo que invade a sela túrsica aumentam em pacientes com sela vazia e portanto o acompanhamento periódico dos níveis hormonais e imagens radiológicas desses pacientes seria apropriado.

**Palavras-chave**
- Sela Vazia
- radiologia
- morfologia
- hormônio
- bioquímica

## Introduction

Primary empty sella (PES) syndrome is an anatomical condition where the subarachnoid space herniates into the sella turcica.[1] Primary empty sella syndrome is a syndrome of unknown etiology in patients who have not undergone surgery, radiotherapy, or pharmacological treatments to the sellar/ parasellar region.[2] However, in secondary empty sella syndrome, patients generally have a history of central nervous system/hypothalamic-pituitary diseases, a history of pituitary surgery, a history of radiotherapy or medical treatment, and a history of functional pituitary diseases such as acromegaly, Cushing's disease or prolactinoma.[3,4] Although many hypotheses have been put forward to date regarding the pathogenesis of empty sella syndrome (such as intracranial hypertension, cerebrospinal fluid pulsatility, obesity, lactation, pregnancy, and hypophysitis), its etiopathogenesis has not been revealed yet.[3–7]

Clinical findings of empty sella are variable. It does not cause clinical findings in most patients, and empty sella is usually discovered incidentally on radiological images and is a relatively common finding in autopsies. Most patients are admitted to different departments with non-specific symptoms such as intracranial or ocular complaints and their disease are diagnosed incidentally.[5] However, empty sella syndrome can sometimes reach severe extremes in both clinical symptoms and hormonal changes. Therefore, it must be well differentiated clinically and managed appropriately based on clinical findings.[3–5] Studies have been conducted to evaluate the prevalence of primary empty sella syndrome and the hormonal status in patients with this syndrome. However, there are very few studies on the size of the pituitary gland within the sella in patients with this syndrome and the effect of empty sella syndrome on the secretory function of this gland.

 

This study aimed to investigate the effect of the volume of the subarachnoid space extending into the sella turcica on pituitary gland functions in patients with primary empty sella.

## Materials and Methods

This retrospective clinical study was conducted after obtaining the approval of the Non-Interventional Research Ethics Committee (Decision date: 10.01.2024, decision number: 2024.01.09).

### Patients

Patients with primary empty sella detected on radiologic images between 2020 and 2023 were included in the study. These patients were then grouped as follows:

- "Partial empty sella (PBS)" group (subarachnoid space volume <70%).
- "Total empty sella (TBS)" group (subarachnoid space volume >70%).

Patients were also grouped according to their gender as follows:

- Female group ($n = 32$)
- Male group ($n = 3$)

In addition, 24 participants (7 males, 17 females) who had no empty sella were included in the study to compare sella dimensions. Patients who had been previously treated for pituitary disease, patients who underwent surgery in the sellar/parasellar region, patients with adrenal gland disease/tumor, patients with non-pituitary hormonal disorders, or patients receiving hormonotherapy for various reasons, pregnant women, patients with incomplete blood or radiological imaging tests and pediatric patients were excluded.

### Materials

Patients' age, gender, complaints and symptoms at the time of admission to the hospital, and medical history were recorded. In addition, the hemoglobin level values (reference range 10–18 g/dL), leukocyte (reference range 4400–11300/uL), neutrophil (reference range 1,100–9600/uL), lymphocyte (reference range 500–6000/uL), monocyte (reference range 100–1400/uL), basophil (reference range 0–300 /uL), and platelet (reference range 150000–500000/uL) count values were determined using an analyzer device (Mindray BC-6800, Shenzen, China).

