CRYPTORCHIDISM IN CHILDREN: DIAGNOSIS, TREATMENT, PROGNOSIS

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Monograph on the modern level described diagnostic criteria and methods of surgical treatment of cryptorchism in the children, based on the results of a clinical-experimental research, which were included to the curriculum on the speciality "Pediatric Surgery". Methods of diagnosis and treatment different forms of cryptorchism in the children were proposed.

For students of the higher medical education establishments IV level of accreditation, master’s degree and postgraduate students.

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CONTENTS

LIST OF ABBREVIATIONS

DIR	–	deep inguinal ring
VPP	–	vaginal process of peritoneum
ITD	–	intrauterine development
HTB	–	hematotesticular barrier
ESC	–	elements of the seminal cord
IGC	–	inguinal cryptorchism
SC	–	spermatic cord
USE	–	ultrasound examination
ABC	–	abdominal cryptorchidism

INTRODUCTION

Topicability of the problem. Cryptorchidism is one of the most common anomalies of development of testicles in the childhood. Thus, according to various authors, the prevalence of this pathology among newborn boys ranges from 2-3% in the UK [47] to 10-12% in the Post-Soviet Union countries [68]. In the newborn boys, cryptorchidism is found in 30% of cases, at the age of 1 year – in 2-4%, from 1 year to the adolescence age – only in 1.8-2% [86].

The endocrine and germinal functions of the testes are very important in a determining overall condition of the human body, associated with many parameters of homeostasis, have a variety of effects on internal world of humans [313, 308, 49]. Atrophic processes in the testicle, which has not fallen, directly lead to violations of the excretory function, which is expressed in the development of eunuchism, feminization. Changes in a spermatogenic epithelium in cryptorchidism cause the development of male infertility, impotence and malignant tumors – seminomas, teratoblastomas [56].

Cryptorchidism has a heterogeneous clinical and morphological picture, a high combination with concomitant malformations and chromosomal diseases, so all these factors create a multiplicity of its variants and require the surgeon to know the full range of a surgical treatment for this pathology.

Blowing a testicle into the scrotum as known leads to damage in the testicular vessels, cremaster muscle, anastomoses between the testicular vessels and vaginal process of peritoneum (VPP), this causes a high likelihood in the development of these circulatory disorders. These factors in a further increase the risk of atrophy of the testis.

Cryptorchidism creates medical and social problems that need to be improved by operational techniques [45]. Despite improvements in a surgical procedure, no significant increase in the positive results in the surgical treatment of this pathology has been achieved. There is no information on the effect of the destruction of the vascular anastomoses on a removal and intersection of VPP during mobilization of the spermatic cord.

In this regard, a clinical and experimental work was carried out to study effects of a collapse of vascular collaterals between the parietal peritoneum and elements of the spermatic cord. The obtained results provide the basis for the development of the new methods of surgical treatment of cryptorchidism in children in order to effectively improve the blood supply of a testicle in the postoperative period.

Therefore, relevance of a topic is conditioned by the presence and widespread of the social and medical problems that create the consequences of prompt correction of cryptorchidism in childhood. The reason for this is the unresolved issues of improving the conditions of a blood supply of the testicles in the operative treatment of cryptorchidism and lack of such methods of diagnosis and treatment of cryptorchidism, which would significantly reduce the percentage of infertility in the reproductive period and improve quality of life.

Aim of research: to improve effectiveness of treatment in children with cryptorchidism based on the optimization of ultrasound diagnostics, doppler ultrasound of the testicular vessels and improvement of the surgical treatment methods.

Objectives of research:

1. To evaluate informativeness of ultrasonographic examination in the testicular states in a case of cryptorchidism in children before and after surgery.
2. To study and substantiate use of a video-laparoscopic technique in the diagnosis of cryptorchidism in children.
3. To justify in the experimental conditions on the rats a role of vascular anastomoses between membranes of the testis and a spermatic cord.
4. To develop a new method for the stepwise surgical correction of cryptorchidism in the children.
5. To evaluate effectiveness of a proposed method of surgical correction of cryptorchidism in the children.

Object of the study is cryptorchidism in the children.

Subject of the study is a model of the pathological process during exclusion of vascular anastomosis between vaginal process of peritoneum and other elements of the spermatic cord in rats, means of diagnostics of circulation in the testis at the intersection of the vaginal process of the peritoneum in children with cryptorchidism, and evaluation effectiveness of treatment a new method of surgical treatment.

Methods of investigation – clinical (investigation of clinical criteria for the diagnosis and treatment of cryptorchidism), instrumental (ultrasound and doppler ultrasound make it possible to evaluate effectiveness of a new method of surgical treatment of cryptorchidism in children; the following indicators were evaluated with using laparoscopy: condition of a deep inguinal ring and vaginal process of peritoneum, presence, location and size of testicle, degree of appendage development and its relationship with testicle, presence, stage of development, location of testicular vessels and seminiferous duct), experimental (simulation of pathological process was focused on the exclusion of anastomoses between the vaginal process of the peritoneum and other elements of the spermatic cord and development a new method of surgical treatment of cryptorchidism), morphological (study of morphological changes in the testes of rats at the intersection of vaginal appendix of the peritoneum with using histological techniques). Statistical methods were used in the distribution of patients into the groups, in the analysis results of treatment.

Scientific novelty of the obtained results

In the conducted scientific work the facts of disturbance a blood supply of the testicles in a preoperative and postoperative period in cryptorchidism by means of dopplerography of the testicular vessels are established. Primary, in experimental conditions carried out in the rats, there were obtained data that testify to the dynamics of morphofunctional changes in the testicles at the intersection of vaginal process of the peritoneum. In the experiment and in the clinic, a scientifically valid role of preserving vascular anastomoses between vaginal process of the peritoneum and spermatic cord in the improving of a testicular blood flow during surgical treatment of cryptorchidism has been demonstrated. A new method of stepwise surgical correction of cryptorchidism in children is proposed in order to prevent undesired traction of the testicular vessels during intervention, to maximize vascular collateral between vaginal process of the peritoneum and a spermatic cord. It is proved that a new method of gradual surgical treatment of cryptorchidism allows to reduce the traction of testicular vessels, to preserve vascular collaterals between testicular vessels and vessels of a vaginal process of the peritoneum, helps to reduce the risk of testicular atrophy. The priority was confirmed by Declaration Patent of Ukraine for Invention № 18280 (Method of phased surgical treatment of cryptorchidism in children, 2006).

Practical significance of the obtained results

The results of research work justified use of a proposed method of the stepwise surgical treatment of cryptorchidism in children. The preservation of vascular collaterals between vaginal process of the peritoneum and a spermatic cord helps to reduce the risk of atrophy in a reduced testicle in the postoperative period and through additional blood supply to the testicle in cryptorchidism. The developed method of surgical correction of cryptorchidism allows to increase results of treatment of this pathology, which promotes its introduction for use in pediatric surgery and urology. Twenty-four months after two-stage orchiopexia, the testicular blood vessels had improved testicular blood flow compared to their pre-operative condition during their own doppler ultrasonography: decrease in the resistance index (0.607–0.600), increase in the peak systolic blood flow rate (11.0–13.0 cm /sec) and a terminal diastolic blood flow rate (4.2–5.3 cm /sec).

Results of the study were implemented in the practical activity of the urological department of the Regional Children's Clinical Hospital in Dnipro, urological department of the Regional Children's Clinical Hospital in Kharkov, surgical department of the 1st Children's City Clinical Hospital in Kiev, pedagogical activities departments of clinical surgery and topographic anatomy of the medical universities in Kiev, Vinnitsa, Uzhgorod, Zaporizhzhia, Chernivtsi, Ivano-Frankivsk, Dnipro and recommended for a widespread use in the specialized medical institutions of Ukraine.

CHAPTER 1

LITERATURE REVIEW AND SELECTION OF RESEARCH AREAS

1.1. Etiology and pathogenesis of cryptorchidism

Cryptorchidism is a delay in the lowering of the testis to the scrotum (from Greek kryptos – hidden, orchis – testis).

Reports of cryptorchidism go back to the time of ancient Greece. Thus, the term "orchis" was proposed by the scientist Theophrastus from Heres in the work "Plant Research", which was written about 370 – 285 years ago. The genital organs were perfectly described by Gerophil from Chalkidon 300 years BC. The abdominal location of a fetal testicle was known to Claudius Galen (129 – 199 years AD), where he mentions this in his work "On the Assignment Parts of the Human Body" [89]. Galen and Vesalius (1514–1564 years) were aware with cases of abnormal location of the testicle. Vesalius first described the vaginal process of a peritoneum [91].

In the Middle Ages, Zerkis was the first one, who mentioned lowering of the testicle in the embryo (1495). Fabricius (1606) described location of the testis in fetus in the upper abdomen [214]. Regnerus de Graaf was the first, in 1668, who shown presence of sperm in the testis and appendage using morphological methods [91].

Albrecht von Haller in 1755 in the work "Opuscula Pathologica" proved the intraperitoneal origin of the testes in humans, their migration into the scrotum during intrauterine development (ITD), relationship of the testis in the peritoneum and organs of the abdominal cavity, identified a structure that John Gunther later called gubernaculum [16].

The first theory of cryptorchidism was proposed by John Gunter, according to which the reason for the given pathology lies in the testicle itself. The role of the gunter tendon and vaginal process of the peritoneum in the migration of the testicle to the scrotum during which elements of the spermatic cord are formed has been proved [38, 166].

According to embryogenesis, testis of a human embryo is known to be located in the abdominal cavity and pass through the inguinal canal to the scrotum during five months of embryonic development.

Process of moving the genital gland from the posterior wall of the abdomen to the pelvis finished at the end of a third month of prenatal development. Subsequently, part of the peritoneum accompanying the testicle enters the inguinal canal and penetrates the scrotum, forming vaginal process of the peritoneum. Its distal part reaches scrotum in the seventh month of prenatal development. As a rule, in the interval between 6 and 8 months, testicles fall behind the posterior wall of a vaginal process of the peritoneum, pass through the inguinal canal and before the baby’s birth reach the scrotum.

Gorbatiuk D.L., Zhila V.V., Gorbatiuk O.M. have been proved (1997) that embryonic cells – gonocytes, which give rise to the spermatogenic epithelium, are trapped in the ectoderm of the yolk sac and migrate toward the gonad layer [38]. The laying of these gonads and genital ducts at the kidney occurs within 3–4 weeks of embryo life. In the first stages of its development, the gonads and ducts (Müllerian and Wolfian) are formed in male and female embryos. Sexual differentiation begins at 7–8 weeks of pre-natal development. From 10–12 weeks, genital organs are formed from the Müllerian and Wolfian ducts.

The male genitalia are formed from mesenchyme around cloacal membrane at the beginning of the second month under the influence of testicular androgens. For complete masculinization, maximal secretion of androgens by the testicular glandulocytes is required, which is possible only with sufficient stimulation by the gonadotropic hormones of the fetal hypothalamic–pituitary system. At the end of the third month of prenatal development, testis migrates from the lower pole of the kidney to the deep inguinal ring. In the future, the testis move upwards, and by the fifth month they fall again and lie near the deep inguinal ring. Passing through the inguinal canal in the 7–8 months of prenatal development, they are placed at the entrance to the scrotum. The testis reaches bottom of a scrotum by the ninth month or immediately after birth as a result of differentiation vaginal part of the inguinal tract into the scrotum ligament of the testicles. The scrotum ligament or gubernaculum Hunteri extends from a lower pole of the testicle to the scrotum, passing through the muscles of the anterior abdominal wall. In the sixth month of prenatal development, gubernaculum Hunteri begins to shift towards the scrotum and pull over peritoneum. At 6–7 months, vaginal process of the peritoneum along with gubernaculum Hunteri passes through the anterior abdominal wall and at 8–9 months falls into the scrotum.

The vaginal process of the peritoneum is formed before migration of the testicles through the inguinal canal. It prepares pathways for the migration of the testicle and together with gubernaculum Hunteri provides it is lowered into the scrotum. When lowering gubernaculum Hunteri together with serous membrane of peritoneum brings with it other layers of the anterior abdominal wall. In a case when the testicles lingers at any level of its path into the scrotum, cryptorchidism occurs.

The first theory of cryptorchism was proposed by Jonn Hunter when he wrote in "Animal Oeconomy": "It is not easy to determine the causes of the failure of the testicle lowering into the scrotum, but I suspect that a defect is in the testicles themselves," – and gives conclusion that: "... nothing can be done to give the testicles a stimulus to perfection" [91]. This theory has been accepted by many scholars, including modern scientists [329]. Followers of Gunter's theory assume that the testicular, which has not fallen, is characterized by birth defects and therefore surgery is not able to improve testicular function.

M.E. Demko views migration of the testicle as a sequential movement of it from the abdominal cavity into the scrotum [91]. Depending on the stages of movement, topography of the testicle also changes. The stage of movement of the testis is related to the reciprocal relationship between muscles of the inguinal area and inguinal cortex. The pathophysiological basis for disorders of the testicular movement can be morphofunctional changes on the part of an inguinal tract or muscles of the inguinal area, neuromotor apparatus, presence of mechanical obstacles to the migration of the testicle.

The innate imperfection of the testes was tried to explain the various lesions at the stage of pre-natal development in a form of fetal peritonitis, transferred at the time of orchitis, formation of peritoneal adhesions, as indicated by Yu.K. Shimanovsky, T. Kocher [16]. In the recent years, importance of the disease of rubella carried by the mother in the first trimester of pregnancy [352].

It is assumed that the fetal malformation causes abnormal thigh pressure on the inguinal canal and prevents the testicle from descending. The role of the gluteal presentation of the fetus is discussed [40].

The cause of omission of the testicles is shown in the insufficient length of the testicular vessels [204].

Since ancient times, cryptorchism has been considered a consequence of developmental delay [238]. The theory of reversible anomaly gives non-omission of the testicle atavistic value. In addition, cryptorchidism is not only seen as a malformation. Cryptorchism is identified as an intersex phenomenon, which is confirmed by a high frequency of intersexuality among patients with this pathology – 27% [59, 177]. The prevalence of surgical treatment for cryptorchidism has enabled accumulation of data in a favor of the mechanical interference theory [195].

The role of gubernaculum Hunteri is emphasized in the experimental model of cryptorchidism proposed by Cheung K.H, when the intersection of ligature in newborn rats blocks the migration of the testis [193].

The cause of cryptorchidism is called a decrease in intra-abdominal pressure. That is why gastroschisis and anomalies of the bowel area increase on 10% the frequency of cryptorchidism, especially in combination with violation of the regulatory action of androgens [12, 231, 256].

The non-overgrowth processus vaginalis is the cause of the lag in the development length of the elements of a spermatic cord, so in adults with age there is a mismatch between this length and growth of a person, which is the cause of acquired cryptorchidism (retractile testicle) [44, 45].

In the recent years, hormonal theory has been intensively considered, according to which violation of gonadotropic hormone secretion during the ante- and post-natal life is a major etiological factor [267]. According to the literature, the endocrinological aspects of cryptorchidism have been studied in a sufficient depth, especially role of the hypothalamic-pituitary-gonadal system [313].

The issues of primary and secondary disorders of the hypothalamic-pituitary system take central place in endocrine theory [34, 53, 322]. According to some authors, change in hypothalamic-pituitary activity is a primary in the development of cryptorchidism [78, 199]. In the opinion of other authors these changes occur as a reaction in response to retention of a gland. There are reports that experimental cryptorchidism in laboratory animals can develop under the influence of local factors even under conditions of hypophysectomy [248, 254].

Experience of hormonal drugs use in the treatment of cryptorchidism is gained. At present stage, hormonal therapy is preferred and good results have been obtained [231].

At the same time, there is evidence of a high percentage of ineffectiveness role of hormonal treatment of cryptorchidism, primarily unilateral forms [78, 45, 399, 236]. One of the main roles in the appearance of cryptorchism belongs to the atrophy of Leydig cells [163].

The great importance in the etiopathogenesis of cryptorchidism is provided to autoimmune mechanisms [223, 47, 29]. In a case of cryptorchidism, autoimmune effect against autoantigens of a sperm can be detected already in childhood, regardless of the location of the testicle and type of orchiopexia, and at puberty, risk of such antibodies increases [98, 46, 199].

In the cryptorchidism, some authors note that there are violations of the neuromuscular apparatus of the inguinal area, in a scrotum [79, 88, 236, 299].

Genetic studies in cryptorchidism have gained a new development. Thus, features of the structure of Y-chromosomes have been determined [87, 112, 377]. Significant progress has been made in studying the combination of cryptorchidism with other congenital anomalies. Thus, at the present stage, multifactorial theory has become dominant [67, 348]. However, hypothesis of pluricusality of cryptorchidism today is only assumption based on the clinical data, but not confirmed by clear functional or morphological evidence [34, 49, 123, 376].

Many works are devoted to the issues of clinical manifestations and diagnostics of cryptorchidism [39, 45, 333]. The heterogeneity of cryptorchidism causes specialists to use many instrumental methods (testimetry, orchiovolometry, orchiothermometry, testicular venography) of research methods [11, 49, 143, 344].

Many new hardware research methods have been introduced for the diagnosis of cryptorchidism: computed tomography, nuclear magnetic resonance [234, 400].

Laparoscopy has been widely used in the diagnostics and treatment of retention testicles, namely, intraperitoneal forms, which make up about 21% of all cases of cryptorchidism [123, 199, 284, 299]. According to some authors, laparoscopy is the best method for removal of a highly retentive testicle in its atrophy, malignancy, poliorichidism, hypoplasia [13, 43, 77, 127, 234, 345, 389]. For diagnosis, it is shown only in the absence of positive results from use other methods of diagnosis [366].

Many authors [14, 56, 77, 235, 377, 401] emphasize the need for dynamic dispensary monitoring such contingent of children in connection with the development of various complications: development of inflammation, oncogenic determination, entrapment and reversal of the testis and spermatic cord, which is widely represented in the literature [39, 45, 322, 398].

