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Features of Quantitative Indicators of UBM in the Study of Structures of the Anterior Segment of the Eye in Primary Zug with Pupillary Block

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Abstract The article discusses modern research methods in ophthalmology, such as ultrasound biomicroscopy (UBM). UBM allows you to accurately assess the state of the anatomical structures of the anterior eye. The use of these modern research methods makes it possible to carry out differential diagnosis in complex clinical cases, as well as to predict the outcomes and course of ophthalmopathologies. In recent years, technologies for diagnostics and visualization of eye structures have been intensively developed. All this has significantly expanded the understanding of pathogenesis, clinical course options of various ophthalmopathologies, and contributes to the development of more effective methods of their treatment.This review will present the diagnostic capabilities of the most commonly used diagnostic research methods - ultrasound biomicroscopy (UBM) of the anterior segment of the eye.

Keywords Ultrasound biomicroscopy, Ophthalmopathology

1. Introduction

Ultrasound examination of the eyes as a diagnostic method has been used in ophthalmology since the 50s of the last century. The need for this method is determined by its advantage over other methods of ophthalmological diagnostics, including the usual examination of the structures of the anterior segment of the eye on a slit lamp. UBM is much better at visualizing opaque fabrics because it uses high-energy sound waves [1,2,3]. That is, its advantage lies in the possibility of lifetime visualization of all anatomical structures of the anterior segment (conjunctiva, cornea, anterior chamber, sclera, iris, lens, ligamentous apparatus, ciliary body, anterior vitreous), including in conditions of reduced transparency of optical media [5,6,7]. However, due to the limited penetration depth of UBM into tissue structures (5 mm penetration depth), it is mainly used in ophthalmology to visualize anterior structures such as the angle and ciliary body. The UBM method significantly expands the possibilities of studying the structures of the anterior segment of the eye [9,10,11].

Objective

To study theprevalence of quantitative indicators of UBM in the study of the structures of the anterior segment of the eye in primary ZUG with pupillary block.

2. Research Methods

The study uses the methods of epidemiological, general clinical, biochemical, instrumental, special and statistical studies.

The age-and gender-specific UBM indicators of primary ZUG were studied by the mechanism of blocking the anterior chamber angle, which determines not only the increase in IOP, but also the subsequent course and outcome of the disease. On the basis of which it is necessary to choose the treatment of primary ZUG [12,13,14].

In patients with primary angle-closure glaucoma, several pathogenetic variants of the disease were identified that differ in the mechanism of formation of anterior chamber angle block: pupillary block, flat iris (iris plateau type), vitreous-crystalline block corresponding to the malignant form of glaucoma, and a shortened anterior chamber angle known as" creeping " glaucoma [15,16,17].

Traditional methods of ophthalmic examination — biomicroscopy and gonioscopy-did not allow to fully differentiate the mechanism of blockage of the anterior chamber angle due to limited visualization of deep structures. However, the use of ultrasound biomicroscopy (UBM) in

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combination with morphometric analysis of linear and angular parameters made it possible to study in detail the spatial relationships of anatomical formations of the anterior segment of the eye. This approach significantly increased the accuracy of topographic diagnostics and allowed a reasonable approach to the choice of individual treatment tactics for different types of angle-closure glaucoma [18,19,20].

The gonioscopy data obtained by us in PSOG shows that the number of patients with pupillary block is about 75% and the second advanced stage prevails. Functional block most often develops in eyes with relative pupillary block, when the angle of the anterior chamber is closed by the protruding anterior root of the iris. In addition, in eyes with a narrow angle of the anterior chamber, its sharp apex, or the posterior position of the Schlemm canal, the trabecular zone may close when the pupil dilates with the basal fold of the iris (Fuchs fold). At the same time, the iris is not protruding, flat, and the anterior chamber is of medium depth [21].