Blood urine nitrogen (BUN) (reference range 17–43 mg/dL), creatinine (reference range 0.84–1.24 mg/dL), sodium (reference range 136–146 mmol/L), potassium (reference range 3.5–5.1 mmol /L), adrenocorticotropic hormone (ACTH) (reference range 7.2–63.3 pg/ mL), morning cortisol (reference range 6.2–19.4 ug/dL), total testosterone (reference range 8.4–48.1 ng/dL), estradiol (20–47 pg/mL), progesterone (ng/mL), follicle-stimulating hormone (FSH) (1.27–22.51 mIU/mL), luteinizing hormone (LH) (1.24–103.03 mIU/mL), prolactin (reference range 6–29.4 ng/mL), growth hormone (GH) (reference range 0–10 ng/mL), insulin-like growth factor-1 (IGF-1) (reference range 109–284 ng/mL), β-human chorionic gonadotropin (β-HCG) (reference range 0–5 mIU/mL), free T3 (FT3) (reference range 2–4.4 pg/mL), free T4 (FT4) (reference range 0.93–1.7 ng/mL), and thyroid stimulating hormone (TSH) (reference range 0.27–4.2 uIU/mL) levels were recorded.

### Radiological Measurements

Morphologic measurements were performed on MR images of patients with primary empty sella. First, the maximum height of the subarachnoid space invading the sella tursica, the maximum height of the sella tursica, and the maximum width of the sella tursica, the maximum width of the diaphragm sella were measured on the T2 weighted sagittal MR images. Furthermore, the maximum width of the sella tursica was measured in the axial MR images (►**Figs. 1** and **2**). The ratio of the height of the subarachnoid space

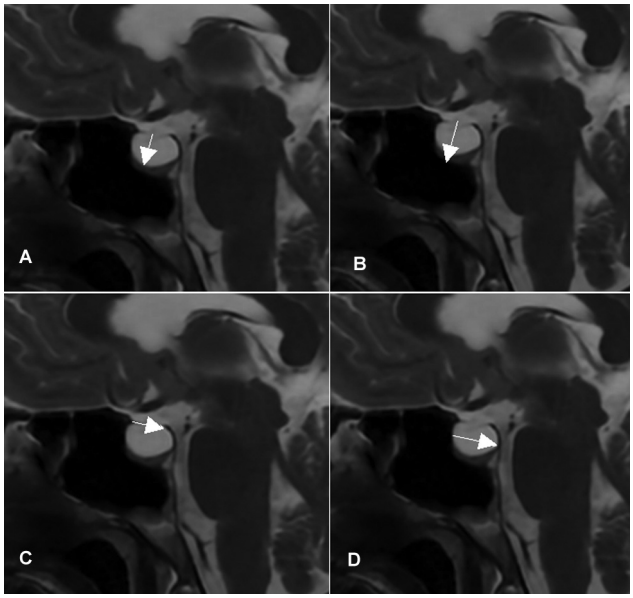


**Fig. 1** The pictures obtained from the sagittal MR images show the morphological measurement methods of the subarachnoid space invading the sella tursica (**A**), the maximum height of the sella tursica (**B**), the width of the sella tursica (**C**), the width of the diaphragm sella (**D**).

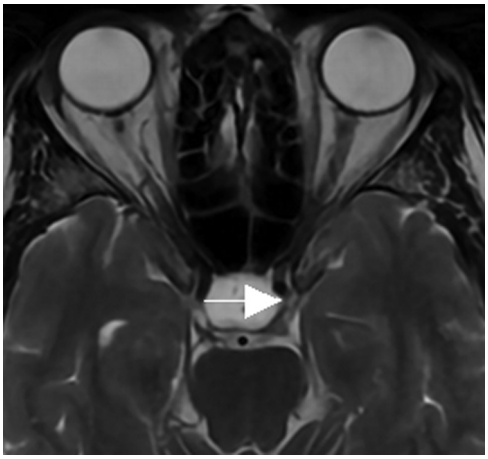

**Fig. 2** The picture shows the width of the sella turcica in the axial MR image.

 

invading the sella tursica to the height of the sella tursica called the invasion ratio was also recorded. In addition, the volume of the subarachnoid space invading the sella tursica was also calculated and recorded. The volume was calculated as follows:

Volume = ⅓ × (maximum height of the subarachnoid space invading the sella tursica x maximum width of the sella tursica in the sagittal plane x maximum width of the sella tursica in the axial plane).