Particular importance for all complications has malignancy of the testicle, which has not dropped [14, 39, 77, 123, 282, 301]. It can develop regardless of whether there is genuine cryptorchism or testicular ectopia [344]. According to A.B. Okulova [116], tumors were observed at the patients in 4.2% of cases.

A.V. Lyulko, E.G. Topka [87, 152] concluded that malignancy of the testicle in a case of cryptorchidism occurs in 20-25% of cases, according to Mirilas P. [297] in 3–18% of cases.

Various by histogenesis malignant tumors, which were developed on the basis of cryptorchidism have been described: Leydigoma [253, 410], rhabdomyosarcoma [255, 354, 387, 390], seminomas [78]. If the correction of cryptorchidism is not performed in all cases, seminomas are observed more often [23, 366].

Embryonic tumors, teratomas [278], teratoblastomas, even in adults, may occur in the non-descending testes [364].

1.2. Structure of blood vessels and parenchyma of the testes and appendage in a normal condition

It is known that in the vascular system of testis main artery is the testicular, because only it directly penetrates into the parenchyma of this organ [7, 15, 35]. The artery of the appendix departs from it within the spermatic cord. The artery of seminiferous duct and artery of the cremaster muscle of testis participate in the blood supply of the testis and through anastomoses, the most pronounced of which is anastomosis between testicular and artery of the seminiferous duct [4]. The diameter of the testicular artery ranges from 0.2 to 1.9 mm, arteries of the seminiferous duct - within 0.2-1.8 mm, arteries of a cremaster muscle of the testicle - 0.1-1.5 mm, with diameter of the testicular artery is equal or greater than the amount of other two largest arteries more than in 50% of cases [6, 197, 240].

According to studies, intracranial vessels of the testis are formed by 2 groups of arteries: those arising from the testicular artery, which enters its parenchyma in the area of centrifugal arteries and those emanating from a vascular network located under the protein membrane (centripetal, radial arteries), which is also formed from the branches of a testicular artery [184]. Some authors [108, 109] describe three parts of a microcirculatory channel of human testis: afferent (arterial link of capillaries, permeating groups of Leydig cells), peritubular (capillaries of own membrane of the seminiferous tubules) and efferent (venous capillaries, penetrating Leydig cell groups) capillaries. They begin with arterioles emanating from the branches of segmental arteries. The architectonics of human hematocirculatory duct is complex. Peritubular capillaries do not form a clear mesh and distinct loops.

The parenchymal veins are located in a testicular septum and run radially to its mediastinum. Vine-shaped plexus is formed by superficial and deep intraorganic veins of the testicle, veins of the appendage and seminiferous duct [7]. Within the spermatic cord, they formed about 12 vessels with a diameter of 0.3-2.0 mm. Veins of a vine-shaped plexus are classified into several groups [107].

Veins of the first group form a dense plexus around the testicular artery with help of anastomoses. Veins of the second group formed anastomoses with each other without approaching the artery. Veins of the third group formed anastomoses between I and II groups. Veins of the fourth group formed anastomoses with the testicular artery. This is confirmed by Fijak M.L., Iosub R., Schneider E. (2005), who found connections in the form of capillary network between testicular artery and veins of a vine-shaped plexus within spermatic cord [213]. Klepikov F.A., Shapoval V.I., Fedotov P.P., Kuzminsky R.Yu. (1972) described that variations are often found in the veins of testis than in the corresponding arteries [67]. Namely on the left side (in 21.3% of cases), where, as a rule, they enter to the left renal vein, and considered to be a cause of development varicose dilatation veins of the spermatic cord. In 18.8% of cases variations were found bilaterally. Only in 2 cases the right testicular vein falls into the right renal vein instead of the inferior vena cava.

Astrakhantseva A.F., Krupkova N.M. (1996), shown that in 80% of cases, the appendage artery penetrates into its capsule from the posterior medial margin, gives artery to the head of appendage and proceeds along its medial part as the marginal artery of the appendage [3]. The artery of appendage may depart from artery of a seminiferous duct, the head of appendage has blood supplying from vessels of upper pole of the testis. Artery of the cremaster muscle of the testis is placed between the fibers of eponymous muscle in the composition of 6-12 small trunks that anastomose in the area of the appendage tail with marginal artery of the appendage, or with artery of the seminiferous duct.

Among blood vessels of the appendix, there are short, significantly twisted small arteries, from which microcirculatory network begins. It is denser, compared with testicular tubules [17]. Branches artery head of the appendix send lateral branches between cones of outlying tubules. From this branches depart arterioles with a diameter of 100-120 microns, but near wall of excretory tubules depart precapillary arterioles. The last one give rise to 1-2 capillaries extending along the outlying tubules and interconnecting short transverse capillaries [2, 182]. Postcapillary venules (with a lumen of 20-25 microns) are formed by the fusion of adjacent capillaries. The branches of marginal artery of appendage are the source of microvasculature in the distal part of appendage head, its body and tails.

The microcirculatory bed of appendage is characterized by zonal specificity associated with optimal provision blood flow of the duct wall during its reduction. In the body of appendage, vascular mesh is two-layer, in the tail − three-layer, due to the formation of peritubular, intramural and subepithelial branches.

The veins of appendix are divided into two separate systems: veins of the parenchyma of appendage and veins accompanying arteries of the appendage [114, 118, 179, 203].

The main feature histological structure of the testis is anatomical and physiological compartmentalization of its parenchyma. In the parenchyma there is interstitial tissue and tortuous seminiferous tubules (steroidogenic and spermatogenic compartments) distinguished [103, 137, 139].

Twisty seminiferous tubules on a cross-section have circular shape, with a diameter from 150 to 250 microns [11, 15]. According to works [15, 178], in mature men found a small percentage of tubules with abnormalities in the structure of spermatogenic cells, which is probably related to apoptosis during their differentiation, which accounts more than half cells until mature to spermatozoa in the normal conditions. They are selectively phagocytosed by Sertoli cells [176]. Histological examination parenchyma of the testes in mature men [95] revealed that only in 70% of cases, the tortuous seminiferous tubules were characterized by usual cytological structure.

Quantitative characteristics of cells in tortuous seminiferous tubules, distribution of Sertoli cells and their relation to the number of spermatogenic cells in the normal conditions and changes of these parameters with age have been investigated [89, 147, 233].

A lot of works is devoted to the research cells of the twisting seminiferous tubules and process of their development. The seminiferous tubules consist of their own membrane and spermatogenic epithelium containing it, which contains two main populations of cells - Sertoli cells and cells of the spermatogenic epithelium, which represented by the spermatogonia, spermatocytes, spermatozoa at the different stages of differentiation [99, 147, 173]. Spermatogenesis involves proliferation of spermatogonia, meiosis of spermatocytes and differentiation of spermatids into spermatozoa (spermiogenesis) [74, 142]. In the study [173] was proved, that in the process of spermatogenesis about 256 spermatozoa develop from one spermatogonia.

The most characteristic feature of Sertoli cells is a large oval, pear-shaped nucleus with invaginations and a large nucleus [147, 233]. Among spermatogonia distinguished the light and dark. Dark refers to "backup" stem cells, and the light refers to the semi-stem cells that are rapidly updated. These are cells of rounded shape, which located in the basal part of a tubule. They are characterized by oval nucleus with a diffuse chromatin, 1–2 nuclei near the nuclear membrane, a large content of ribosomes, polysomes in the cytoplasm, a small number of other organelles [89, 147]. Spermatogonia, spermatocytes of II order are smaller than spermatocytes of I order. Spermatids are small, rounded cells with a small nucleus that are gradually compacted and diminished [11, 125].

The interstitial testicle consists from tufts of the collagen fibers, which form supporting system of the organ’s parenchyma. The connective tissue is a thickly penetrated by hemocapillaries and lymphocapillaries [134, 153]. In the interstitial tissue, Leydig cells are located in a form of small clusters near the blood capillaries [65, 133]. According to Akre O., Lipworth L., Cnattingius S., Sparen P., Ekbom A. (1999), these cells are large in size, rounded or polygonal in a shape, with acidophilic cytoplasm poor in organoid, vacuolated at the periphery and the large oval nucleus, with an average volume is 90 μm3 [177].

Description the anatomical and histological structure of appendage was found in many works, according to which it is conventionally divided into a head, body and tail [17, 72, 139, 225]. Removal tubules are considered as the connecting link between the testis and appendage, but studies have shown their important role in the development a fertilizing capacity of sperm [5].

The appendage tubes are round or polygonal form [72], close to each other. Wall of the epididymis duct (0.4-0.5 mm thick) consists of three layers: the adventitious, muscular and epithelial. According to Kutsenko N.A. (1981), Romanenko A.M. (1990) movement of sperm through the appendage is ensured by contraction of its muscular membrane [72, 135]. A tail of the epididymis is the reservoir for sperm until moment of ejaculation.

The appendage duct epithelium is located on the basement membrane and consists of basal and high (30 to 80 μm) prismatic epitheliocytes. Their nuclei lie at different heights [88, 139]. On the surface facing the middle of a duct, they carry beams of stereocilia. Under the layer of prismatic cells is a layer of basal cells smaller in a size, round or polygonal form. They appear during puberty. The epithelial cells of appendage are connected by dense complexes, their cytoplasm is penetrated by the endoplasmic reticulum, it has a well-developed Golgi apparatus. The numerous vesicles are available, indicating the secretory and absorptive activity [157, 191]. It has been confirmed that the epithelium of appendage carries out actively the secretion and absorption of fluid (it was considered that Sertoli cells and a testis mesh are involved in this process) [93, 94, 113].

In the work of Korenev M.M. (2002), hemato-testicular barrier is the set of structures located between gaps of the capillaries and tubules [69]. It includes a wall of blood capillaries, own membrane of tortuous tubules, and Sertoli cells. The hemato-testicular barrier prevents transportation of the small or hydrophilic molecules into parenchyma of an organ and protects the sperm, preventing development of an autoimmune reaction, because they appear in the spermatogenic epithelium in puberty, when immunotolerance is already established [79, 115, 144].

In the works of Volozhin S.I. (1980), Rautkis V.A., Pogorely V.V. (2000), Ceylan H., Yuncu M., Armutcu F., Gurel A. (2005) found information on the structure blood capillaries of the testis [22, 133, 189]. Their wall consists of a basal membrane, on which endothelial cells are located by a solid layer, with a nucleus of elongated shape, chromatin is placed evenly. Near nucleus is the Golgi complex, the endoplasmic reticulum, ribosomes, a small number of mitochondria, and micropinocytotic vesicles. Peripheral cytoplasmic endothelial cells divide in some places. Cells are contacted by the finger-like connections. There are no pores and fenesters in the capillary wall [77, 108, 109].

The endothelial cells microvessels in the testis have relatively impermeable compounds [148] that can open at random to allow passage of macrophages and neutrophils during inflammation [241]. The intrinsic membrane of human seminiferous tubules consists of a basal membrane of the spermatogenic epithelium (about 80 nm thick) and 5-7 layers of cells located outside of it [97]. The basement membrane is a homogeneous substance with a collagen fiber network. The inner 3-4 cell layers are formed by myofibroblasts (myoid cells). The outer layers of cells are fibroblasts, so they are considered to be a part of the interstitium.

In myoid cells, organelles are scattered throughout the cell, many pinocytotic vesicles are located under the plasmolemma [15]. Nuclei are spindle-shaped, with varying amounts of chromatin condensed at the nucleolem. Thin peripheral processes of cells cytoplasm are closely adhere to each other, but there is not observed direct desmosome contacts or membrane fusion. According to Hem A., Cormac D. (1983) myoid cells contain thin contractile actin filaments, located longitudinally and circularly, as well as other cytoskeletal proteins [164].

Self-contained myofibroblasts have features of both fibroblasts and smooth muscle cells [138]. They provide rhythmic contractions of the tubules wall. Contacts between myoid cells formed by "end-to-end" or getting of the ends (with a slit 20 nm), similar to vascular endothelium, it has some barrier function. In the contact areas, cytoplasm is characterized by a high electron density due to the accumulation of fibers.

It has been established that the dynamics of Sertoli cell connections depend on the integrity of a basement membrane and maturation of germ cells [106, 211, 212].

Investigations of Nagorny I.I., Lise V.L., Ivashchenko T.E., Fellu M., Baranova B.C. (1996) demonstrate that transport of substances from the interstitial tissue of testicle to the cells of tortuous seminiferous tubules takes place through Sertoli cells in the intercellular and transcellular pathways [101]. Romanenko A.M., Tereshchenko A.V., Persidsky Yu.V., Petersburg V.F. (1988) considered that Sertoli cells and their specialized compounds are the most important structural component of the hemato-testicular barrier [136].

Sertoli cells have an irregular conical shape, a large nucleus, with invaginations, located in the basal part of the cytoplasm. There are three-membered nuclei (nucleus and two groups of nucleolus chromatin). It is well-developed agranular endoplasmic reticulum, elements of the Golgi complex. The cytoplasm is rich in electron-dense lipid droplets. It has oval or elongated mitochondria, large vesicles. There are lysosomes, crystalloid inclusions [123, 137, 190, 202]. There are pronounced elements of the cytoskeleton (microtubules, microfilaments) in Sertoli cells and their role is important in the dynamics of compounds [68]. Studies [156, 241] are devoted to the ultrastructural organization and dynamics of specialized compounds of Sertoli cells during spermatogenesis, and impact on the pathological conditions.

According to work [241], the main role of dense compounds is to prevent small molecules from passing through them. Besides the functioning of Sertoli cell compounds as an immunological barrier for postmeiotic germ cells − carriers of antigens (spermatocytes at the pachytene stage, spermatids in the different stages of differentiation and spermatozoa), they form a special environment for their development, determine their polarity [235]. The zones of tight conjunctions of Sertoli cells are delimit their upper parts [186].

According to research [87, 162], in a course of spermatogenesis the movement of spermatocytes from basal compartment to the adlumenal occurs without breaking a barrier closure, as a result of restructuring compounds, as shown in the studies [39, 173]. Specialized Sertoli cell conjunctions are formed from tightly packed actin filaments located under the cytoplasmic membrane, parallel to the contact area, and endoplasmic reticulum [121, 155, 185, 211, 222]. Often, two contacts are associated with one bundle of filaments. The gap between adjacent plasmas is about 12 nm in a size.

Studies [121, 155] are devoted to the structure of contacts between cells of the spermatogenic epithelium. The connections between Sertoli cells and spermatogonia are much stronger than between Sertoli cells and spermatocytes or spermatids [234].

Lyulko O.V. (1983), Nakonechnyi A.J. (2001), Fernandez Valades R., Lopez de la Torre Casares M., Castilla J. (1998) investigated the ultrastructural characteristics of the different cell types of spermatogenic epithelium [89, 102, 210].

Leydig cells have a well-developed smooth endoplasmic reticulum, the Golgi complex, numerous mitochondria with a light matrix and lamellar combs [98, 127, 177]. The cytoplasm contains a large number of lipid inclusions. Chen L., Xia W.P., Zhou Z.H. (2003) described the structure of lamellar complexes in mitochondria, which consist of closely spaced lamellar crosses, investigated the cell mitochondria of Leydig cells [192].

1.3. Morphofunctional changes of testis in the disorders of local circulation in a case of cryptorchidism and its surgical treatment

Vascularization disorders in cryptorchidism play a significant role in the development of various pathological conditions in the male sex gland [47]. In this regard, many scientists have studied influence of experimental ischemia on the structure and function of the testes. The development of collateral in these conditions was considered as one of the main compensatory processes that contributed to the restoration of organ's life [122]. The authors noted increasing in the collateral vascular connections of the testis after ligation of testicular arteries, but these connections are insufficient and the testis atrophies.

The first experimental works were performed by J. Muller. He shown microscopic changes in the testes after exclusion of blood supply [303]. The scientist observed atrophy of a glandular parenchyma in the organ, development of degenerative changes in the tortuous seminiferous tubules, infiltration of the interstitium by lymphoid cells.

As shown by Lebedev N.B. (1985), Topka E.G., Kushnaryova O.O. (1994), Koh K.B. (1996) in the first time after ligation of a testicular artery in the experiment on rats in the testicle, there were noted significant disorders of microcirculation and metabolic processes. At the same time, spermatogenic epithelium was removed from basal membrane of the tubules [79, 155, 256]. Circulatory disorders of the testicle according to Gorbatiuk O.M. (1997) were carried out to pronounced destructive changes in it [49]. The high sensitivity of the testicle to the blood supply disorders contributed to the development of irreversible destructive changes in it parenchyma after 1-2 hours of ischemia.

Studies of Lyulko O., Minkova N., Tsvetkova D. (1993) have shown that the tolerance of parenchymal organs and muscles to ischemia did not exceed 45-60 minutes [89].

A great interest should be focused on the possibility of a lifelong study for regional blood circulation in the testicles in cryptorchidism. Successful study of local circulation in the testicle by the method of rheotesticulography was carried out by Kozlovsky I.V. (2002) [68].

In recent years, ultrasound scans of organ vessels with doppler effect have been used in order to study vital state of vessels in the regional circulation bed of testis in children.

By B.V. Grytsuliak (1996-1999) disorders of the vascularization in the testis occupy a significant place in the development of hypogonadism [51, 52].

Podrabinek T.R. (1985) revealed congestion in the organ's vessels, extensive blood lacunae, enlarged arterioles with altered myocytes, spermatogenic epithelium conjunction, rupture in a lumen of the seminiferous tubules in a case of acute ischemia during ligation of the testicular artery at pubescent rats in 120 minutes after surgery [123].

Due to a high sensitivity of testicular tissues to the blood supply disorders, which lead to destructive changes in the organ, various methods of revascularization of a male gland have been proposed [156].

Arterial perfusion of the testes was increased by direct vascularization of the male genital gland, which was achieved by forming an anastomosis between inferior adrenal and testicular arteries [159]. This intervention was aimed at improving the arterial blood supply of the organ.