Usually in clinical practice, it is observed that the course of this form of glaucoma is undulating, attacks are replaced by calm, asymptomatic intervals. As a result of each attack, spikes in the drainage system remain, which later lead to chronically high ophthalmotonus and changes in the visual fields characteristic of glaucoma. UBM study of patients with angle-closure glaucoma was performed mainly in the early-I and advanced-II stages of the disease. The first group included 103 patients (183 eyes) who showed characteristic anatomical and topographic changes in the anterior segment of the eye, including a shallow anterior chamber, a convex contour of the iris, its thinning in the basal zone, as well as a narrow or completely closed angle of the anterior chamber in combination with an increase in the depth of the posterior chamber. In ultrasound biomicroscopy, the posterior chamber had a triangular shape, and the combination of the above morphological features corresponded to the ultrasound picture of the pupillary block — one of the key pathogenetic variants of angle-closure glaucoma. UBM study in the early – 1 stage in PSG with pupillary block is characterized with the following characteristic features: In patients of the first group with pupillary block, according to ultrasound biomicroscopy (UBM), characteristic morphometric features of the structures of the anterior segment of the eye were noted. The anterior chamber of the eye was characterized by a shallow depth and a narrow or closed angle. The averagevalues of anatomical parameters were: anterior chamber depth-2.13±0.09 mm in men and 2.14±0.08 mm in women; anterior chamber angle-8.15±1.75 ° and 8.16±1.57 °, respectively. The thickness of the iris root was 0.38±0.02 mm in men and 0.39±0.03 mm in women. The distance "trabecula-iris" was sharply reduced — 0.107±0.08 mm and 0.108±0.07 mm, respectively, which indicates a pronounced narrowing of the angle. The distance "trabecula–ciliary processes" was 0.494±0.018 mm in men and 0.492±0.021 mm in women. The depth of the anterior cornice bay of the posterior chamber reached 0.474±0.018 mm and 0.482± 0.017 mm, respectively, and the iris-lens distance was 0.31±0.02 mm for men and 0.32±0.03 mm for women. The rear camera had a typical triangular shape.

The posterior chamber depth in healthy individuals averaged 0.563±0.014 mm (0.537–0.578 mm) in men and 0.562±0.013 mm (0.527–0.577 mm) in women. In patients with primary angle-closure glaucoma (PSOG) with pupillary block in the early (I) stage, this indicator was significantly increased and amounted to 0.63±0.03 mm (0.624–0.645 mm) in men and 0.62±0.04 mm (0.623–0.652 mm) in women. - The shape of the rear camera has been changed to a triangular configuration. According to this form of early – stage PSG-1, the number of patients with pupillary block studied by us was 28 people and 43 eyes, most of them were diagnosed with pathology of both eyes.

Table 1. Quantitative parameters of ultrasound biomicroscopy (UBM) of the iridociliary zone of the eyes in healthy individuals and patients with primary angle-closure glaucoma with pupillary block in the early (I) stage (M±m, mm)

№	Indicator no	Healthy individuals without pathology of the organ of vision		with pupillary block (early-I stage)	
		Men	Women	Men	Women
1	Depth in front of her camera, mm	2,79±0,07	2,78±0,05	2,13±0,09	2,14±0,08
2	Front Camera angle, °	16,62±1,43	16,69±1,26	8,15±1,75	8,16±1,57
3	Thickness of the iris root, mm	0,397±0,009	0,389±0,008	0,38±0,02	0,39±0,03
4	Distance "trabecula-iris", mm	0,196±0,009	0,192±0,005	0,107±0,08	0,108±0,07
5	Distance "trabecula – ciliary processes", mm	0,698±0,008	0,702±0,004	0,494±0,018	0,492±0,021
6	Position of the ciliary body	average	average	average	average
7	Depth of the posterior chamber cornice bay, mm	0.883±0,008	0,889±0,009	0,474±0,018	0,482±0,017
8	Distance "iris-lens", mm	0,31±0,01	0,31±0,02	0,22±0,03	0,22±0,03
9	Rear camera shape	triangular	triangular	triangular shape	triangular
10	Rear camera depth, mm	0,567±0,009	0,564±0,008	0,63±0,03	0,62±0,04

PSG with pupil block in advanced – II stage, the number of patients studied was 53 people and 98 eyes, and most of them were diagnosed with pathology of both eyes. Characteristic features of UBM: - In patients of the second group with a flat iris, ultrasound biomicroscopy revealed pronounced anatomical and topographic changes in the anterior segment of the eye. The anterior chamber was sharply shallow, and its angle was significantly narrowed, which indicated a pronounced predisposition to impaired outflow of intraocular fluid. The average values were: anterior chamber depth-1.53±0.09 mm for men and 1.54± 0.08 mm for women; anterior chamber angle-5.73±1.58 °and 5.76±1.57 °, respectively. The thickness of the iris root in the basal zone at a distance of 250 microns from the scleral spur was 0.40±0.02 mm in men and 0.39±0.03 mm in women. The distance "trabecula-iris" was sharply reduced and reached only 0.08±0.01 mm in men and 0.08±0.07 mm in women. The indicator "trabecula-ciliary processes" was 0.584±0.018 mm in men and 0.582±0.021 mm in women, and the depth of the anterior cornice bay of the posterior chamber was 0.424±0.018 mm and 0.422±0.017 mm, respectively. These data reflect a significant flattening of the iris and a pronounced narrowing of the angle of the anterior chamber, which creates prerequisites for the formation of blocks and an increase in intraocular pressure.

This type of angle-closure glaucoma was characterized by the following morphological features:

- flattened iris profile.
- a small front camera with a sharply narrowed angle.
- moderate thickening of the iris in the basal zone;
- relative alignment of the contour of the anterior segment of the eye.