### Statistical Analysis

As a result of the G*Power analysis, it was found that the minimum total study population size could be 14 (effect size d = 2.00, power = 0.95, critical t = 1.782, actual power = 0.970, total sample size = 14). Parametric data was analyzed with the *Independent Samples t-test* to evaluate group differences ($p < 0.05$). Non-parametric data was analyzed using the *Mann-Whitney U* test to compare the groups ($p < 0.05$). Categoric data were analyzed using the *Pearson Chi-square* test ($p < 0.05$). *Spearman's rho Correlation* test was used to determine the correlation between the parameters ($p < 0.05$).

## Results

A total of 35 patients (3 males and 32 females) were included in the study. Almost all of the patients included in the study were female. When the anamnesis of the patients was analyzed, it was found that 14 patients had headaches for a long time, 2 patients had nausea, 2 patients had dizziness, and 1 patient who was 42 years old had menstrual irregularities. It was learned from their history that 4 patients were under treatment for hypertension, 1 patient for hypothyroidism, 1 patient for hyperthyroidism, and 2 patients for diabetes mellitus. Obesity was found in only 1 patient. It was observed that almost all patients' blood count values, blood biochemistry, and hormone values were within laboratory normal values (►**Table 1**).

There was no difference between PBS and TBS groups regarding age, complete blood count, serum biochemistry parameters, and serum hormone levels. However, subarachnoid space invasion length (t = -4.614, $p < 0.001$), sella tursica sagittal width (t = -3.338, $p = 0.002$), diaphragm sellae sagittal width (t = -3.639, $p = 0.001$), sella tursica axial width (t = -2.683, $p = 0.011$), and subarachnoid space invasion volume (t = -3.245, $p = 0.001$) values were found to be different between the two groups (►**Table 2**).

Platelet-to-lymphocyte ratio (t = 2.132, $p = 0.041$), LH (t = -3.706, $p = 0.001$), FSH (t = -4.324, $p < 0.001$), estradiol (Z = -3.571, $p < 0.001$), progesterone (Z = -2.728, $p = 0.006$), testosterone (Z = -2.036, $p = 0.042$), prolactin (Z = -2.245, $p = 0.025$), and free T3 (t = 2.651, $p = 0.012$) levels were found to be different between the age groups (►**Table 3**).

When the sella tursica dimensions of the patients were compared with the individuals without empty sella syndrome, it was found that the length of the sella tursica measured in the sagittal plane was statistically significantly different. (t = 4.807, $p < 0.001$) (►**Table 4**).

Correlation analysis revealed a negative correlation between gender and subarachnoid space invasion volume (r = -0.344, $p = 0.043$), between gender and sagittal width of the sella turcica (r = -0.364, $p = 0.032$), between cortisol level and axial diameter of the sella turcica (r = -0.348, $p = 0.041$), between progesterone level and axial diameter of the sella turcica (r = -0.346, $p = 0.042$), between testosterone level and axial diameter of the sella turcica (r = -0.426, $p = 0.012$), between adrenocorticotropic hormone level and axial diameter of the sella turcica (r = -0.478, $p = 0.008$), between TSH level and subarachnoid space invasion rate (r = -0.336, $p = 0.049$), between free T4 hormone level and sagittal width of the diaphragm sellae (r = -0.431, $p = 0.010$) and between free T4 hormone level and sagittal width of the sella turcica (r = -0.368, $p = 0.030$).

## Discussion

The most common clinical finding of empty sella syndrome is headache. However, hormonal deficiencies are a rare clinical condition. Therefore, since hormonal deficiencies are rare and most likely acquired, growth and sexual development are less likely to be affected. For this reason, the empty sella diagnosis is a syndrome discovered incidentally during the examination of other neurological complaints and symptoms. Recent studies reported that PES is more than an incidental finding and the prevalence of accompanying endocrine abnormalities was found to be high.[8] For this reason, they argued in their study that these patients should be examined in more detail by endocrinologists, otherwise, the hormonal evaluation would be largely insufficient, which would lead to poor clinical management and the risk of not replacing missing hormones.[9]