Normal function of the testis in most mammals and humans is carried out only at the temperature on 3-5 °C below than a body temperature. It is provided by thermoregulatory mechanisms of the scrotum, crematory muscle, which is responsible for sufficient mobility of the organ, arterial-venous supply of the organ and its lymphatic drainage [122].

Overheating of the testicles in cryptorchidism disrupts spermatogenesis, causes destructive changes in the organ, violates the enzymatic processes in it [166].

Effective thermoregulatory properties are possible due to the thin skin of the scrotum with a large number of sweat glands, which has no subcutaneous fat, and presence of elastic fibers in a fleshy membrane [121].

The optimal testicular temperature required for active spermatogenesis is supported by the normal functioning of a cremaster muscle [122]. An important physiological factor contributing to the optimum temperature conditions for the testicle is the specificity of the organ vessels. The testicular artery outside the testis has a very tortuous course and is densely entwined with veins of plexus pampiniformis [144]. Such relationships of different blood vessels provide a certain way of heat exchange between a blood flowing in opposite directions. As shown in the studies [145], at the directly measuring temperature inside the testicular artery in dogs, the blood temperature decreased on average in 3 °C along length of this artery.

Indirect vascularization of the testicles by enhancing the bypass blood supply organs of the scrotum also had a positive effect on the androgenic and reproductive functions of the organs [156].

Okulov A.B. (2001) distinguished several stages of male genital mutilation under hypokinesia condition, which led to the chronic ischemia in organ [113]. In the hypokinesia of testicles were shown dilatation of the blood vessels, a slight violation of spermatogenesis up to 9 days in rabbits and dogs. There was found a relative stabilization in the 40 days of hypokinesia, despite certain changes. After 60 days of the experiment, there was a sharp narrowing of vessels, the irregularity of their walls due to the endothelium splicing, the dislocation of elastic membrane, the fragmentation of a muscular membrane. There was a local and then complete expansion of connective tissue and complete extinction of reproductive function.

On the basis of experimental-morphological experiments Okulov O.B., Matkovskaya A.N., Chuvakov G.I. (1984) concluded that in a case of hypokinesia over 60 days were observed changes in the male parenchyma, which are identical to changes in the organ at acute ischemia by ligation of the testicular artery [114]. In these conditions were noted disorders of a blood supply in the testicle, mainly due to an impaired blood flow in it. Chronic venous plethora maintained the state of tissue hypoxia in the organ. This condition is normally excluded because the testicle is located in a circulatory bed due to the anatomical features of its membranes and cremaster muscle, which is constantly contract and relax, promote normal microcirculation in a body, basicly, and carried out to venous outflow.

One of the adverse factors that cause significant testicular dysfunction is cryptorchidism [47]. Trauma of the male genital gland occurs during surgery on the testicle and its location [366, 389]. Lowering of the testicle into scrotum causes damage of the testicular vessels, cremaster muscle, anastomoses between the testicular vessels, and vaginal process of the peritoneum, which causes a high likelihood of impaired circulation. The following factors, in the future, lead to the atrophy of testis, development disorders of the hormonal function and fertility in a reproductive period.

A.A. Maximov (1898), who studied reparative regeneration of the testis, gave a clear description of pathological changes that develop in the organ.

The hypothesis about role of autoimmune processes in cryptorchidism and destruction of the testicle containing "hidden" antigens was formulated by Raytsina S.S. (1982) [127]. Later, veracity of this hypothesis was confirmed by V.A. Bozhedomov (2005) [10].

According to the immunological mechanism hypothesis, destruction of the seminiferous tubules, the development of pathological process in the body occurs as a result of traumatic violation of autoantigenic cells isolation a spermatogenic epithelium from centers of an immune response and the development of immunological conflict between germ and immunocompetent cells [178].

Today it is known that the main cause of autoimmune process in the testicle, which has not fallen, is a violation an integrity main components of the hematotesticular barrier (HTB) [389, 399]. As a kind of histogematic barriers, HTB is a morphofunctional system that provides selective passage of substances from the vascular bed into a tortuous seminiferous tubule and, on the contrary, prevents development of autoimmune aggression, contributes to the preservation of the organ homeostas [277].

Chronic circulatory disorders of the testis in cryptorchidism are exacerbated by concomitant inguinal hernia, content of which creates periodic or permanent compression into the blood vessels of a spermatic cord. In the majority of cases, operation itself has a negative effect on the testicle [345]. Morphological studies of the testes on a side of operation have revealed a disorder spermatogenic function of the organ. In this case, decreasing function of the testicle leads to atrophy in it [199, 299].

1.4. The most common methods of surgical correction of cryptorchidism in the children

The first operation devoted to cryptorchism was performed by Koch from Munich in 1820. He uncovered the scrotum, ran a ligature through the vaginal membrane, hoping that the following traction would help dip the testicle into the scrotum. This operation finished with the death of patient.

In 1888, Seemann defended a dissertation that suggested castration in a case of cryptorchidism. At the same years became widespread operation of celiaplasty (moving the testicle into the abdomen), which was proposed by Rizzoli (1871). At the beginning of XX century, this method was already proved as ineffective [109].

It should be noted that the first attempts focused on the surgical treatment of cryptorchidism were unsuccessful not because of the purulent complications, but also because surgeons at that time did not have knowledge about the anatomical-topographic relationships elements of the spermatic cord and vaginal process of the peritoneum.

The advent of Lister's antiseptic has formed the basis for further systematic improvement surgical treatment of cryptorchidism.

One of the first successful operations of the testis lowering was performed by Max Schuller (1881). Schuler's merit was a correct description of the anatomic-topographic relationship between elements of the spermatic cord and vaginal process of the peritoneum in cryptorchidism. Schuler orchiofixation was performed by applying a single suture to the fleshy membrane in the region of the scrotum base [83, 84].

The number of methods, which covered surgical treatment of cryptorchidism and their modifications in children, exceeded now 250 methods [88, 131, 323]. The main issues of therapeutic tactics in cryptorchidism as well as timing of surgical intervention, choice method of surgery remain debatable. This is due to the discrepancy between the results of a comparative evaluation of the main and common methods of the testis lowering to the scrotum.

The following step of our research is analysis and comparative evaluation of the most known methods of surgical correction of cryptorchidism in children in the historical aspect.

Biven's method (1899) concerned to the first successful surgical intervention in cryptorchidism – it is fixation of the reduced testicle in the scrotum by a stitching ligature, both ends of which are deduced through a scrotum and tied on a gauze "ball" [57, 58, 373].

The method of Ombredan (1910) is a method of intracardiac orchiofixation, in which the unoccupied testis is put through intersection of a scrotum and testis is immersed on the cavity of the contralateral testicle. The method is especially effective in ectopic testes [47].

Mikster's method (1924) is consists in fixing of the reduced testicle in the scrotum with a piercing ligature to the skin of the opposite thigh. An anchor suture is imposed through the testicle membrane. However, defect of this method is the compression main branch of the testicular artery [363].

Keetley’s method is temporal orchiofixation with creation of a skin calico-femoral cuff on the side of surgery, which was further refined by Torek and Herzen. However, modification by Torek excessively complicates the second stage of surgery by the need to remove testicle from a thigh tissues and create a new bed in the scrotum. In addition, the anchor suture, passing through the protein membrane, as well as by Mikster’ method, can capture branch of the testicular artery. Thigh traction is allowed in the method, and any extraction elements of the spermatic cord is detrimental to the reduced testicle [25].

Method of Sokolov (1925) is to create a temporary traction for the ligature, carried through the distal part of the vaginal process of peritoneum and fixed to the gypsum lumbar of a thigh. The method is not widely used in general practice, because there is an undetected traction of the testicular vessels and complexity of the intervention [36].

Method of Petrivalsky-Schmaker (1931) is focused on the fixation of testicle in the membranes bottom of a scrotum directly under the skin during operation. This method is the simplest, most reliable. It is shown in the relative insufficiency elements of the spermatic cord. But the method involves an intersection in the proximal area below an internal oblique abdominal muscle, the cremaster muscle, resulting to the destruction of important vascular collaterals. Even with maximal mobilization elements of a spermatic cord, the testis never reached the bottom of a scrotum. In the early postoperative period, half of the scrotum was drawn towards outer inguinal ring due to the retraction elements of the scrotum.

V. Vermoot (1947) proposed to create a bed in the testicle with a help of clamp. The ligatures that pierce remnants of the Gunter tendon are drawn out through the created bed of a scrotum outward and formes elastic thrust to the opposite thigh, as well as the surgery by R. Gross, or on the side of operation (orchiopexia by N.N. Sokolov) [50].

Biven and Kocher suggested that a purse seam should be applied to the entrance of a scrotum after the testicle had been download. This stops the retraction of the reduced testicle to outer inguinal ring in the early postoperative period.

A modification of Sokolov’s operation is R. Gross method (1958). Author proposed to stop retraction of the testicle in the first days after surgery. It should be fixed to the remnants of the Gunter tendon, but in the opposite thigh. The special feature of the operation is a wide access, which creates conditions for careful preparation of tissues in ventral space and maximum mobilization elements of the spermatic cord. The disadvantage of this method, as well as in the operation by Sokolov, is undetected traction of the testicular vessels, which can lead to atrophy of the reduced testis.

The method of Perron and Signarelli (1963) proposes to sew a testicle with anchor seam to the septum of a scrotum.

Fowler's method (1972) is the fixation of a lowered testicle in the scrotum using anchor suture through bottom of scrotum to the crotch, which does not cause significant tension of the testicular vessels. The testicle may be as high as possible in the scrotum. However, after tying peritoneal suture, testicle is pulled to the back wall of the scrotum, without giving the testicular contour.

Fowler and Stephens (1963) developed a "long loop lumen" operation, which involves intersection of testicular vessels with maximum preservation of collateral between the testicular artery and arteries of a duct, cremaster muscle of the testicle. The decision should be made during revision and mobilization elements of the spermatic cord before dissection by Fowler and Stephens samples with clamping of a testicular artery and incision testicular membrane (wound should bleed for 2-3 minutes). This operation is shown only with insufficient length of the testicular vessels and the impossibility of performing other one-time orchio fixations.

Weisbach and Ibach (1975) were the first who used tissue adhesive in order to fix the testicle in a scrotum. This method is not widely used.

In a case of absolute insufficiency of the testicular vessels perform a gradual movement of the testicle by Cabot and Wesbit (1931), Shyder and Chaffen (1955), Kiesewetter et al. (1981) methods. Depending on the length of testicular vessels, testicle is fixed to the pubis, to the inguinal ligament, or to the top of a scrotum. The requirement remains unchanged – there is no traction on the testicle to prevent its atrophy. The second stage of an intervention should be performed after 1 year. The disadvantage of stepwise movement of the testicle in this way is presence of a rather rough scar process around testicle in the second stage of intervention, which complicates its removal from the surrounding tissues and leads to impaired blood supply in the reduced testicle.

In the case of absolute insufficiency of vessels, autologous transplantation of the non-descending testicle, which was firstly performed by Nesa S., Lorge F. It is considered to be the most successful [311]. The testicular artery is connected by microsurgical anastomosis with inferior epigastric artery, and seminiferous vein with the branch of a large subcutaneous vein. The method is very effective in the absolute insufficiency of testicular vessels, but complexity of its implementation and the need for special technical support narrow indications for its use in general practice.

O.V. Lyulko and D.P. Chukhrienko proposed an orchio-fixation method in which testicle is fixed in a scrotum between the skin and a fleshy membrane [89]. Additionally, the fleshy membran should be fixed to the scrotum opposite wall, starting from the spermatic cord and to the bottom of a scrotum.

The testicle is fixed by the free ends of the filaments, which are stitched by the distal part vaginal process of the peritoneum to a new-created wall. The testicle is fixed in the lowest part of a scrotum between its skin and double wall of the fleshy membrane [156, 157].

Despite variety of methods of orchiofixation, they are continued to improve. However, their improvement in the recent years has reached a maximum level, and the results of surgical treatment of cryptorchidism worldwide are not improving. The advances carried out in the treatment of cryptorchidism are not provided with

one or another method of orchiofixation, but, focused on the mobilization elements of the spermatic cord within an inguinal canal, including area of an inner inguinal ring, without traction. Recently, thesis about the leading role of mobilization elements of a spermatic cord and subordinate value of orchiofixation in the surgical treatment of cryptorchidism has been put forward.

Methods for enhancing blood supply of the testicle after its descent by restoring m. cremaster with rectus abdominis muscle have been developed. E.G. Topka (1980) suggested several methods of surgery to put the testicle into a scrotum without impaired circulation and ensure the mobility of organ [156]. These techniques are performed in the abdominal location of the testis, short testicular vessels. In the first method of revascularization through the layered section of tissues of the inguinal area, the testicle is removed from retroperitoneal space, and vascular vessels are mobilized from adhesions. Then a patch of 8 to 10 cm in length is forming from lateral side of inferior abdominalis muscle, which includes the inferior epigastric vessels and nerves. The free end of this patch is brought to the upper pole of the testicle. The testicle is lowered into the scrotum, fixed by Schuller. In the second method, muscular patch on a vascular leg is created from a gentle thigh muscle at the level of lateral edge of the scrotum. Thus, all these methods use method of organopexy, the morphological basis of which is adhesion, which is formed as the organ grows– donor with the organ –recipient.

Increasing a blood supply of the testes is performed also by restoring of m. cremaster from an internal oblique abdominal muscle [129].

The basics of mobilization a spermatic cord in vaginal process of the peritoneum was laid by A.D. Bevan (1899). Davison (1911) developed the theory of the "seminal surgical triangle". Its essence lies in finding ways to shorten the path of the testes vessels. It has been subject to multiple modifications and has become relevant again in the last decade. Finding a way to shorten the path of the testes is a necessary part of cryptorchidism. The mobilization elements of the spermatic cord are not just a step in the operation, but the key to deciphering the whole idea of a technological concept: bringing down a retained testicle without tension. An important role in this is played by a pre-peritoneal access, which has a theoretical justification. From the standpoint of the doctrine devoted to "seminal surgical triangle" (hypotenuse is the midline of a body, upper cathetus is the peritoneal course of the testicular vessels, lower cathetus is inguinal course of the same vessels) – extension length of the hypotenuse can be achieved by the decision of this triangle [131].

In the presence peritoneal forms of cryptorchidism, resolution of seminal surgical triangle is necessary in full volume and not at the expense of the lower cathetus (which is practically absent), but at the expense of upper cathetus, i.e. due to the mobilization of blood vessels above a deep inguinal ring, which can be performed at a pre-abdominal access, with the purpose of medial movement of them to the place of hypotenuse.

Gorbatiuk D.L., Voitenko G.N., Gorbatiuk O.M. (1988) consider that "normal mobilization" gives an extension of 3–4 cm; intersection of the seminal bundle by Parsons J.K. (2003) gives 1 cm more; solution of seminal triangle gives another 1-2 cm [37, 326]. The section of a muscle, raising the testicle, gives an extension not more than 1 cm; mobilization vaginal process of the peritoneum – from 1 to 1.5 cm; retroperitoneal dissection at inguinal access – 0.6 cm, at the preperitoneal access – 2.7-2.8 cm. General elongation at inguinal access is 2–3 cm, at the preperitoneal access – 5-5.4 cm. According to the authors point, at mobilization elements of the spermatic cord are not necessarily treated and crossed lower epigastric vessels, as they are flexible and do not interfere with its movement. The difficulty of operation on the testicle is increased in proportion with distance of the testicle from a scrotum. The distance on which the testicle should be moved becomes larger at the baby grows, because there is a certain disproportion between anticipated increase in the distance from pubis to the bottom of a scrotum as compared with elongation elements of the spermatic cord in non-descending testicle. Therefore, orchiopexia is easier to perform in infants with minimal mobilization of the spermatic cord, and rarely need full retroperitoneal mobilization, which, in contrast, is often required for the older boys with non-palpable testicles [121].

For non-palpated testis, laparoscopic diagnostics with two-stage reduction of the testicle by Godbole P.P., Najmaldin A.S. is recommended [221]. Laparoscopy gives a reliable positive diagnosis, which is especially valuable in aplasia of the testes, poliorchidia and other cases where laparoscopy is the only way of diagnosis and treatment.

At the present stage, questions about role of vascular collateral between vaginal process of the peritoneum and other elements of the spermatic cord, as well as impact of their destruction during surgical correction of cryptorchidism on the development disorders of hormonal function and fertility are left without attention of scientists and general practitioners.

Thus, cryptorchidism creates medical and social problems that need to be addressed. At the present stage, no significant increasing the positive results in surgical treatment of this pathology has been achieved. There is no information focused on the effect destruction of vascular anastomoses to removal and intersection vaginal process of the peritoneum during mobilization of the spermatic cord. Therefore, study effects of vascular collateral destruction between the parietal peritoneum and elements of the spermatic cord has a great importance in the development new methods of surgical treatment of cryptorchidism in children with the aim of effectively improving blood supply of the testicle in the postoperative period.

CHAPTER 2

MATERIALS AND METHODS OF RESEARCH

Scientific work combines the experimental and clinical parts. The experiment, in accordance with aim and objectives, was performed on rats and included two series of experiments (in one day after surgery, 30 days after surgery) and control group without surgery. The simulation of pathological process has to exclude function of vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord and to develop new method of surgical treatment of cryptorchidism.

During experimental studies in rats were obtained positive results, which formed basis for new method of surgical correction of cryptorchidism in children.

In the clinical part of work a new method of surgical treatment abdominal forms of cryptorchidism in children was implemented to the practice. It includes mobilization of retentate testicle in the first stage, which was carried out depending on the length of testicular vessels without fixation of the testicle or spermatic cord to surrounding tissues. The vaginal process of peritoneum was opened along front surface of a spermatic cord to deep inguinal ring in the longitudinal direction without crossing it across. There was eliminated entrance to the abdominal cavity due to the applying an internal purse suture on the parietal peritoneal membrane at the level of deep inguinal ring, and laying the testicle to a scrotum in the second stage, which was performed after 14-16 months and fixed it to the tunica dartos in the membranes directly under the skin from the side of intervention (Declarative Patent № 18280, 2006). The evaluation of efficacy was performed in comparison with the results of surgical treatment cryptorchidism with a complete section vaginal process of the peritoneum.