These signs correspond to the typical UBM picture of angle-closure glaucoma with a flat iris. The iris-lens distance is 0.22±0.03 and 0.22±0.3, respectively.

In patients with stage II primary angle-closure glaucoma accompanied by pupillary block, the iris had a convex profile with a slight thinning in the basal zone, which indicated its displacement anteriorly. The posterior chamber was of increased depth, which reflected the formation of a functional block and impaired circulation of intraocular fluid. The average depth of the posterior chamber, defined as the distance from the posterior surface of the iris to the first visualized fiber of the zinn ligament, was 0.47±0.03 mm in men and 0.49±0.04 mm in women. At the same time, the shape of the rear camera remained changed, but more often it retained a triangular configuration. These changes indicate pronounced morphofunctional rearrangements characteristic of the progressive course of pupillary block.

The combination of these features corresponds to the ultrasound biomicroscopic picture of the advanced stage of pupillary block in primary angle-closure glaucoma.

The data of ultrasound biomicroscopy, the structure of the iridociliary zone of the eyes in the sexual section in the far – advanced stage-III stage of PSG with pupillary block, in our studies gave on average the following results: In patients with primary angle-closure glaucoma with pupillary block, ultrasound biomicroscopy revealed typical anatomical and topographic changes in the anterior segment of the eye. The anterior chamber was shallow, with a narrow or completely closed angle, which indicated a pronounced violation of the outflow of intraocular fluid. The iris had a convex profile and a slight thinning in the basal zone, indicating its anterior displacement. The rear camera was characterized by an increased depth, and its shape was changed, mainly triangular in configuration. The combination of these features formed a characteristic ultrasound picture of the pupillary block, characteristic of primary angle-closure glaucoma.

Table 2. Quantitative parameters of ultrasound biomicroscopy (UBM) of the iridociliary zone of the eyes in healthy individuals and patients with primary angle-closure glaucoma (PZG) with pupil block in advanced (II) stage (M±m, mm)

№	Indicator no	Healthy individuals without pathology of the organ of vision		with pupillary block (developed-IIstage II)	
		Men	Women	Men	Women
1	Depth in front of her camera, mm	2,79±0,07	2,78±0,05	1,53±0,09	1,54±0,08
2	Front Camera angle, °	16,62±1,43	16,69±1,26	5,73±1,58	5,76±1,57
3	Thickness of the iris root, mm	0,397±0,009	0,389±0,008	0,40±0,02	0,39±0,03
4	Distance "tra bekula-raduzhka", mm	0,196±0,009	0,192±0,005	0,08±0,01	0,08±0,03
5	Distance "trabecula – ciliary processes", mm	0,698±0,008	0,702±0,004	0,584±0,018	0,582±0,021
6	Position of the ciliary body	average	average	average	average
7	Depth In front of the cornicebay of the posterior chamber, mm	0,883±0,008	0,889±0,009	0,424±0,018	0,422±0,017
8	Distance "ra shackle – crunch face", mm	0,31±0,01	0,31±0,02	0,22±0,03	0,22±0,03
9	Rear camera shape	triangular	triangular	triangular shape	triangular
10	Back camera depth, mm	0,567±0,009	0,564±0,008	0,47±0,03	0,49±0,04

PSG with pupillary block in the advanced – III stage, the number of patients studied was 17 people and 32 eyes, and most of them were diagnosed with pathology of both eyes. When studying the comparative indicators of UBM at this stage with PSG with a pupillary block in the developed-II stage, no special differences were observed in the age and sex sections, but minor deviations had their own characteristics.

PSG with pupillary block in the terminal-IV stage, the number of patients studied was 5 people and 10 eyes, in all cases the patients were diagnosed with pathology of both eyes.

Morphometric analysis of linear and angular parameters of the angle of the anterior chamber of the eye made it possible to objectively assess topographic changes in the structures of the anterior segment in primary angle-closure glaucoma with pupillary block at various stages of the disease. The results of the study revealed statistically significant differences ($p < 0.001$-0.0001) in comparison with similar parameters in healthy eyes of hypermetropic type of structure. Blockage of the anterior chamber angle at the level of the iris was recorded in 26 eyes, which was confirmed by ultrasound biomicroscopy — the "trabecula-iris" distance was completely absent, reflecting complete closure of the angle and pronounced anterior bulge of the iris, mainly in its basal zone. Despite maintaining the triangular shape of the posterior chamber, its depth was significantly increased ($p < 0.001$) and averaged 0.472 ±0.06 mm in men and 0.473 ±0.08 mm in women. The posterior chamber cross- sectional area was also increased to 1.54 ±0.02 mm2, which was approximately 30% higher than normal values and indicated the development of compensatory morphological rearrangements associated with the formation of the pupillary block and changes in the hydrodynamics of intraocular fluid.