Empty sella syndrome is the herniation of the subarachnoid space into the sella for various reasons and the sella is filled with cerebrospinal fluid.[1] Accordingly, normal pituitary tissue may compress and flatten, the pituitary stalk may lengthen and thin, and the sella may widen or remain normal. When the cerebrospinal fluid filling percentage is <50% or the pituitary gland thickness is measured at 3–7 mm, this is called "partial empty sella." If the cerebrospinal fluid filling percentage is >50% and the pituitary gland thickness is <2 mm, it is called "total empty sella."[3,4,10–12]

Almost all the patients included in the study were female. In the present study, many patients (14 patients) complained of headaches. In addition, two patients had nausea, two patients had dizziness, and one patient who was 42 years old had menstrual irregularities. However, only one patient was under treatment for hypothyroidism, two patients for diabetes mellitus, and one patient suffered from obesity. Almost all these patients had a subarachnoid space invasion rate of >70%. However, when the hormone levels of the patients were analyzed, it was found that all of them had serum hormone and biochemistry values within the normal laboratory result range. It was observed that subarachnoid space invasion length, sella tursica sagittal width, diaphragm sellae sagittal width, sella tursica axial width, and subarachnoid space invasion

 

**Table 1** Descriptive table of demographic data, blood count values, blood biochemistry, and hormone levels, and radiological morphological measurements of all patients

| Variable | | Mean ± SD/ Median (min-max)/N (%) | Normal value |
|---|---|---|---|
| Age (year) | | 48.54 ± 13.76 | – |
| Gender | Female | 32 (%91.4) | – |
| | Male | 3 (%8.6) | |
| Hemoglobin | | 13.38 ± 1.79 | 10-18 g/dL |
| Leukocyte | | 7722 ± 1980.01 | 4400-11300 /uL |
| Neutrophil | | 4610 (2140–8140) | 1100-9600/uL |
| Lymphocyte | | 2532 ± 744.69 | 500-6000 /uL |
| Monocyte | | 437 ± 124.84 | 100-1400 / uL |
| Basophil | | 40 (20–110) | 0-300 /uL |
| Platelets | | 272457 ± 63215.48 | 150000-500000 /uL |
| Neutrophil-lymphocyte ratio | | 1.93 ± 0.92 | – |
| Monocyte-lymphocyte ratio | | 0.18 ± 0.07 | – |
| Platelet-lymphocyte ratio | | 117.82 ± 49.62 | – |
| Sodium | | 136.09 ± 23.79 | 136-146 mmol/L |
| Potassium | | 4.56 ± 0.35 | 3.5-5.1 mmol /L |
| Blood urine nitrogen | | 26.37 ± 7.22 | 17-43 mg/dL |
| Creatinine | | 0.71 ± 0.22 | 0.84-1.24 mg/dL |
| Adrenocorticotropic hormone | | 21.55 (8.20-96.20) | 7.2-63.3 pg/ mL |
| Morning cortisol | | 11.28 ± 6.70 | 6.2-19.4 ug/dL |
| Luteinizing hormone | | 17.95 ± 12.51 | 1.24-103.03 mIU/mL |
| Follicle-stimulating hormone | | 26.50 (0.40-78.20) | 1.27-22.51 mIU/mL |
| Estradiol | | 22 (0.00-209.00) | – |
| Progesterone | | 0.22 (0.00-21.90) | – |
| β-human chorionic gonadotropin | | 0.20 (0.00-2.35) | 0-5 mIU/mL |
| Testosterone | | 18.70 (0.00-492.00) | 8.4-48.1 ng/dL |
| Prolactin | | 10.50 (0.20-107.00) | 6-29.4 ng/mL |
| Free T3 | | 2.92 ± 0.48 | 2-4.4 pg/mL |
| Free T4 | | 1.57 ± 1.92 | 0.93-1.7 ng/mL |
| Thyroid-stimulating hormone | | 1.79 (0.02-6.59) | 0.27-4.2 uIU/mL |
| Growth hormone | | 0.41 (0.05-40.50) | 0-10 ng/mL |
| Insulin-like growth factor-1 | | 117.40 ± 60.17 | 109-284 ng/mL |
| Sella tursica sagittal length (mm) | | 10.40 ± 2.14 | – |
| Subarachnoid space invasion length (mm) | | 7.22 ± 2.33 | – |
| Sella tursica sagittal width (mm) | | 9.92 ± 2.55 | – |
| Diaphragm sellae sagittal width (mm) | | 7.68 ± 1.42 | – |
| Sella tursica axial width (mm) | | 11.68 ± 3.44 | – |
| Subarachnoid space invasion volume ($mm^3$) | | 242.89 (0.00-2150.98) | – |
| Subarachnoid space invasion rate | | 68.40 ± 11.91 | – |