Examination methods for patients included such modern diagnostic technologies as ultrasound examination and dopplerography of testicular vessels, laparoscopy.

The observation period in the experiment lasted 30 days, in the clinic after surgery – from 3 months to 2 years.

2.1. General characteristics of the material

The experimental part was performed on the basis of State Institution "Dnipropetrovsk Medical Academy Ministry of Health of Ukraine" in the department of operative surgery and topographic anatomy. The experimental animals were presented with 30 white adult Wistar rats weighing 180–250 grams (Table 2.1).

Table 2.1.

Distribution of animals by the experimental groups

Series of experiments	Number of observations (n)
Control (without operation)	10
I series (1 day after surgery)	10
II series (30 days after surgery)	10
Totally	30

Animals were quarantined before being introduced to the experiment and kept for at least 7 days in vivarium under supervision worker of Medical Academy. The experimental animals were divided into 2 series of experiments. The control group includes organs of non-operated rats. Animal care and handling were carried out in accordance with the requirements Annex 4 of the "Rules for Use of Experimental Animals", approved by order of Ministry of Health №755 from 12.08.1997 "On Measures to Further Improve the Organizational Forms of Working with Experimental Animals" and provisions of the "General Ethical Principles of Experiments on Animals approved by the First National Congress on Bioethics" (Kyiv, 2001). We kept animals in vivarium conditions, in the usual diet. The animals in the experimental and control groups were kept in the same conditions, and material taken for the study was studied in parallel.

In the I series of experiments, 10 sexually mature males were used to study effect of exclusion of anastomoses between vaginal process of the peritoneum and other elements a spermatic cord on the blood supply of testicle by completely crossing of vaginal process of the peritoneum. The results were analyzed in 1 day after surgery. Preparation of the operative field is focused on the epilation of a skin, treatment three times a day with a solution of firsthand, 5% solution of iodine and 96% of ethyl alcohol. Under general ether anesthesia, the skin and soft tissues were layered in layers in one of the inguinal areas by the transverse access to aponeurosis of the external oblique muscle of abdomen. In the area outer inguinal opening, a spermatic cord was taken on the turnstile, performing a full section of the vaginal process of the peritoneum across it. After that, the wound was stitched tightly by layer.

Experiments of II series were aimed at studying the effects of complete intersection vaginal process of the peritoneum in 30 days after operation on the blood supply of testis. There were used 10 adult male rats.

Control group included 10 adult rats, males, in which were selected testis without performing any operations on the vaginal process of peritoneum.

In the clinical part of work were represented 109 boys, mostly under the age of 7 years – 75.2% (Table 2.2). The children were treated in Dnipropetrovsk Regional Children's Clinical Hospital from 2018 to 2019 years from cryptorchidism.

Control group was represented by 60 practically healthy boys who lived in Dnipropetrovsk region (15 boys in each age group).

Results of the studies were shown in the medical records of inpatients and contained: complaints, medical history, clinical data, ultrasound examination with doppler imaging of the testicular vessels, method of surgical intervention.

Table 2.2.

Distribution of children with cryptorchidism by age into groups

Age groups	Number of observations (n)	
	Absolute	%
From 3 to 5 years	33	30.3
From 5 to 7 years	49	44.9
From 7 to 12 years	18	16.5
12 – 14 years	9	8.3
Totally	109	100

The diagnosis was specified with using ultrasound, diagnostic laparoscopy and intraoperatively, depending on the location of testis (in the abdominal cavity or inguinal area). Totally 109 boys with cryptorchidism were operated. The distribution of performed surgeries depending on the location of retention testis and age of children is presented in Table 2.3.

When analyzing results of treatment, all children were divided into two main groups according to the method of surgical intervention – by the authors' method (55 patients), and with using traditional method, which was focused on the crossing a cremaster muscle in the proximal section below internal oblique muscle of the abdomen in a transverse direction, removal vaginal process of the peritoneum throughout its entire intersection - two-stage reduction without fixation of the testicle to surrounding tissues in the first stage. According to these methods, 54 boys were operated, including in the inguinal location of the testicle (IGC) – 4, with abdominal forms of cryptorchidism (AC) – 50 (Table 2.4).

Table 2.3.

Location of a retention testicle depending on the place and age of children

Age groups	Location of the testicle				Total operations	
	Abdomen cavity		Inguinal area			
	Absolute	%	Absolute	%	Absolute	%
From 3 to 5 years	36	33.0	5	4.6	41	37.6
From 5 to 7 years	39	35.8	8	7.3	47	43.1
From 7 to 12 years	11	10.1	1	0.9	12	11.0
12 years and older	9	8.3	-	-	9	8.3
Totally	95	87.2	14	12.8	109	100

Using of the proposed method step-by-step surgical treatment of cryptorchidism helps us to operate 55 children on the basis of the Regional Children's Clinical Hospital in Dnipro for the period from 2018 to 2019 years (Declarative Patent №18280). The distribution of surgical interventions was performed by own method, taking into account the age of patients and location of the retention testis. It is shown in (Table 2.5).

Table 2.4.

Traditional surgical interventions depending on the age of patients and form of cryptorchism

Age groups	Location of the testicle				Total operations	
	Inguinal area		Abdomen cavity			
	Absolute	%	Absolute	%	Absolute	%
From 3 to 5 years	-	-	12	22.2	12	22.2
From 5 to 7 years	3	5.6	20	37.1	23	42.7
From 7 to 12 years	1	1.8	10	18.5	11	20.3
12 years and older	-	-	8	14.8	8	14.8
Totally	4	7.4	50	92.6	54	100

It should be noted that number of babies under 5 years operated by our own method (29-52.7%) was higher than in traditional approaches (12-22.2%) for surgery. About 45 (81.8%) boys were operated on AC and 10 (18.2%) on IGC with using own method. But it should be noted that in all cases of inguinal retention the testicles were located in a deep inguinal ring on the border with abdominal cavity, and correction of this defect in one stage was impossible without the complete intersection of cremaster muscle and vaginal process of the peritoneum.

Table 2.5.

Distribution of surgical interventions performed by own method, depending on the age of patients and location of retention testis

Age groups	Location of the testicle				Total operations	
	Inguinal area		Abdomen cavity			
	Absolute	%	Absolute	%	Absolute	%
From 3 to 5 years	5	9.1	24	43.6	29	52.7
From 5 to 7 years	5	9.1	19	34.6	24	43.7
From 7 to 12 years	-	-	1	1.8	1	1.8
12 years and older	-	-	1	1.8	1	1.8
Totally	10	18.2	45	81.8	55	100

2.2. Basic methods of research and statistical processing of the material

The research methods, used in the work were highly informative and widely available in general clinical practice, which allows to use these methods not only by scientists, but also by practitioners in the healthcare practitioner.

One of the strong arguments in a choice of research methods, besides informativeness and accessibility, was their low invasiveness and absence of pain in children during their treatment.

The main method of investigation, which allowed to determine volume of the testes, testicular blood flow in the normal and ischemia conditions was ultrasound scan of the testicles and a pulse-wave doppler ultrasound of the testicular vessels.

Research of the testicular circulation were performed on Siemens acuson CV 70 apparatus, on the ultrasound scanner with using 7.5 MHz linear sensor in the mode of siroscal sonography, color doppler (color doppler angio-mapping and energy doppler) and the pulsed-wave doppler modes.

Condition of the testicular vessels was evaluated in children with cryptorchidism and in the normal state with pulse-wave doppler. Peak systolic blood flow velocity (Ps, m /s), a final diastolic blood flow velocity (Md, m /s) and resistance index (RI) were determined in arterial vessels.

Statistical processing of research materials was carried out with using variational statistics methods, implemented by the standard packages of statistical analysis programs EXCEL-2003, STATISTICA 5.5. The mean values (M), error of the mean value (m), standard square deviation (σ), the intensive and extensive indices (%) were determined. Probability of differences mean values was performed according to the criteria of Student and Mana-Whitney (Lapach); for relative indicators – by X-square (χ^2), Fisher angular transformation and Student's criteria with Yates correction for continuity. The difference between comparative values was considered as significant at $p < 0.05$.

Statistical analysis of clinical information was performed on the basis of mathematical evaluation of the mean values and their characteristics in each clinical group. We determined arithmetic mean of the sample, the sample variance, standard square deviation, confidence interval for the groups.

The average arithmetic mean ($\overline{X}$) was calculated by the formula:

$$\overline{X} = \frac{\sum_{i=1}^{N} Xi}{N},$$

where N – number of observations;
the sample variance was calculated by the formula:

$$\sigma^2 = \frac{\sum_{i=1}^{N} \left(Xi - \overline{X}\right)^2}{N-1},$$

standard deviation, respectively:

$$S = \sqrt{\sigma},$$

confidence interval of the average mean:

$$\left[\overline{X} - t_{n,p} \frac{S}{\sqrt{n}}, \overline{X} + t_{n,p} \frac{S}{\sqrt{n}}\right],$$

where S – is standard square deviation; “n” – is the number of observations; $t_{n,p}$ – is a tabulated value of the Student's test with the number degrees of freedom "n" and confidence significance "p".

When conducting a statistical analysis of the primary information, it was taken into account the fact, that the law of distribution a raw data is unknown. For these reasons, a correct choice of mathematical apparatus requires a series of steps to analyze the law of distribution a raw data.

In order to check the hypothesis of a normal law of distribution the analyzed data, we checked the following conditions:

$$\left| \frac{\Delta abs}{S} - 0{,}7979 \right| \langle \frac{0{,}4}{\sqrt{N}}$$

$$\Delta abs = \frac{\sum_{i=1}^{N} \left| Xi - \overline{X} \right|}{N}$$

where:

S – standard deviation of the sign;

N – volume of test samples;

$\overline{X}$ – arithmetic mean of the sample.

In some cases, sampling of censorship was performed to eliminate accidental errors in data logging.

Reliability of the statistical difference an obtained means values was evaluated with using parametric methods (Schaeffe, LSD - criterion).

In the case of discrete values, or a non-normal law of data distribution, nonparametric analogs were used (Kraskell-Wallis test, Friedman nonparametric analysis of variance). When comparing indicators in one clinical group (evaluation efficacy of therapy), the Student's t-test was used for the related samples.

2.3. Method of removing animals from the experiment and sampling of material for morphological studies

Animal euthanasia was performed by overdose of ether for anesthesia and the testes were collected according to the dates of an experiment.

For histological examinations, 2 pieces of a free-edge tissue 1 cm size were collected from each selected testicle, which were fixed 2 weeks in Buen's solution at the room temperature. The fixed material was washed in a running water and dehydrated in alcohols with increasing concentration. After that, pieces of tissue were poured into paraffin. Chloroform was used as the intermediate medium. The microtome was used for the permanent preparations. There were obtained sections with a thickness of 5-7 μm from paraffin blocks. From each block were obtained

2 glasses with 4-5 sections each. The obtained sections were stained with hematoxylin-eosin and Schiff-iodic acid reagent with Ehrlich hematoxylin staining and enclosed in polystyrene.

In the study micropreparations of the testes were obtained under the microscope evaluated state of own membrane of the tortuous seminiferous tubules, Sertoli cells, cells of a spermatogenic epithelium, interstitial tissue and Leydig cells, walls of blood vessels.

During the study was identified the following in each of the selected groups:

1) diameter of tortuous tubules of the testicle and their number per 1 cm^2;

2) a thickness own membrane of the tortuous seminiferous tubules in the testis;

3) degree of damage cells of spermatogenic epithelium in the tortuous seminiferous tubules in the testis;

4) number of spermatogenic epithelium cells that occur at VII stage cycle of spermatogenic epithelium: spermatogonia, spermatocytes, spermatid;

5) volume of Leydig cell nuclei;

6) thickness of a wall and diameter of the blood vessels lumen.

Calculations and measurements were performed with using Biolam microscope at magnification × 100 or × 400. The movement of the preparation was performed such way to avoid a double-entry into the field of view of the same objects.

The measurements were performed using a eyepiece- micrometer AM-2 (MOF-1-15^X).

To determine the diameter of convoluted seminiferous tubules, the distance between two diametrically opposite points lying on a border between inner part of basement membrane and cells of spermatogenic epithelium was measured with using an ocular micrometer. The number of convoluted tubules per 1 mm of the preparation was determined using a mesh mounted in the eyepiece. The height of epithelium in a deferent duct was determined by an ocular micrometer, measuring the distance from point lying on the border between basal membrane and epithelium duct to the point lying on a border between epithelial cells and lumen of the duct, perpendicular to the base membrane. Thickness of own membrane the seminiferous tubules was determined by measuring a shortest distance between points located on its outer and inner surfaces by eyepiece micrometer.

To assess the functional activity of Leydig cells was determined volume of their nuclei using a screw-micrometer AM-2 with an immersion lens and magnification × 900. In each testicle, 2 diameters (minimum and maximum) of 50 Leydig cell nuclei were measured.

The volume of nuclei was calculated by the formula of ellipse:

$$V = n/6 \times LB^2$$

where: V − nuclei volume, L − maximum diameter, B − minimum diameter. The obtained volume values were expressed in cubic micrometers.

In the experimental material, calculations of the tortuous seminal tubules in white laboratory rats were performed at VII stage cycle of the spermatogenic epithelium, cellular composition of which is represented by type A spermatogonia, 1st order of spermatocytes at the preleptotene stage, spermatocytes at the pachytene stage, spermatids of 7 and 16 stages of epithelial development. With advent an adequate method for assessing dynamics of spermatogenesis, the possibility of quantitative examination of spermatogenic epithelial cells in normal state and after injury was obtained. The VII stage of spermatogenic epithelium cycle is the most optimal for calculation and detection selective sensitivity of spermatogenic cells to the factor of inflammatory process due to the following circumstances:

1) among 14 stages a cycle of spermatogenic epithelium in rats, it is the longest and therefore cross sections of the tortuous seminiferous tubules corresponding to this stage, are most commonly found on the preparations;

2) number of "drowsy" spermatogonia type A at this stage remains constant, whereas at this time there is no mitotic division;

3) number of spermatocytes in the preleptotene stage is also relatively constant, which allows to detect loss of cells in a case of their sensitivity to the inflammatory process;

4) acrosome characteristic for spermatozoa, serves as a marker in a cycle stage of the spermatogenic epithelium, in VII stage forms a structure that resembles umbrella and is easily identified;

5) characteristic structure nuclei of spermatids in the VII stage cycle of spermatogenic epithelium allows to identify this stage even when the spermatids are altered.

CHAPTER 3

COMPLEX APPROACH TO THE DIAGNOSTICS OF CRYPTORCHISM IN THE CHILDREN

3.1. Doppler imaging of a testicular blood flow in the children at the normal and ischemic conditions

One of the basic tasks was to study testicular circulation in the normal conditions and at the ischemia (in cryptorchidism) using ultrasound examination and dopplerography of testicular vessels. For this purpose, 169 boys were examined, including 109 boys with cryptorchidism and 60 are practically healthy boys from control group. Data analysis was performed taking into account the patients' age.

Doppler examination revealed that cryptorchidism in all cases had a decreased blood flow in a testicular artery, which was shown in increasing of the resistance index (RI), significant decrease in a peak systolic blood flow velocity (Ps) and a final diastolic blood flow velocity (Md) ($p<0.05$) compared with healthy children (Table 3.1). The most significant circulatory disorders were observed in patients older than 12 years: maximum systolic and final-diastolic blood flow rates were in 1.9-2.1 and 3.2-3.3 times lower than in the healthy children of appropriate age.

During data analyzing in Table 3.1, was observed an increased resistance index (RI) in children of different age groups with cryptorchidism (from 0.711 to 0.742), compared to the healthy children (from 0.577 to 0.559) in control group, and decreased peak systolic blood flow velocity (Ps) and final diastolic blood flow velocity (Md). These indices of testicular circulation are objective and reliable, enabling them to be used in clinical practice to evaluate effectiveness of surgical treatment of cryptorchidism in children.

Table 3.1.

Indicators of a testicular blood flow in children with cryptorchidism before surgery (M ± m)

Age groups	Patients with cryptorchidism				Healthy patients (control group)			
	n	RI	Ps (cm/s)	Md (cm/s)	n	RI	Ps (cm/s)	Md (cm/s)
From 3 to 5 years	33	0.711± 0.020*	5.7± 0.3*	1.7± 0.3*	15	0.577± 0.018	12.0± 0.6	5.3± 0.3
From 5 to 7 years	49	0.682± 0.016*	7.3± 0.3*	2.5± 0.4*	15	0.576± 0.033	13.1± 0.5	6.2± 0.6
From 7 to 12 years	18	0.705± 0.036*	7.2± 0.4*	2.7± 0.5*	15	0.545± 0.030	14.3± 0.3	7.3± 0.4
12 years and older	9	0.742± 0.035*	7.7± 0.3*	2.3± 0.2*	15	0.559± 0.043	14.8± 0.6	7.7± 0.3

Note. * - $p<0.05$.

Based on the obtained results, it can be concluded that impaired testicular circulation in cryptorchidism is itself a risk of developing organ atrophy, and subsequent operative trauma in the correction of defect significantly increases this risk. Therefore, it is important before surgery to clearly understand this fact and to perform surgery for preservation a cremaster muscle, important vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord, which will significantly improve condition of the testicle in a postoperative period and reduce development of infertility in men.

3.2. Laparoscopic diagnosis abdominal forms of cryptorchidism in the children

Absences of testicular in the inguinal canal at cryptorchidism, impossibility of its detection cause in the surgeon additional questions about further tactics. As a rule, further surgery is performed with element of uncertainty, because there may be several options – location of the testicle in different departments of the abdominal cavity, testicular agenesis, presence of rudimentary gonad tissue, etc. To clarify localization of the testicle, many research methods have been proposed: ultrasound examination, selective testuloarteriography, computed tomography, radionuclide scintigraphy, pneumoperitoneography and others. However, the most objective picture of location and condition of a testicle gives diagnostic laparoscopy, results of which determine the further tactics of treatment. Diagnostic laparoscopy makes it possible to form indication to open inguinal canal audit in the absence of clear data about the testicular agenesis.