Table 3. Quantitative parameters of ultrasound biomicroscopy (UBM) of the iridociliary zone of the eyes in healthy individuals and patients with primary angle-closure glaucoma (PZG) with pupillary block in advanced (III) stage (M ±m, mm)

№	Indicator no	Healthy individuals without pathology of the organ of vision		with pupillary block (advanced-IIIstage III)	
		Men	Women	Men	Women
1	Front camera depth, mm	2,79 ±0,07	2,78 ±0,05	1,23 ±0,07	1,24 ±0,08
2	Front Camera angle, °	16,62 ±1,43	16,69 ±1,26	3,51 ±1,58	3,52 ±1,55
3	Thickness of the iris root, mm	0,397 ±0,009	0,389 ±0,008	0,27 ±0,01	0,28 ±0,03
4	Distance "trabecula-iris", mm	0,196 ±0,009	0,192 ±0,005	0,03 ±0,01	0,03 ±0,01
5	Distance "trabecula – ciliary processes", mm	0,698 ±0,008	0,702 ±0,004	0,482 ±0,017	0,482 ±0,021
6	Position of the ciliary body	average	average	average	average
7	Depth of the anterior cornice bay of the posterior chamber, mm	0.883 ±0.008	0,889 ±0,009	0,324 ±0,018	0,322 ±0,017
8	Distance "iris-lens", mm	0,31 ±0,01	0,31 ±0,02	0,13 ±0,01	0,13 ±0,02
9	Rear camera shape	triangular	triangular	triangular shape	triangular
10	Rear camera depth, mm	0,567 ±0,009	0,564 ±0,008	0,61 ±0,01	0,62 ±0,02

Table 4. Quantitative parameters of ultrasound biomicroscopy (UBM) of the iridociliary zone of the eyes in healthy individuals and patients with primary angle-closure glaucoma (PSOG) with pupillary block in the terminal (IV) stage (M ±m, mm)

№	Indicator no	Healthy individuals without pathology of the organ of vision		with pupillary block (terminal-IV stage)	
		Men	Women	Men	Women
1	Depth in front of her camera, mm	2,79 ±0,07	2,78 ±0,05	1,08 ±0,06	1,07 ±0,07
2	Front Camera angle, °	16,62 ±1,43	16,69 ±1,26	3,14 ±1,57	3,12 ±1,54
3	Thickness of the iris root, mm	0,397 ±0,009	0,389 ±0,008	0,25 ±0,01	0,26 ±0,03
4	Distance "trabecula-iris", mm	0,196 ±0,009	0,192 ±0,005	0,03 ±0,01	0,03 ±0,01
5	Distance "trabecula – ciliary processes", mm	0,698 ±0,008	0,702 ±0,004	0,39 ±0,01	0,39 ±0,02
6	Position of the ciliary body	average	average	average	average
7	Depth of the front cornice bay of the posterior chamber, mm	0.883 ±0,008	0,889 ±0,009	0,314 ±0,018	0,312 ±0,017
8	Distance "iris-lens", mm	0,31 ±0,01	0,31 ±0,02	0,16 ±0,01	0,16 ±0,02
9	Rear camera shape	triangular	triangular	triangular shape	triangular
10	Rear camera depth, mm	0,567 ±0,009	0,564 ±0,008	0,43 ±0,01	0,44 ±0,02

3. Conclusions

1. Based on the most informative parameters of the UBM study, we have developed a simplified scheme for UBM diagnostics: According to the depth of the anterior chamber; according to the width of the CCP; according to the position of the ciliary body: medium; posterior and anterior; according to the shape and depth of the posterior chamber: triangular deep; triangular medium; triangular small and arched very small. (characteristic of "creeping" glaucoma) and by the degree of structural damage to the anterior segment (atrophy of the iris) and iridociliary zone by the thickness of the iris of 3 degrees.
2. According to ultrasound biomicroscopy data, all patients with primary angle-closure glaucoma revealed closure of the anterior chamber angle with the basal zone of the iris adjacent to the trabecula and corneal endothelium by an average of 1.33±0.02 mm. Reducing the distance "trabecula-iris" serves as an objective indicator of the degree of convergence of the iris with the trabecular apparatus. The complete absence of this distance indicates the contact of the basal part of the iris with the trabecular zone and, consequently, the complete closure of the angle of the anterior chamber. This feature is of great diagnostic importance, as it allows not only to confirm the presence of a block, but also to accurately determine its anatomical localization and extent within the angle of the anterior chamber.
3. Indicators of UBM in the study of age and gender in primary ZUG, shows that the mechanism of blocking the angle of the anterior chamber determines not only the increase in IOP, but also the subsequent course and outcome of the disease. Our new simplified scheme of UBM in primary glaucoma may be useful in the early diagnosis of OCD and determination of treatment tactics. Of particular importance is the choice of the surgical method of anti-glaucomatous surgery.

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