(SD: standard deviation, min: minimum, max: maximum, N: patient number)

volume (t = -3.245, $p = 0.001$) values in the subarachnoid space invasion rate >70% group were higher than those in the <70% group. However, there was no statistical difference between the two groups regarding hormone values, serum biochemistry values, and blood count values. In light of these findings, it was concluded that a subarachnoid space invasion rate >70% did not lead to decreased pituitary hormones and therefore did not cause a

 

**Table 2** Distribution table of the patients' data according to the subarachnoid space invasion rate groups

| | | INVASION RATIO | | | |
|---|---|---|---|---|---|
| | | <%70 | >%70 | | |
| **Variable** | | **Mean ± SD/ Median (min-max)/ N (%)** | **Mean ± SD/ Median (min-max)/ N (%)** | **t/Z/X²** | **p** |
| Age (year) | | 45.81 ± 15.80 | 50.84 ± 11.73 | -1.080* | 0.288 |
| Gender | Female | 15 (42.9%) | 17 (48.6%) | 0.203‡ | 0.653 |
| | Male | 2 (5.7%) | 1 (2.9%) | | |
| Hemoglobin | | 13.42 ± 1.86 | 13.34 ± 1.78 | -0.361* | 0.720 |
| Leukocyte | | 7780 ± 2169.00 | 7672 ± 1865.24 | 0.159* | 0.874 |
| Neutrophil | | 4555 (2140-7640) | 4610(2210-8140) | -0.199† | 0.843 |
| Lymphocyte | | 2498 ± 803.07 | 2560 ± 712.88 | -0.244* | 0.809 |
| Monocyte | | 453 ± 94.36 | 424 ± 147.02 | 0.677* | 0.503 |
| Basophil | | 35 (20-70) | 40 (20-110) | -0.256† | 0.798 |
| Platelets | | 277063 ± 54561.85 | 268579 ± 70942.32 | 0.391* | 0.699 |
| Neutrophil-lymphocyte ratio | | 2.08 ± 1.23 | 1.81 ± 0.56 | 0.849* | 0.402 |
| Monocyte-lymphocyte ratio | | 0.20 ± 0.08 | 0.17 ± 0.05 | 1.338* | 0.190 |
| Platelet-lymphocyte ratio | | 123.41 ± 50.36 | 113.109 ± 49.86 | 0.607* | 0.548 |
| Sodium | | 140.38 ± 2.99 | 139.79 ± 2.30 | 0.655* | 0.517 |
| Potassium | | 4.52 ± 0.39 | 4.60 ± 0.32 | -0.655* | 0.517 |
| Blood urine nitrogen | | 25.25 ± 6.90 | 27.31 ± 7.53 | -0.840* | 0.407 |
| Creatinine | | 0.67 ± 0.10 | 0.74 ± 0.28 | -0.940* | 0.354 |
| Adrenocorticotropic hormone | | 25 (9.10-96.20) | 20 (8.20-72.70) | -0.977† | 0.329 |
| Morning cortisol | | 12.11 ± 4.90 | 10.58 ± 7.97 | 0.667* | 0.509 |
| Luteinizing hormone | | 19.62 ± 14.73 | 16.54 ± 10.50 | 0.720* | 0.477 |
| Follicle-stimulating hormone | | 22 (1.70-78.20) | 27 (0.40-61.40) | -0.364† | 0.716 |
| Estradiol | | 30 (5-173) | 17 (0-209) | -1.335† | 0.182 |
| Progesterone | | 0.22 (0.05-21.90) | 0.22 (0-7.73) | -0.066† | 0.947 |
| β-human chorionic gonadotropin | | 0.35 (0-2.35) | 0.20 (0-1.60) | -0.142† | 0.887 |
| Testosterone | | 22.15 (7.06-492) | 14.95 (0-444) | -1.277† | 0.202 |
| Prolactin | | 10.90 (4.40-42.40) | 9 (0.20-107) | -1.275† | 0.202 |
| Free T3 | | 2.824 ± 0.40 | 3.00 ± 0.54 | -1.091* | 0.283 |
| Free T4 | | 1.24 ± 0.18 | 1.84 ± 2.60 | -0.927* | 0.361 |
| Thyroid-stimulating hormone | | 2.23 (1.28-6.59) | 1.57 (0.02-6.45) | -1.772† | 0.076 |
| Growth hormone | | 0.27 (0.13-7.75) | 0.50 (0.05-40.50) | -0.356† | 0.722 |
| Insulin-like growth factor-1 | | 118.56 ± 56.53 | 116.52 ± 65.24 | 0.075* | 0.941 |
| Sella tursica sagittal length (mm) | | 9.69 ± 1.26 | 10.99 ± 2.56 | -1.862* | 0.071 |
| Subarachnoid space invasion length (mm) | | 5.66 ± 1.18 | 8.54 ± 2.25 | -4.614* | **<0.001** |
| Sella tursica sagittal width (mm) | | 9.81 ± 2.58 | 13.24 ± 3.35 | -3.338* | **0.002** |
| Diaphragm sellae sagittal width (mm) | | 6.86 ± 1.91 | 10.89 ± 1.24 | -3.639* | **0.001** |
| Sella tursica axial width (mm) | | 8.76 ± 1.85 | 11.01 ± 2.65 | -2.683* | **0.011** |
| Subarachnoid space invasion volume ($mm^3$) | | 166.8 (46.56-703.41) | 414.44 (111.72-2150.98) | -3.245† | **0.001** |