During the period 2018–2019 we performed 23 diagnostic laparoscopes for a non-palpable testicular syndrome unilateral in all cases (Fig. 3.1).

By the age, children were divided into the following groups: from 3 to 5 years – 9 children, 5 - 7 years – 12 children, 7 - 12 years – 1 children, over 12 years – 1 boy. In 22 children, the testicles were placed in the abdominal cavity near a deep inguinal ring. In one patient the testis was located in the upper third of the inguinal canal (inguinal retention).

All children with diagnostic purpose were performed by laparoscopy according to the standard procedure under total intravenous anesthesia with artificial ventilation by endotracheal method (recofol in a dose of 8–10 mg/kg / hour). The intervention began in the position of patient on his back. The first 5-mm blunt trocar was introduced into the abdominal cavity for imposition of pneumoperitoneum (8-10 mm Hg). The abdominal cavity was inspected using a laparoscope (5 mm, 30º). If necessary (in our study in 5 cases) an additional 3-5 mm trocar was introduced for a probe – palpator to a left half of the abdominal cavity.

Fig. 3.1. Appearance of the testicle in the abdominal cavity.

For more convenient revision of abdominal cavity, the patient was placed in the Trendelenburg position with a slope in one direction or another up to 30º.

In diagnostic laparoscopy the following indicators were evaluated: condition of an inner inguinal ring and vaginal process of the peritoneum (presence or absence of its obliteration), the presence, location and size of a testicle, the degree of development epididymis and its relationship with testis, the presence, stage of development, location of the testes vessels and spermatic duct.

There are 22 children with abdominal location of testicles (n = 22). In all cases of abdominal cryptorchidism, the testicles were placed in abdominal cavity near a deep inguinal ring. There was also observed a testicular hypoplasia, insufficient length of testicular vessels.

According to the results of diagnostic laparoscopy, a variety of tactics were chosen. There were revealed testicular vessels and spermatic duct that ended blindly. This situation was observed in two boys of 6 and 7 years old, whose parents were first addressed on the children's hospital with complaints about absence one of the testicles in a baby's scrotum. After laparoscopic diagnosis and diagnosis aplasia of the testicle, these children were recommended treatment in the endocrinologist.

Two-stage orchiopexia was performed in 21 boys at the different variants of testicles location in the abdominal cavity. Descending of testicles in these cases was performed by stages. In the first stage, during diagnostic laparoscopy was performed sanation a vascular bundle of testicle in cryptorchidism by Fowler – Stephens way of a “long duct loop” surgery, which involved the intersection of testicular vessels with maximum collateral collapse between the testicular artery and arteries of a duct and cremaster muscle (Fig. 3.2).

Dissection of the testicular vessels was performed by Fowler – Stephens test, with clamping on a testicular artery and incision of a testicular membrane (wound had to bleed 2–3 minutes). This operation is shown with insufficient length of testicular vessels and inability to perform other one-time orchio fixations.

Second stage was performed after 14-16 months with inguinal access. The fixation of testicle in a scrotum was done by Petrivalsky (fixation of testicle membranes to tunica dartos directly under the skin from the side of operation).

Fig. 3.2. Intersection a vascular bundle of the testicle in cryptorchism.

Thus, the results of study showed that one of the most reliable methods of diagnosis abdominal cryptorchidism in children is laparoscopy. This method allows not only to show location of testis in the abdominal cavity, to assess its condition, but also determine the further tactics of treatment.

CHAPTER 4

SURGICAL CORRECTION OF CRYPTORCHISM IN THE CHILDREN

4.1. Anatomical-experimental model of justification a new method of surgical correction of cryptorchidism in the children

At the present stage, all surgeries in cryptorchidism, regardless of age and method of the testicle fixation in a scrotum, are accompanied by a significant injury elements of a spermatic cord and involve a complete intersection not only m. cremaster, but also vaginal process of the peritoneum. Historically, these negative effects focused on the injury elements of a spermatic cord are considered to be complications of cryptorchidism itself, than conditions that arose during the mobilization of a testicle during surgery.

In order to find pathogenetic mechanisms negative consequences of surgical interventions in testicular dystrophy and to justify new possibilities for their elimination, we conducted an experimental study for effect of intersection vaginal process of the peritoneum on the morphofunctional state of a spermatic cord and the testicle. It allowed us to create anatomic and experimental model of intersection vaginal process of the peritoneum.

In accordance with this task, a series of experiments were performed with exception function of the vaginal process of peritoneum by its complete cross section. For this purpose, 20 adult rats were used. Rats were operated without premedication under general ether anesthesia.

From a cross section in one of the inguinal sections, skin and soft tissues were layer-by-layer cut to aponeurosis of the external oblique abdominal muscle. In the area of outer inguinal ring, the spermatic cord was taken on a turnstile and vaginal process of peritoneum was circularly crossed. The inguinal canal was not dissected. The wound was sutured tightly.

The postoperative motor activity of rats was restored on average in a day. The scrotum from the side of surgery was moderately hyperemic and swollen even after 5-7 days. The postoperative wounds healed by a primary tension. The testicle in this period was in the upper third of a scrotum. There were no active movements and its texture was a slightly denser than in the control group.

Control group consisted of 10 rats which were not cross vaginal process of the peritoneum. Animals were sacrified from experiment by overdosing ether for anesthesia. Testicles were selected with appendage and all elements of a spermatic cord. The tortuous spermatic ducts, testicular tissue, interstitial tissue, epidydymus, and surrounding tissue were examined histologically. As the normal state was taken intact fabric tissue without any changes. Normally, blood supply of the testicle is performed by the testicular artery, artery of uterine duct, and the artery of muscle cremaster. Branches of a spermatic duct artery in the area of epididymal tail create anastomosis with the testicular and crematory muscles artery of the testis. The testicular artery penetrates under a protein membrane in the area of cranial pole of the testicle along its dorsal margin. It runs along it, bends around caudal pole and goes to the ventral edge, where it forms a "serpentine" that occupies all ventral surface of the testicle. The testicular artery deepens into the parenchyma, where it divides on the trunk, giving rise to six or more branches, with a diameter of 0.15-0.20 mm. Waving curved, they pass in a direction from mediastinum of the testicle to its ventral edge, giving its branches with a diameter of 0.1-0.12 mm to the parenchyma of organ. From the given branches depart smaller vessels of 0.05 mm in diameter, which pass between spermatic tubules in an oblique or transverse direction and disintegrate into arterioles with diameter of 30 µcm on average, which pass between spermatic tubules in a longitudinal direction and are divided into hyper capillaries with a diameter of 17-27 µcm. They are placed mainly in transverse direction relative to the spermatic tubes and directly give rise to capillaries.

One arteriole can feed by several tubes at a time, and capillary grids of adjacent tubules are widely anastomosed with each other. By the nature of placement, the capillaries are divided into longitudinal and transverse. Longitudinal capillaries, 10-17 µcm in diameter, extend along spermatic tubules. Longitudinal capillaries considered to be extension of the precapillaries. Transverse capillaries, 7 to 12 µcm in a diameter, depart from precapillaries and longitudinal capillaries, preferably at a right angle. The longitudinal and transverse capillaries are more closely adjacent to the walls of tubules, while the arterioles and precapillaries are located in the intertubular gaps. Thus, vessels of a microcirculatory bed on the walls of tubules form a dense mesh with loops of a rectangular shape. Around tubules they are placed in the form of mesh with loops of hexagonal shape. Their formation involves longitudinal and transverse microvascular vessels that anastomose with each other. The longitudinal capillaries are closely interacting with the groups of Leydig cells, while the transverse capillaries are directly adjacent to the seminiferous tubules. Going around the perimeter of tubule, the arterial capillaries pass into the venous, with a diameter of 13-22 µcm. They are differentiating into the longitudinal and transverse. The last one is turn into prevenules (22-36 µcm in a diameter) and venules (34-45 µcm in a diameter) that run parallel to the tubules. Venules are united into small veins (40-100 µcm in a diameter). Some of which are located in the parenchyma of testis, others are located directly below the protein membrane. Fusing with each other in the area of dorsal edge ventral pole of the testis, they form the middle (diameter of 100-150 µcm) and large (diameter of 150-300 µcm) testicular veins, forming a vine-shaped plexus together with epididymis veins.

The testicle of rat is covered externally by a protein membrane, its lobular structure is poorly expressed because of the small number of connective tissue elements. Structure of the lobule includes several sinuous tubules that are rounded in a cross-section and closely adjacent to each other.

Twisty tubules have such structure. The fibrous layer is represented by spindle cells, tubules of oviduct form. The first row (basal) is represented by follicular cells (Sertoli cells). The second row is spermatogonia with a large size hyperchromic nucleus. The fourth and fifth rows are spermatocytes that lie scattered with a lighter nucleus and smaller, compared to spermatogonia.

Mitotic activity cells of the convoluted tubules are high. Interstitial tissue consists of: layers of fibrous connective tissue with vessels that have thin walls and flattened endothelium. In its lumen there are free-lying erythrocytes. Epydydymus includes: sections of the ducts are represented by the rounded and ovidinal tubules, which are located among fibrous connective tissue with thin vessels. A double-row epithelium of the ducts is represented by rounded cells with chromatin in the nucleus. In the lumen there is accumulation of spermatozoon. The surrounding tissue is represented by fatty, muscular, and loose connective tissue with moderately full blood vessels.

When sacrafied from experiment and dissection of rats after 1 day (I series – 10 rats), it was found that edges of a crossed vaginal process of the peritoneum diverged in the opposite directions on 1.5-2.0 cm, completely exposing other structures of a cord. The blood vessels and spermatic duct were covered with fibrin and a small amount of blood. The surrounding tissues were hyperemic. There was a small amount of swelling fluid in the distal part around testicle. The testicle in a volume did not exceed the contralateral ($p < 0.05$).

The diameter of convoluted semiferous tubules is significantly increased to 200.91±0.52 μcm in 1 day after intervention, while the volume of Leydig cell nucleus is slightly increased ($p < 0.05$) (Table 4.1).

After 30 days in rats structure of the spermatic cord did not fully recover. The connective tissue in aponeurosis of external oblique muscle of the abdomen and interval between ends of a twisted vaginal process of the peritoneum is a tightly grew with all structures of a spermatic cord. It is difficult to separate and deform them. The semiferous duct at this place formed an excessive bend in the form of loop fixed to the aponeurosis. Such significant deformation, in our opinion, can lead to impaired sperm evacuation and development of mechanical obstructive infertility.

Table 4.1.

Diameter of tortuous semiferous tubules and nuclei volume of Leydig cell in testes of rats in the dynamics of experiment (M±m)

Experimental groups	n	Diameter of semiferous tubules (microns)	The nuclei volume of Leydig cell (μcm^3)
Control group	10	194.98±0.69	84.65±0.76
After 1 day	10	200.91±0.52* $p<0.05$	86.46±0.27* $p<0.05$
After 30 days	10	180.21±0.77* $p<0.05$	76.78±0.37* $p<0.05$

Notes: 1. * - $p < 0.05$ compared to control group.

A significant ($p<0.05$) decrease diameter of the convoluted semiferous tubules was observed on 180.21±0.77 μcm and nuclei volume of Leydig cell on 76.78 ± 0.37 μcm^3.

Histologically was shown increased amount of arteriovenous anastomoses and number of blood vessels in a microcirculatory bed. It takes place in the loose connective tissue of a spermatic cord below intersection a vaginal process of the peritoneum. The large venous magistrales were unevenly filled with blood with phenomena of stasis. In such veins there was found focal thinning a wall with varicose extension of the lumen. The testicular artery was diminished in a size by intimal enlargement and sclerosis of the wall.

During microscopic examination of the testicles in a side of operation and in comparison with contralateral and control testes, a considerable disturbance of the hemo- and lymphodynamics was detected after the first day. There was congestive plethora, lymphostasis and perivascular edema both in the capsule section and in the stroma of testis (Fig. 4.1).

Fig. 4.1. Blood extension lumen of a vein with the signs of stasis, perivascular edema at the rat in 1 day after intersection vaginal process of the peritoneum. Coloring with hematoxylin and eosin. Increase under a microscope × 100.

The blood flow of the arterioles, capillaries was significantly smaller than in the control group and in the contralateral testes. In their lumen, cellular elements of blood were not identified at all. Significant swelling of endothelial cells and increasing of a reserve tortuosity of the wall in small arteries and arterioles indicated about reflex spasm (Fig. 4.2).

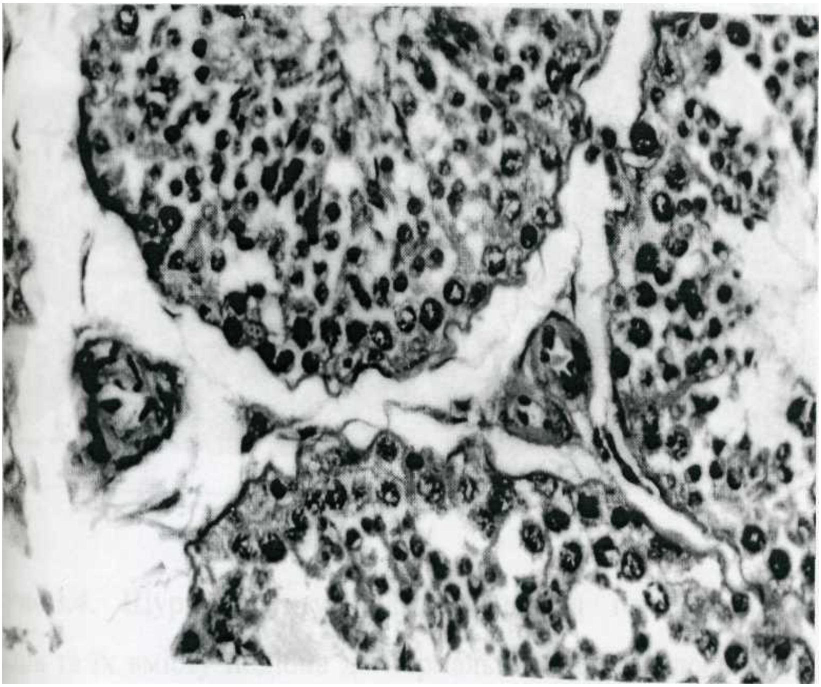

Fig. 4.2. Swelling arterioles of endotheliocytes, which were protruding into lumen of the tubules in a form of palisade, parenchyma of the testes at the rat in 1 day after intersection vaginal process of the peritoneum. Coloring with hematoxylin and eosin. Increase under a microscope × 400.

Fibrous layer of the semiferous ducts was moderately thickened by a cell swelling. The phenomena of granular dystrophy occurred in Sertoli cells. There were observed spermatogonia with increased mitotic activity (appearance of multinucleated cells), which desquamate into the lumen of tubule. Contents of the tubules were different: filamentous, homogeneous, eosinophilic. The contours of the tubules were clear. In the smooth, muscular and argyrophilic fibers of HTB, which are compactly arranged, were found a moderate spare flexion (Fig. 4.3).

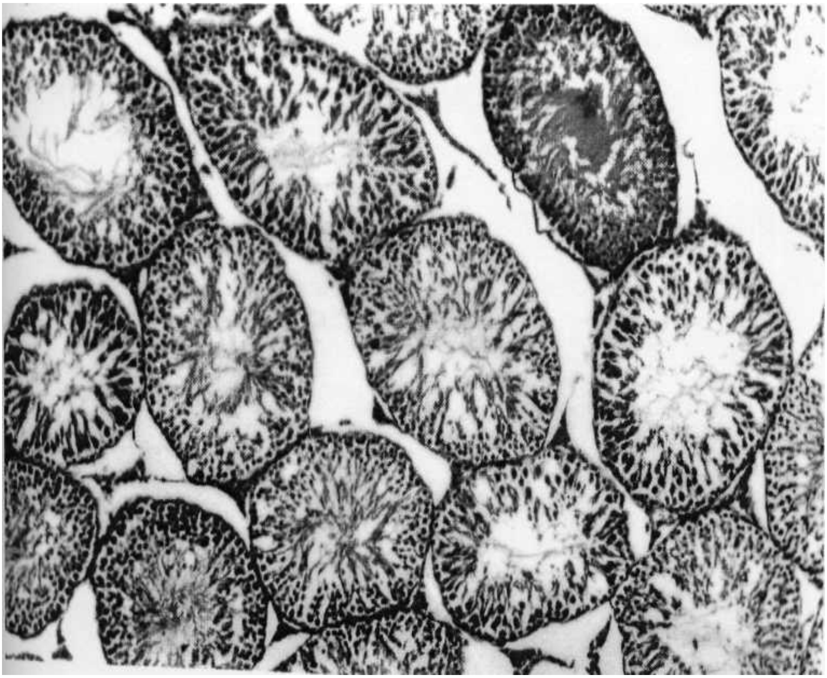

Fig. 4.3. Semiferous tubules with signs of atrophy and its content at the rat in 1 day after crossing vaginal process of the peritoneum. Coloring with hematoxylin and eosin. Increase under a microscope × 100.

Regenerative processes prevailed at the rats in 30 days after surgery. Semiferous tubules restored the size and structure. There were tubules with signs of atrophy. The fibrous layer is represented by number of cells that have shape of a spindle. The first layer (basal) was represented by Sertoli cells. The second layer was shown by spermatogonia with large size hyperchromic nuclei, spreading in some places on the third row. In the fourth and fifth rows were determined spermatocytes of different degrees of maturation, which have a lighter nucleus than in the spermatogonia (Fig. 4.4).

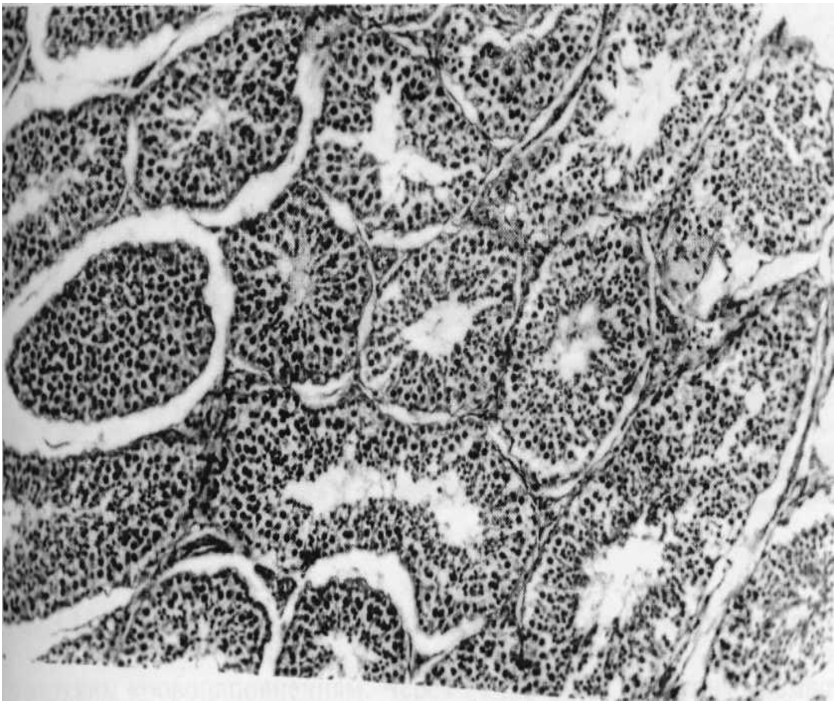

Fig. 4.4. Final sclerotic changes in a stroma of the tubules at the rat in 30 days after intersection vaginal process of the peritoneum. Coloring with hematoxylin and eosin. Increase under a microscope × 100.

There were found a sperm between spermatocytes and lumen of the tubule. The mitotic activity cells of the convoluted tubules are a quite low. There are moderately expressed desquamous changes in 3-4 rows of cells and the fibrotic changes. Sclerosis was formed with obliteration vessels of the microcirculatory bed around such altered tubules. It was shown moderate sclerosis around the tubules, which were normal in a size, and on a way of the blood vessels capsule.

There was moderate swelling in the loose connective tissue of a spermatic cord. Sections of epididymis ducts are represented by rounded tubules, which are located among the fibrous connective tissue with thin blood vessels (Fig. 4.4).

Generally, experiment carried out on the animals with a complete section across vaginal process of the peritoneum showed its negative impact on the structure and function of the testis. All experimental rats after modeling of the pathological process (intersection a vaginal process of the peritoneum) had significant disorders on the testicular circulation with development of hypoxia. There are irreversible processes – sclerosis and atrophic phenomena. Venous plethora and stasis cause lymphostasis with development of focal and diffuse edema in the testicular stroma, which leads to disruption of HTB. Throughout the whole period of the experiment, there was shown development of the sclerotic changes in the stroma of spermatic cord, which leads to its deformity. The latter, in our opinion, may leads to impaired sperm evacuation in further and to the development of mechanical obstructive infertility. Intersection and excessive growth of connective tissue in the area of intersection a vaginal process of the peritoneum deform elements of a spermatic cord, which is caused an excessive bending of the semiferous duct with impaired fluid dynamics.

The obtained results indicate the important role of vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord in the blood supply of testis. It is testify about nessesity of development new methods of surgical treatment in a case of cryptorchidism, which would improve testicular circulation in the postoperative period.

4.2. A new method of stepwise surgical treatment of cryptorchidism in the children

Lowering the testicle into a scrotum in cryptorchidism leads to the damage of testicular vessels, cremaster muscle, anastomoses between testicular vessels and vessels of vaginal process of the peritoneum, which causes a high probability of development its circulatory disorders. These factors in the future lead to the atrophy of testis, development of disorders in the hormonal function and fertility in the reproductive period. However, according to the results of our experimental study, when performing operations with a complete section vaginal process of the peritoneum suffers a blood supply of the testicles. Improvement of postoperative results is possible at improvement ways of mobilization elements of a spermatic cord, preservation of vascular anastomoses with vaginal process of the peritoneum that will promote improvement of blood supply in a reduced testicle.

We have developed a method of step-by-step surgical treatment of cryptorchidism (Declaration Patent №18280, 2006), which is focused on the follows.

The first phase of operative intervention began with traditional inguinal access. The anterior abdominal wall was layered in layers to aponeurosis of external oblique muscle of the abdomen. The front wall of inguinal canal was dissected so that the free edge of inner oblique muscle of the abdomen was exposed in the wound and a deep inguinal ring was fully visible. Subsequently, the testicles and a spermatic cord were mobilized from tissues of the inguinal canal or abdominal cavity near a deep inguinal ring (Fig. 4.5).

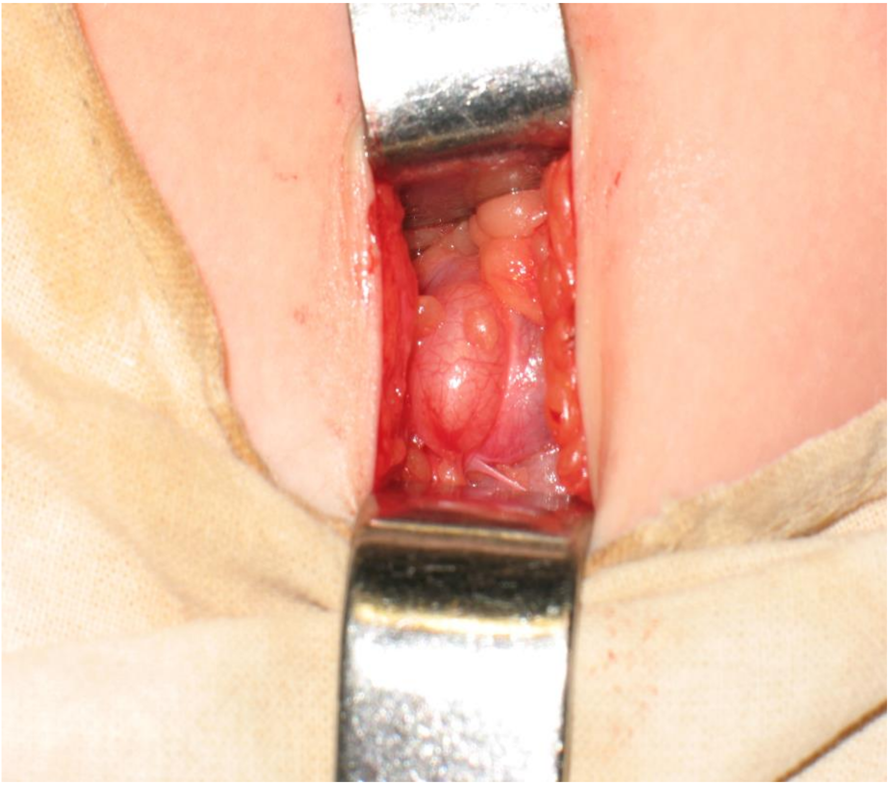

Fig. 4.5. Testicular retention in the region of a deep inguinal ring.

Farabef's hooks raised the free edge of inner oblique abdominal muscle and transverse muscle of the abdomen. The spermatic cord mobilization continued on the level of a deep inguinal ring with tufters. On the Kocher probe, the posterior wall of inguinal canal was crossed so that the intact lower adrenal arteries and veins were exposed. Extra-deep mobilization a spermatic cord structures was performed through an extended deep inguinal ring. Separation of the spermatic duct with intersection a fixative connection between it and bladder was performed when viewing an operating field at the angle of 90°. In this case, size of operating field allowed to carry out mobilization of a duct to the neck of bladder. At this stage of surgery the displacement of a spermatic duct closer to the pubic hump was achieved by reducing radius and perimeter an extraperitoneal part of its loop. The peritoneum was peeled off from the testicular vessels. Testicular vessels from the surrounding tissues were released bluntly with a help of index finger, which made it possible to shift them medially and to straighten the last one to the testicle in a shortest way. Changes a pathway of deferent duct and testicular vessels led to their new location relatively to the inferior adrenal artery and vein. Angle of the apex of Davis' triangle was unfolded. The part of testicular vessels which was not connected with peritoneum extended (Fig. 4.6).

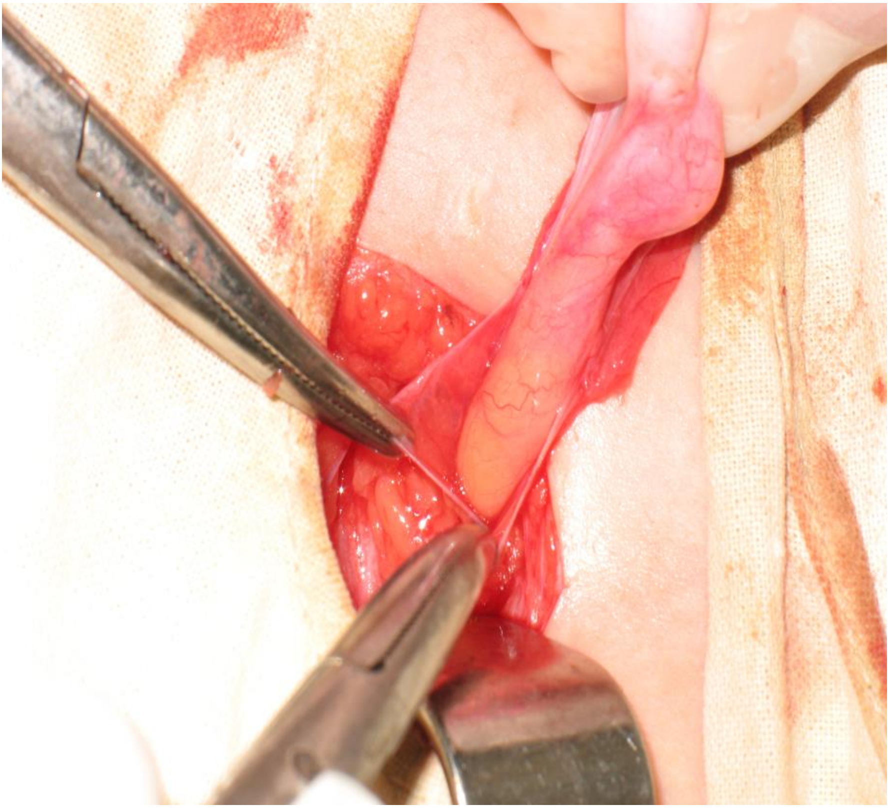

Fig. 4.6. Mobilized testicle with elements of a spermatic cord.

Additionally, the cryptorhilic testicle mobilization in the first stage was performed depending on the length of testicular vessels without fixation the testicle or spermatic cord to the surrounding tissues. Vaginal process of the peritoneum was opened along anterior surface of a spermatic cord to a deep inguinal ring without longitudinal direction, leaving a small area (Fig. 4.7).

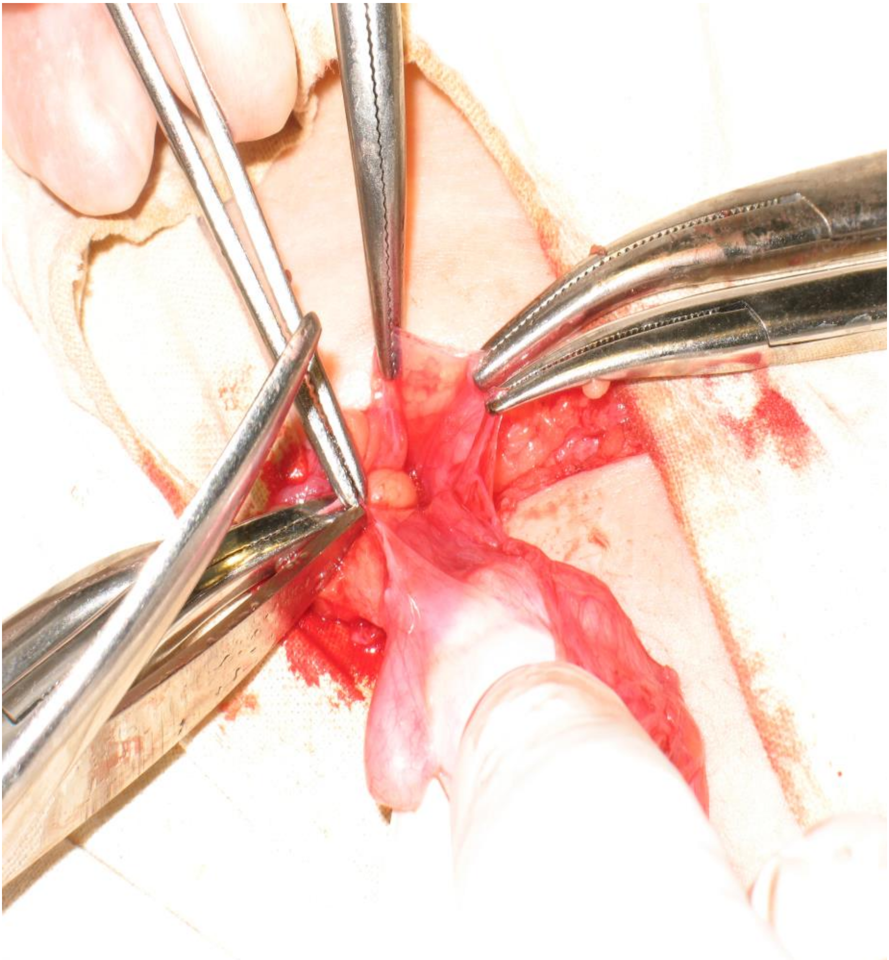

Fig. 4.7. Opening of the vaginal process of peritoneum on anterior surface of a spermatic cord to a deep inguinal ring in the longitudinal direction without crossing it across and preservation of small area.

The entrance to the abdominal cavity was eliminated by imposing an internal purse suture to the peritoneal membrane on the level of a deep inguinal ring (Fig. 4.8).

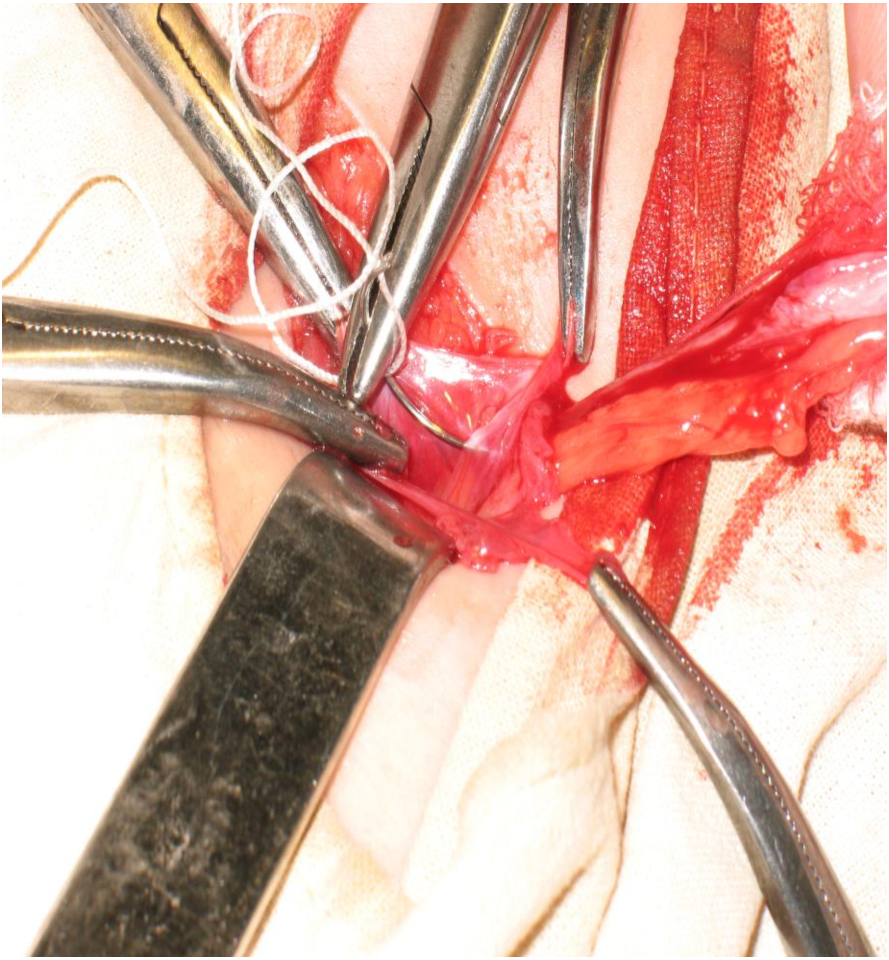

Fig. 4.8. Overlapping of inner purse seam to the peritoneal membranes on the level of a deep inguinal ring.

The testicle mobilized such way was left on the level to which it was able to be removed (more often in the area of upper third of a scrotum). The posterior wall of inguinal canal was sutured. Plastic aponeurosis of external oblique abdominal muscle was performed by Bobrov. The wound of anterior abdominal wall was sutured by layer (Fig. 4.9).