(SD: standard deviation, min: minimum, max: maximum, N: patient number)
(*)t value, Independent Samples t-test
(†)Z value, Mann-Whitney U test
(‡)$X^2$ value, Pearson chi-square test, $p < 0.05$

 

**Table 3** Distribution table of the patients' data according to the age groups

| | | Age <50 | Age >50 | | |
|---|---|---|---|---|---|
| **Variable** | | **Mean ± SD/Median (min-max)/ N (%)** | **Mean ± SD/Median (min-max)/ N (%)** | **t/Z/$X^2$** | **p** |
| Age (year) | | 37.53 ± 9.74 | 58.94 ± 7.32 | – | – |
| Gender | Female | 15 (42.9%) | 17 (48.6%) | 0.430‡ | 0.512 |
| | Male | 2 (5.7%) | 1 (2.9%) | | |
| Hemoglobin | | 12.91 ± 2.26 | 13.82 ± 1.09 | -1.520* | 0.138 |
| Leukocyte | | 7650.59 ± 1702.00 | 7789 ± 2259.35 | -0.204* | 0.840 |
| Neutrophil | | 4800 (2380-7170) | 4520 (2140-8140) | -0.858† | 0.391 |
| Lymphocyte | | 2326 ± 595.87 | 2726 ± 832.35 | -1.625* | 0.114 |
| Monocyte | | 429 ± 101.21 | 445 ± 146.30 | -0.364* | 0.718 |
| Basophil | | 30 (20-110) | 40 (20-70) | -0.578 | 0.563 |
| Platelets | | 287176 ± 80909.85 | 258556 ± 37547.18 | 1.355* | 0.185 |
| Neutrophil-lymphocyte ratio | | 2.20 ± 1.15 | 1.68 ± 0.58 | 1.687* | 0.101 |
| Monocyte-lymphocyte ratio | | 0.20 ± 0.07 | 0.17 ± 0.06 | 1.087* | 0.285 |
| Platelet-lymphocyte ratio | | 135.33 ± 61.27 | 101.28 ± 28.20 | 2.132* | **0.041** |
| Sodium | | 139 ± 2.02 | 140.78 ± 2.94 | -1.728* | 0.093 |
| Potassium | | 4.58 ± 0.33 | 4.55 ± 0.38 | 0.215* | 0.831 |
| Blood urine nitrogen | | 25.59 ± 6.76 | 27.11 ± 7.75 | -0.618* | 0.541 |
| Creatinine | | 0.73 ± 0.21 | 0.69 ± 0.22 | 0.526* | 0.602 |
| Adrenocorticotropic hormone | | 21.80 (9.10-72070) | 21.30 (8.20-96.20) | -0.439† | 0.660 |
| Morning cortisol | | 11.32 ± 7.92 | 11.24 ± 5.53 | 0.034* | 0.973 |
| Luteinizing hormone | | 11.07 ± 11.50 | 24.44 ± 9.83 | -3.706* | **0.001** |
| Follicle-stimulating hormone | | 6.10 (0.40-62.40) | 49 (6.60-78.20) | -4.324† | <**0.001** |
| Estradiol | | 56 (5-209) | 14 (0-46) | -3.571† | <**0.001** |
| Progesterone | | 0.24 (0.05-21.90) | 0.13 (0-0.39) | -2.728† | **0.006** |
| β-human chorionic gonadotropin | | 0.20 (0-2) | 0.70 (0-2.35) | -2.968† | **0.003** |