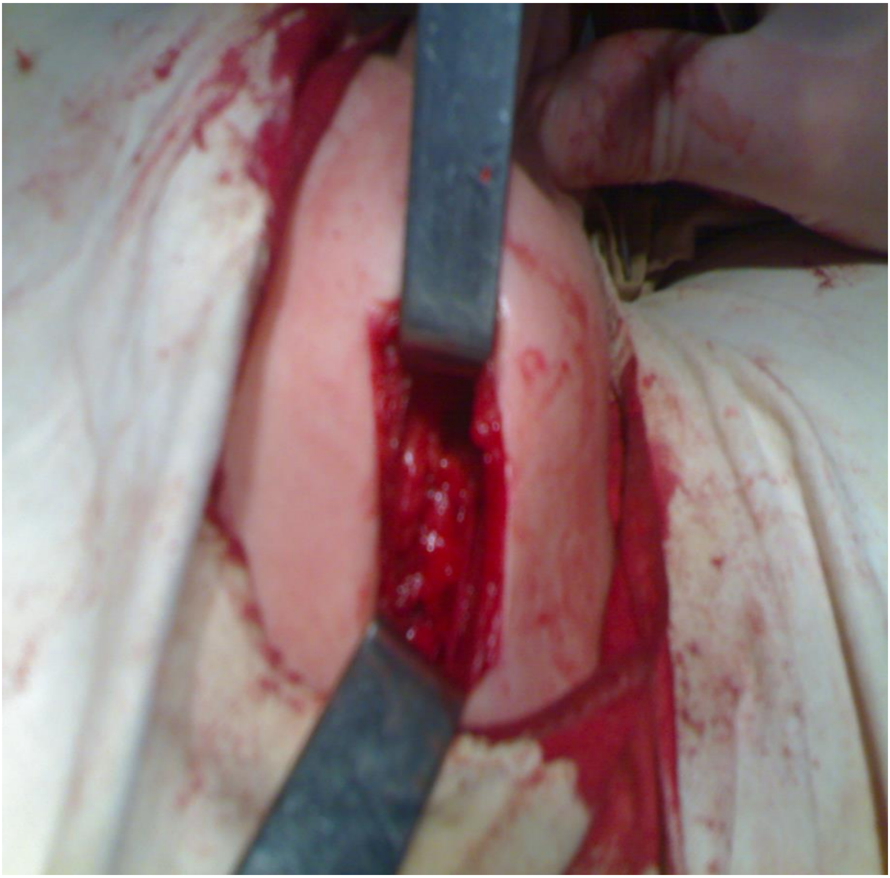

Fig. 4.9. Testicle left without fixation on the level of upper third of a scrotum.

Descending of the testicle in a scrotum in the second stage was carried out after 14-16 months and fixed to the tunica dartos in the membranes, directly under the skin in the side of intervention.

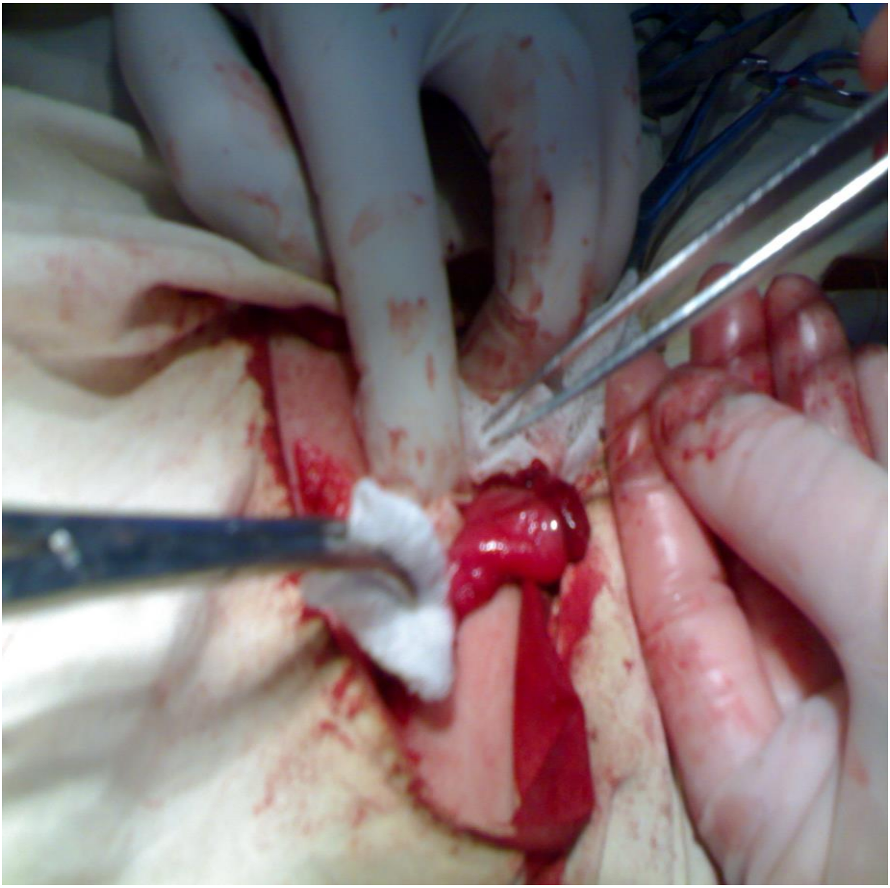

Fig. 4.10. Descending of the testicle in a scrotum at the second stage of intervention (after 16 months)

Two-stage orchiopexia was performed in 55 children using own technique for abdominal and "high" inguinal forms of cryptorchidism. Descending of the testicle in these cases was performed step by step in the manner described above. The second stage was performed after 14-16 months with inguinal access. Fixation of the testicle in a scrotum was done according to Petrivalsky – fixation of the testicle in membranes to the tunica dartos and to a bottom of scrotum directly under the skin from side of the operation (Fig. 4.10).

Therefore, the proposed method of surgical treatment of cryptorchidism is characterized by a decrease in vascular traction, absence of injury vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord. The proposed method can reduce risk of testicular atrophy in the postoperative period. The given stage in the treatment abdominal forms of cryptorchidism allows a descending testicle to gradually adapt to the new conditions. It should not be possible to lower the testicle in one stage if the length of testicular vessels does not allow doing it. Forced and undesired traction of the testicular vessels in the most cases leads to atrophy of the testicle in the postoperative period. Therefore, a greater attention should be payed to the mobilization of the testicle and spermatic cord with preservation of important anatomical structures – cremaster muscle and vascular anastomoses in the vaginal process of peritoneum with other elements of a spermatic cord, which will significantly reduce risk of testicular atrophy.

The experiment performed on animals allowed us to evaluate negative impact of exclusion function of vaginal process of the peritoneum, by its complete cross section, on the structure and function of the testicle: testicular circulation with development of hypoxia, lymphostasis, swelling of a testicular stroma, which leads to the disturbance of hematotesticular barrier, sclerotic changes in the stroma of spermatic cord and its subsequent deformation.

Based on the obtained results, a new method of surgical treatment of cryptorchidism has been developed, which ensures preservation of the main vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord, and allows to improve testicular blood circulation in the postoperative period.

Own method a step-by-step phased surgical correction of cryptorchidism is suggested to use in children at the age of 3 years, and also in cases where correction of defect is not possible without complete intersection of a cremaster muscle and vaginal process of the peritoneum.

CHAPTER 5

EVALUATION AN EFFECTIVENESS OF A NEW METHOD OF SURGICAL TREATMENT OF CRYPTORCHISM IN THE CHILDREN

Efficiency method of mobilization the retentate testicle, which stores vascular anastomoses of a vaginal process of peritoneum with other elements of spermatic cord was determined on the basis of analysis dynamics of the anatomical and physiological changes a reduced testicle in comparison with contralateral and initial state. There were such parameters as location, size, consistency and blood supply of the testes. These parameters were determined during multiple examinations of the patients using the following methods: examination, palpation, ultrasound research with doppler of the testicular vessels.

In addition to the results of direct examination (being in the hospital), these parameters were monitored over a long period of observation – from 3 months to 2 years after surgery.

The object of the study were 109 children and adolescents operated in a case of the abdominal and "high" forms of inguinal cryptorchism, including 54 patients, which undergone traditional method of mobilization a spermatic cord (50 children in IGC and 4 children in ABC). In 55 children was used a new step-by-step method of reduction, covered 45 patients in ABC and 10 boys in a high forms of IGC.

There is quite often and simple method which used by practitioners in the examination of patients with cryptorchidism is palpation of the testicles. The results of palpation examination of reduced testicles in 6 months after surgery are shown in (Table 5.1).

As shown in the Table 5.1, the normal consistency parenchyma of the testes was observed in 51 (92.8%) patients after surgery performed by own method against 24 (44.4%) patients, which were operated traditional way ($p < 0.05$). Softening parenchyma of the reduced testes was noted after surgical correction in 3 (5.4%) patients, according to the traditional method – in 24 cases (44.4%), $p < 0.05$.

Compaction parenchyma of the testes in 6 months after use of own method of testicular lowering was detected only in 1 patient with ABC, while in the traditional approach – in 5 (9.3%) boys. It should be noted that in the abdominal forms of cryptorchidism, normal consistency of the testes was observed in 42 (76.4%) patients which were operated by own method, while only in 24 (44.4%) patients with ABC after traditionally performed operation testicle had a normal consistency ($p < 0.05$). In 1 (1.9%) patient with IGC after traditional treatment, development of testicular atrophy was noted. In children operated on own technique, testicular atrophy was not observed.

Table 5.1.

Character consistency the reduced testicles in 6 months after surgical intervention

Indexes	Traditional technique						Own technique					
	Total (n=54)		IGC (n=4)		ABC (n=50)		Total (n=55)		IGC (n=10)		ABC (n=45)	
	Abc.	%	Abc.	%	Abc.	%	Abc.	%	Abc.	%	Abc.	%
Normal consistency	24	44.4	-	-	24	44.4	51	92.8	9	16.4	42	76.4
Palpatory softening	24	44.4	2	3.7	22	40.7	3	5.4	1	1.8	2	3.6
Palpation density	5	9.3	1	1.9	4	7.4	1	1.8	-	-	1	1.8
Atrophy	1	1.9	1	1.9	-	-	-	-	-	-	-	-

Note. * - $p < 0.05$ between methods with appropriate form of cryptorchidism.

Ultrasound examination of the operated testes, performed in the dynamics before and after surgery, allowed to assess presence of pathological changes in the state of echogenicity, structure, volume of the testis and its appendage.

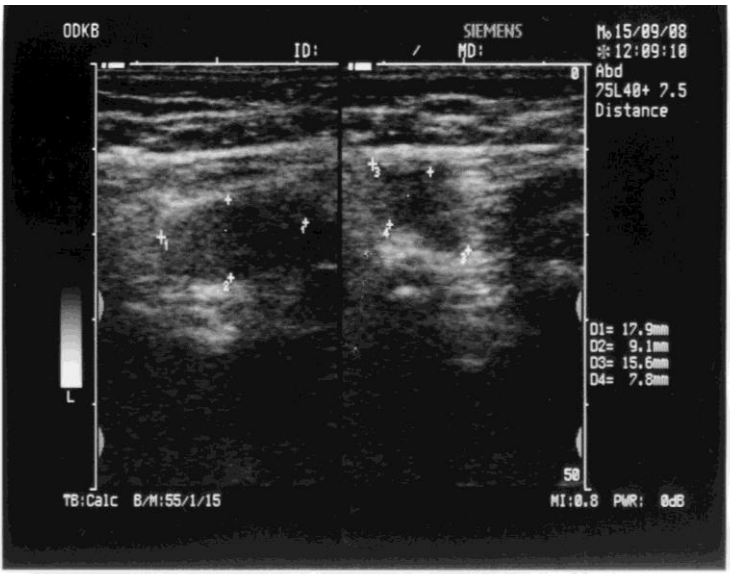

Fig. 5.1. Patient D., 4 years, case history № 3978. Ultrasound picture of a left-sided abdominal cryptorchidism before surgery.

Negative ultrasound characteristics of the operated testes in 6 months after their reduction are presented in (Table 5.2).

When analyzing data in Table 5.2, a significantly higher percentage of increase in echogenicity (72.7%), heterogeneity of the testicular structure (48.1%), an increased size of the epididymis (68.5%) carried out by traditional method of surgery is observed, than at the using of technique, proposed by authors – 25.5%, 16.3% and 12.8% respectively.

Table 5.2.

Ultrasound characteristics of the testicles in 6 months after their reduction

Indexes	Traditional technique						Own technique					
	Total (n=54)		IGC (n=4)		ABC (n=50)		Total (n=55)		IGC (n=10)		ABC (n=45)	
	Abc.	%	Abc.	%	Abc.	%	Abc.	%	Abc.	%	Abc.	%
Increased echogenicity	39	72.7	3	5.5	36	66.7	14	25.5	3	5.5*	11	20*
Heterogeneity of the structure	26	48.1	2	3.7	24	44.4	9	16.3	1	1.8*	8	14.5*
Increase of epididymis in volume	37	68.5	3	5.5	34	63	7	12.8	1	1.8*	6	11*

Note. * - $p < 0.05$ between methods with appropriate form of cryptorchidism.

In the capsular testicular artery, irrespective of the method of surgical correction of cryptorchidism, in the early postoperative period, there was shown a sharp decrease in a peak systolic blood flow velocity (V max) and increasing of the resistance index. Such changes state of a blood flow immediately after surgery can be explained by operative trauma, a compensatory increase in a blood flow in conditions of restructuring vascular bed in a case of significant decrease number of vessels, intravascular anastomoses, mesh a microcirculatory bed of the spermatic cord; development of circulatory hypoxia in the displaced testis. Stability of these indicators in a long-term period of observation (6 months after surgery) was manifested in parallel with other negative characteristics. They are indicated about violation a damping mechanisms of protection, development of hypoxia in the displaced organ, restoration of vessels and mesh of the microcirculatory bed, which were not in a fully volume.

In the testicular artery, different methods of surgical treatment of cryptorchidism in 6 months after surgery showed an improvement in a blood flow compared with condition before surgery: decreasing of the resistance index, increasing of a peak systolic blood flow velocity and final diastolic blood flow velocity (Table 5.3). Moreover, when performing a two-stage orchiopexia according to own method, all changes of indicators were significant ($p < 0.05$) and values of the parameters approached the corresponding levels in healthy children.

Table 5.3.

Indicators of the testicular blood flow in 6 months after surgery (M ± m, cm/s)

Age groups	Traditional technique				Own technique			
	n	RI	Ps	Md	n	RI	Ps	Md
From 3 to 5 years	12	0.646±0.036 p<0.05	7.3±0.3 p<0.05	3.0±0.6 p<0.05	29	0.608±0.033 p<0.05	10.0±0.3 p<0.05	4.1±0.4 p<0.05
From 5 to 7 years	23	0.660±0.016 p<0.05	8.0±0.6 p<0.05	3.0±0.6 p<0.05	24	0.605±0.016	11.3±0.3 p<0.05	5.0±0.6 p<0.05
From 7 to 12 years	11	0.668±0.036 p<0.05	8.3±0.7 p<0.05	3.3±0.7 p<0.05	1	0.610±0.016 p<0.05	13.0±0.3 p<0.05	5.5±0.6 p<0.05
12 years and older	8	0.689±0.030 p<0.05	8.7±0.3 p<0.05	3.1±0.6 p<0.05	1	0.600±0.015 p<0.05	13.0±0.4 p<0.05	5.8±0.4 p<0.05
Total	54				55			

Notes: $p < 0.05$ – significance of difference before and after treatment.

Clinical examples are given to illustrate effectiveness of the treatment.

Example 1. Patient D., 3 years. Case history №9976. He was admitted to the Regional Children's Clinical Hospital in Dnipro with his parents' complaints to the absence of a left testicle in the baby's scrotum, which was confirmed during examination the patient's left inguinal area. An ultrasound research was performed with doppler of the testicular vessels both testicles in the horizontal position of the patient's body. Testicle in the right side is on 12.3 × 8.4 × 5.5 mm. Testicular blood flow indices: RI = 0,5; Ps – 13.0 cm / s. The testicle in the left side is localized in the abdominal cavity near a deep inguinal ring, reduced in size (6.5×4.0×4.5 mm), and blood circulation was not visualized. Diagnosis: the left-sided abdominal cryptorchidism. It was recommended surgery to descending of left testicle in a scrotum. An inguinal canal was opened under general anesthesia. The testis was located in upper third of the inguinal canal and was hypoplasic, with the short testicular vessels.

After mobilization of the testicle and a spermatic cord, the organ is moved upwards with a pulled spermatic cord. The posterior wall of inguinal canal is crossed. The testicle was mobilized to upper third of the scrotum. The cremaster muscle was not performed. The vaginal process of peritoneum was not crossed. The entrance to the abdominal cavity was eliminated by internal purse suture. The fixation of the testicle and spermatic cord to the surrounding tissue was not done. The wound of the abdominal wall was sutured by layers. In the second stage, 14 months later, the testicle was removed to a scrotum from inguinal access and fixed to tunica dartos directly under the scrotum skin on side of the intervention. After surgery, swelling and fever in the left half of a scrotum were observed during 7 days. The child was discharged from hospital on the 9th day after surgery with moderate increase density of the reduced testicle.

On examination in 6 months after the second stage, ultrasound was performed with dopplerography of the testicular vessels in reduced testis at the horizontal position of patient's body. The testicle was located in a scrotum, its size 7.0×5.0×4.5 mm; testicular artery: RI = 0.6; Ps – 10.0 cm/s. Circulatory disorders are minor. Testicular atrophy was not observed.

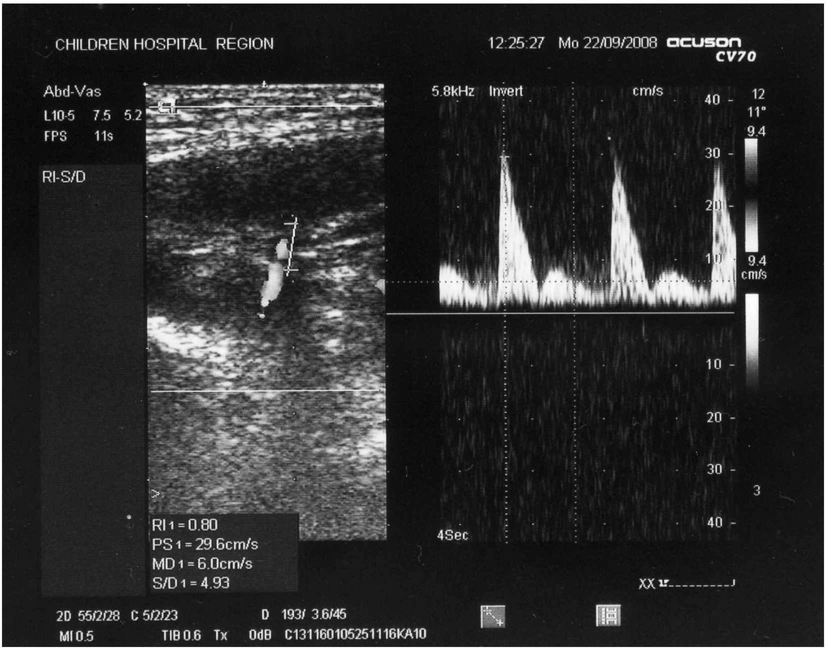

Fig. 5.2. Patient D., 3 years. Case history № 9976. Blood flow in the capsular testicular arteries at the horizontal position of body in 6 months after second stage of surgery by own method.