| Testosterone | | 25.05 (2.50-492) | 13 (0-385) | -2.036† | **0.042** |
| Prolactin | | 14.50 (0.20-42.40) | 8.60 (4.40-107) | -2.245† | **0.025** |
| Free T3 | | 3.12 ± 0.43 | 2.73 ± 0.46 | 2.651* | **0.012** |
| Free T4 | | 1.86 ± 2.75 | 1.29 ± 0.25 | 0.868* | 0.392 |
| Thyroid-stimulating hormone | | 1.70 (0.02-6.59) | 2.10 (0.74-6.45) | -0.776† | 0.438 |
| Growth hormone | | 0.93 (0.13-40.50) | 0.20 (0.05-1.60) | -1.546† | 0.122 |
| Insulin-like growth factor-1 | | 137.40 ± 70.76 | 99.21 ± 44.39 | 1.497* | 0.151 |
| Sella tursica sagittal length (mm) | | 10.15 ± 2.35 | 10.63 ± 1.96 | -0.650* | 0.520 |
| Subarachnoid space invasion length (mm) | | 6.95 ± 2.39 | 7.48 ± 2.31 | -0.818* | 0.419 |
| Sella tursica sagittal width (mm) | | 11.43 ± 3.51 | 11.91 ± 3.47 | -1.654* | 0.108 |
| Diaphragm sellae sagittal width (mm) | | 7.66 ± 1.41 | 7.70 ± 1.47 | -0.069* | 0.945 |
| Sella tursica axial width (mm) | | 9.20 ± 2.48 | 10.59 ± 2.49 | -0.406* | 0.688 |
| Subarachnoid space invasion volume ($mm^3$) | | 186.12 (46.56) | 310.41 (46.97-1493.61) | -1.188† | 0.235 |
| Subarachnoid space invasion rate | | 67.64 ± 10.58 | 69.11 ± 13.31 | -0.360* | 0.721 |

(SD: standard deviation, min: minimum, max: maximum, N: patient number)
(*) t value, Independent Samples t-test
(†)Z value, Mann-Whitney U test
(‡)$X^2$ value, Pearson chi-square test, $p < 0.05$

 

**Table 4** Distribution table of sella tursica morphological measurement values of patients with empty sella syndrome and normal patients

| | PATIENTS | CONTROL | | |
|---|---|---|---|---|
| **Variable** | **Mean ± SD** | **Mean ± SD** | **t** | **p** |
| Sella tursica sagittal length (mm) | 10.40 ± 2.14 | 8.08 ± 1.18 | 4.807 | **<0.001** |
| Sella tursica sagittal width (mm) | 9.92 ± 2.55 | 10.23 ± 1.42 | -0.548 | 0.586 |
| Diaphragm sellae sagittal width (mm) | 7.68 ± 1.42 | 7.89 ± 1.21 | -0.603 | 0.549 |
| Sella tursica axial width (mm) | 11.68 ± 3.44 | 12.52 ± 3.10 | -0.959 | 0.342 |

(SD: standard deviation)
Independent Samples t-test; $p < 0.05$

metabolic disturbance. It was also argued that it did not affect blood count values.

On the other hand, platelet-to-lymphocyte ratio, prolactin, free T3, testosterone, estradiol, and progesterone serum levels were found to be low, whereas LH and FSH levels were found to be high in patients over 50 years of age. However, all these parameters were found to be within the range of normal laboratory values. It was thought that these results may be related to the fact that almost all the study group consisted of female patients and these female patients were in age-related menopause after the age of fifty.

On the other hand, the length of the sella tursica measured in the sagittal plane was different between individuals without empty sella syndrome and patients with empty sella syndrome. With these results, it was seen that the depth of the sella tursica in the sagittal plane was greater in patients with empty sella syndrome compared with normal individuals. However, the diameter of the diaphragm sellae and the axial and sagittal width of the sella tursica were like normal individuals. With these findings, it was found that there was no global enlargement in the sella tursica but the depth of the sella tursica was more in empty sella syndrome. Interestingly, the diameter of the diaphragm sellae was similar between the groups. Thus, it was suggested that there is no morphologic abnormality of the diaphragm sellae in empty sella syndrome, but there may be a structural defect in the dura mater forming the diaphragm sellae, thus, it could not prevent the passage of cerebrospinal fluid into the sella tursica and could be considered a cause of the formation of this syndrome. On the other hand, as a rule of physics, it is known that the fluid pressure in containers is similar on all surfaces of the container, but the pressure exerted on the bottom of the container by the weight of the fluid due to gravity is directly related to the height of the container. With these hypotheses, it was argued that the gravity-induced increased fluid pressure at the base of the sella tursica may increase the sagittal height of the sella in empty sella syndrome.

Based on correlation analysis, it has been established that increasing the axial diameter of the sella turcica may be directly associated with decreasing serum cortisol, progesterone, testosterone, and ACTH levels. Furthermore, an increase in the width of the sella turcica and diaphragm sellae, measured in the sagittal plane, may lead to a decrease in serum levels of free T4. Additionally, a significant decrease in TSH levels may occur with an increased subarachnoid space invasion rate. These observations strongly suggest that an increase in the dimensions of the sella turcica during follow-up periods in patients diagnosed with empty sella syndrome may lead to hypopituitarism including especially the cortisol, progesterone, testosterone, ACTH, TSH, and free T4 levels. Therefore, it is highly recommended that patients with empty sella should undergo regular follow-ups of their serum hormone levels and radiological images.

### Limitations

This study has several limitations. *First*, the sample size of the study was small. *Second*, since the study was retrospective, stimulation tests for pituitary gland hormones were not performed. Therefore, detailed information about the hypothalamo-hypophyseal pathway and target organ responses could not be obtained. *Third*, due to the retrospective nature of the study, hormonal values were not monitored because the patients were not followed up. *Finally*, healthy control subjects' hormonal parameters were not included in this study, but laboratory data of the patients were compared with laboratory normal values.

## Conclusion

With these findings, it was concluded that there was no significant deterioration in hormone activities in patients with PBS or TBS; however, there may be a negative correlation between sella dimensions and cortisol, ACTH, progesterone, testosterone, TSH and free T4 levels and the levels of these hormones may decrease in these patients when sella dimensions and/or the volume of the invaded subarachnoid space increase and therefore periodic follow-up of hormone levels and MR images of these patients would be appropriate.

Conflict of Interest
There is no "conflict of interest" among the authors. Furthermore, through any of the products used in this research, no financial engagement has been established with any company that makes and/or markets these products or with any corporation that produces and/or markets a competing product.

 

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