Stabilization of anatomical and physiological parameters studied after application of a proposed method of surgical treatment is presented in the following example.

Example 2. Patient K., 7 years. Case history № 1234. Clinical diagnosis: "Right-sided abdominal cryptorchidism".

Inguinal canal was opened during surgery. The testicle was located in the abdominal cavity near a deep inguinal ring and was hypoplasic, with short testicular vessels. The testicle was mobilized to the lower third of inguinal canal. The cremaster muscle was not performed. A vaginal process of the peritoneum was not crossed. Entrance to the abdominal cavity was eliminated by internal purse suture. Fixation of the testicle and spermatic cord to the surrounding tissue was not reproduced. The wound of the abdominal wall was sutured. In the second stage, in 14-16 months later, the testicle was removed from a scrotum from inguinal access and fixed to the tunica dartos directly under a scrotum skin on the side of intervention. Three months later after the second stage, ultrasound was performed with dopplerography of the testicular vessels in the reduced testis. The testicle was located in a scrotum, 7.5x5.0 mm in a size. Testicular artery: RI = 0.65; Ps is 11.0 cm/s. Circulatory disorders are minor. Testicular atrophy was not observed.

Table 5.4.

Indicators of testicular blood flow in 24 months after surgery (M±m, cm/s)

Age groups	Traditional technique				Own technique			
	n	RI	Ps	Md	n	RI	Ps	Md
From 3 to 5 years	12	0.636±0.035 $p<0.05$	7.2±0.3 $p<0.05$	3.0±0.6 $p<0.05$	29	0.607±0.033 $p<0.05$	11.0±0.3 $p<0.05$	4.2±0.4 $p<0.05$
From 5 to 7 years	23	0.659±0.016 $p<0.05$	7.9±0.6 $p<0.05$	3.0±0.6 $p<0.05$	24	0.601±0.016 $p_1<0.05$	12.3±0.3 $p<0.05$	5.0±0.6 $p<0.05$
From 7 to 12 years	11	0.662±0.036 $p<0.05$	8.1±0.7 $p<0.05$	3.3±0.7 $p<0.05$	1	0.608±0.014 $p<0.05$	13.0±0.3 $p<0.05$	6.3±0.4 $p<0.05$
12 years and older	8	0.679±0.030 $p<0.05$	8.4±0.3 $p<0.05$	3.1±0.6 $p<0.05$	1	0.600±0.015 $p<0.05$	13.0±0.3 $p<0.05$	6.3±0.5 $p<0.05$
Total	54				55			

Notes: $p<0.05$ – significance of difference before and after treatment.

There was shown improvement of a blood flow in the testicular artery compared with condition before surgery: decreased resistance index (0.607–0.600), increased peak systolic blood flow velocity (11.0–13.0 cm/s) and final diastolic blood flow velocity (4.2–5.3 cm/s), according to the data in (Table 5.4). There were carried out different methods of surgical treatment of cryptorchidism (traditional methods and in the second stage of surgery by own method) in 24 months after intervention (Table 5.4). Moreover, when performing a two-stage orchiopexia by own method, all changes of indicators were significant ($p<0.05$) and values of parameters approached corresponding levels in healthy children (Table 3.1).

An example of specific use proposed model of the step-by-step process of treatment cryptorchidism in children shows that its benefit is primary focused on a high pathogenetic effect, which is confirmed by improvement of the resistance index and a peak systolic blood flow rate in the testicular artery.

Summarizing dynamic observation of children operated on cryptorchidism, it is worth emphasizing a high efficiency proposed method of the stepwise surgical correction with preservation of vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord.

Disease recurrence and testicular atrophy (on one occasion) were observed only when using the traditional method of surgical treatment.

Use of innovative and introduced in the clinic step-by-step method of surgical treatment of cryptorchidism in children with preservation of vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord allows improving testicular circulation in retentate testicle during surgery and after it descending by reducing traction of the vessels and gradual adaptation of testicular circulation to the new conditions.

The proposed surgical intervention is pathogenetically substantiated, because it creates conditions for optimal correction of pathological location the testicle and significantly improves rheological characteristics in the reduced organ. The given method allows ensuring a harmonious development in the reduced testicles.

SUMMARY

The main purpose of this study is to develop and substantiate a new method of surgical treatment of cryptorchidism in the experiment, which should include mechanisms focused on the improvement a mobilization elements of the spermatic cord and blood supply of the testis.

One of imperfect points in performing surgical intervention on cryptorchidism in the inguinal area is damage vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord due to the complete intersection a vaginal process of the peritoneum, which leads to the development of hypoxia and negative effects in the testicle.

In this regard, one of the tasks of scientific work is to study dynamics of the morphofunctional changes of testicle in a complete cross section a vaginal process of the peritoneum.

Simulation of pathological processes in animals on the experiment thorough study of their pathogenesis and morphogenesis is a prerequisite for many theoretical and clinical problems. Taking it into account, 20 male rats underwent an experimental operation with a complete cross section of the vaginal process of peritoneum. The subject of histological examination was a spermatic cord and testicles taken from intersection a vaginal process of the peritoneum.

All existing methods of treatment a retained testicle have the same purpose: to provide normal conditions of development testicle in order to maintain sexual and hormonal functions, to prevent the possible complications, to create cosmetic effect, to avoid psychological discomfort. In order to achieve this goal, a method of gradual lowering at the "high" forms of cryptorchidism in children is proposed. Technique was worked out in an experiment on 20 rats. According to this task, a series of experiments was performed with exception function a vaginal process of the peritoneum by it completely crossing. For this purpose, 20 adult rats were used. Rats were operated without premedication under general ether anesthesia.

From a cross section in one of the inguinal sections, skin and soft tissues were layer-by-layer to aponeurosis of external oblique abdominal muscle. In the area of outer inguinal ring, a spermatic cord was taken on the turnstile and vaginal process of the peritoneum was circularly crossed. The inguinal canal was not dissected. The wound was tightly sutured.

Animals were sacrafied from experiment by overdosing ether for anesthesia after 1 and 30 days. For control were used organs of 10 non-operated rats.

The rats' restored their postoperative motor activity, on average, in a day. The scrotum from the side of surgery was moderately hyperemic and swollen even after 5-7 days. Post-operative wounds healed with a primary tension. The testicle was located, at this time, in the upper third of the scrotum.

Control group consisted of 10 rats that did not cross a vaginal process of peritoneum. The testis were selected with appendage and all elements of a

spermatic cord. Histologically the convoluted ductus deferens, the testicular tissue, the interstitial tissue, the epididymis, and surrounding tissue were examined. The intact tissue without any changes was taken for the standard of norm.

An experiment carried out on animals with a complete section across vaginal process of the peritoneum showed a negative effect on the structure and function of the testis. All experimental rats after modeling of the pathological process (intersection of the vaginal process of peritoneum) have significant disorders of the testicular circulation with development of hypoxia. In most cases, there is firstly observed a reflex enhancement function of the spermatic tubules, which is manifested in expansion lumen of the tubules and dilution their contents, and then their partial normalization. However, there are irreversible processes – sclerosis and atrophic phenomena. Venous plethora and stasis cause lymphostasis with the development of focal and diffuse edema in a testicular stroma, which leads to the disruption of HTB. Throughout of period of the experiment, there is a development of sclerotic changes in the stroma of a spermatic cord, which leads to its deformation. In our opinion, the given changes can lead to impaired sperm evacuation and development of mechanical obstructive infertility. Intersection and excessive growth of connective tissue in the area of cross section a vaginal process of the peritoneum deform elements of the spermatic cord, which is cause excessive bending of ductus deferens with impaired fluid dynamics.

Results of this chapter indicate an important role of vascular anastomoses between vaginal process of the peritoneum and other elements of a spermatic cord in the blood supply of testis and need to development new methods of surgical treatment of cryptorchidism. They would ensure preservation the main vascular anastomoses and improve a blood circulation.

As a result of clinical observation animals in this series of experiments lasting 1 and 30 days, we established a slowdown and decrease amplitude of migration a testicle during irritation. The following issues carried out to the suppression of cremaster reflex, which may be accompanied by a decrease all its functions: regulating temperature of the testicle, protective, regulating dynamics of fluids in the testicle and others.

Excessive growth of connective tissue in the area of diastasis a crossed vaginal process of peritoneum deforms the deep inguinal ring, which becomes slit or irregular in shape, compresses elements of a spermatic cord and causes a partial long-term ischemia of the testis.

In the histological examination of a spermatic cord, both in the early and late observation period, was revealed congestive plethora with significant overflow of veins, including the cingulate plexus, with enlargement of lumen and phenomena of stasis. The artery of muscle cremaster and testicular artery diminished its caliber due to the proliferation of intima cells and sclerosis of the wall. These processes can be considered as adaptive in a reducing blood flow.

Wall of duct deferent is also thickened due to anemia, swelling, and swelling of epithelial cells in the mucous membrane. In one case, a moderate lymphocytic infiltration of the duct wall was observed.

The significant disorders of hemodynamics and lymphodynamics develop in early observation period at the rats after complete cross-section a vaginal process of peritoneum in the testis. There is occasional detachment of capsule from the parenchyma, which causes decreasing of a barrier protective function in the protein capsule, except plethora of a stagnant nature, focal lymphostasis and edema of vasculature and adjacent testicular stroma.

Uneven blood supply of arterioles and capillaries of inter-canal stroma is the result of uneven blood flow across different arteries. And uneven distribution of molded blood elements and plasma in the lumen of arteries indicates their dystonia. These disorders of hemodynamics and lymphodynamics in the testis, caused by intersection a vaginal process of the peritoneum, are exacerbated in cases of exfoliation of the testicular membrane with edema. All this causes the development of hypoxia, the indirect indicator of which is swelling and fragmentation of argyrophilic fibers both in the wall of blood vessels and in the stroma of testes.

Smooth muscle fibers lose their tone in the tortuous family tubules, their nuclei become a rod-shaped, and cytoplasm is poorly stained with eosin. The lumen of lymphatic capillaries widens considerably. The endothelial cells of the vessels in a microcirculatory bed are swelling. All these changes indicate a violation of HTB, value of which is focused on the determining of normal spermatogenic function of the tortuous family tubules.

In the early stages of experiment, we observed microscopically a significant expansion in lumen of the tortuous seminiferous tubules with dilution of their contents, which became almost transparent. The height of the spermatogenic epithelium decreased, mainly due to the number of cells in adjunctive space, which indicates the suppression of spermyogenesis. In some tubules, clusters of residual calf sperm were determined. In our opinion, expansion of the lumen in tortuous seminiferous tubules, on a background of maintaining height of the spermatogenic epithelium, indicates an increase spermatogenic function and regarded as a short-term compensatory process for the development of acute partial ischemia.

In the cause of its elimination, such changes can be reversed. This is confirmed by results of further studies. Thus, in the most experimental animals after intersection of a vaginal process of peritoneum the hemodynamic disorders decline, but proliferative and sclerotic processes progress. Resolving vacuoles appear in a swelling fluid and lymph. The inter-canal spaces are not so wide, the number of argyrophilic and collagen fibers increases in a stroma, especially in the wall of blood vessels, whose lumen is diminished. In the wall of arterioles, there is occasional hyalinosis. Perivascular and periductal large accumulations of Leydig cells appear which can be regarded as a compensatory response to hypoxia. In some places these cells resembled active fibroblasts with a hyperchromic nucleus.

Twisty tubules are enlarged in some places and in the places with normal lumen. Their spermatogenic epithelium is lined. Generally it has sufficient height, but in cell associations, spermatocytes and Sertoli cells predominate, with a little spermatogonia and spermatids. In the expanded sinuous seminiferous tubules, the epithelium is represented by 4-5 rows of cells that form beams. Sertoli cells are swollen, vacuolated at times and lose contact with each other, which is a sign of a violation of HTB. Over time, after 30 days or more, contours of some seminiferous tubules acquire a festoon structure. The lumen narrows. The lacunae of thinning in a lined epithelium disappear. Normalization of cellular associations occurs.

Sometimes connective tissue with reduction of microcirculation vessels grows considerably around such tubules. There were not detected within 30 days any morphological changes (even in the presence of unilateral autoimmune orchitis) in the contralateral testes of all rats in this series.

Thus, in the conditions of complete intersection a vaginal process of the peritoneum, despite the fact that main a.testicularis and a.ductus deferens are preserved a deep partial hypoxia develops, which causes impaired spermatogenesis in the tortuous seminiferous tubules. That is why a vaginal process of the peritoneum requires organ-preserving tactics when performing operations in the inguinal triangle. In the development of severe complications (torsion, testicular atrophy) it is necessary to take into account the pathogenetic role of altered muscle. By preserving arteries of ductus deferens and their anastomoses, spermatogenesis can be restored in the testicular cryptorchidism.

In the period from 2012 to 2019 we performed 23 diagnostic laparoscopes for non-palpable testicular syndrome (unilateral in all cases). By the age, children were divided into the following groups: from 3 to 5 years – 9 children, 5 – 7 years – 12 children, 7 – 12 years – 1 child, over 12 years – 1 boy. In 22 children, the testicles were placed in the abdominal cavity near a deep inguinal ring. In one patient the testis was located in upper third of the inguinal canal (inguinal retention).

All children with diagnostic purpose were performed by laparoscopy according to the standard procedure under total intravenous anesthesia with artificial ventilation by endotracheal method (recofol at a dose of 8-10 mg / kg / hour). The intervention began in the patient's position on a back. The first 5 mm of blunt trocar was inserted into abdominal cavity and pneumoperitoneum (8–10 mmHg) was applied. The abdominal cavity was examined with using a laparoscope (5 mm, 30º). If necessary (in our study in 5 cases), an additional 3-5 mm trocar was introduced into the left half of abdominal cavity for the palpator probe.

For more convenient revision of abdominal cavity, the patient was placed in the Trendelenburg position with a slope in one direction or another up to 30º.

In diagnostic laparoscopy the following indicators were evaluated: the condition of inner inguinal ring and vaginal process of the peritoneum (presence or absence of its obliteration), the presence, placement and size of the testicle, the degree of development epididymis and its relationship with testis, the presence, stage of development, location of the testes and ductus deferens.

In children with abdominal location of testicles (n = 23) in all cases of abdominal cryptorchidism, testicles were placed in the abdominal cavity near the deep inguinal ring. There was also testicular hypoplasia, insufficient length of testicular vessels.

According to the results of diagnostic laparoscopy, a variety of tactics were chosen. In doing so, they revealed the testicular vessels and ductus that ended blindly. This situation was observed in two boys 6 and 7 years old, whose parents first addressed to the children's hospital with complaints about absence one of the testicles in a baby's scrotum. After laparoscopic diagnosis and diagnosis of aplasia of the testicle, these children were recommended treatment by an endocrinologist.

Two-stage orchiopexia was performed in 21 boys in different variants of the location testicles in the abdominal cavity. Testing in these cases was performed by stages. In the first stage, during the diagnostic laparoscopy was performed treatment of a vascular bundle in a damaged testicle by Fowler–Stephens (operation of the "long loop of the duct", which included intersection of testicular vessels with maximum preservation of collateral between testicular artery and arteries of m. cremaster). Dissection of the testicular vessels was performed by Fowler – Stephens test, with clamping on the testicular artery and incision of the testicular membrane (wound had to bleed 2–3 minutes). This operation is shown in a case of insufficient length of testicular vessels and impossibility of performing other one-time orchio fixations. The second stage was performed after 14-16 months with inguinal access. Fixation of the testicle was done to tunica dartos directly under skin from the side of operation.

Thus, laparoscopy allowed not only marking location of the testis in the abdominal cavity, assesses its condition, but also to clearly determine the further tactics of treatment.

The traditional method of mobilization and lowering of a testicle was performed in 54 patients (in IGC–4, ABC–50).

Using the proposed method of step-by-step surgical treatment of cryptorchidism (Declaration Patent №18280, 2006), 55 children (with IGC – 10, ABC – 45) were operated on the basis of Regional Children's Clinical Hospital in Dnipro for the period from 2012 to 2019.

The first phase of operative intervention began with traditional inguinal access. There is layered a front anterior abdominal wall to aponeurosis of the external oblique muscle of the abdomen. The front wall of inguinal canal was dissected so that the free edge of inner oblique muscle of the abdomen was exposed in the wound and a deep inguinal ring was fully visible. Subsequently, the testicles and a spermatic cord were mobilized from the tissues of inguinal canal or abdominal cavity near a deep inguinal ring. Farabef's hooks raised the free edge of inner oblique abdominal and lumbar abdominal muscles. The spermatic cord mobilization continued on the level of a deep inguinal ring with tufters. On Kocher's probe, the posterior wall of inguinal canal was crossed so that the intact lower adrenal arteries and veins were exposed. Extra-deep mobilization of a spermatic cord structures was performed through an extended deep inguinal ring. Separation of ductus deferens with intersection of fixative connection between it and the bladder was performed when viewing of operating field at an angle of 90 °. In this case, size of operating field allowed carrying out mobilization of the duct to a neck of bladder. At this stage of surgery displacement of ductus deferens closer to the pubic hump was achieved by reducing radius and perimeter of retroperitoneal part of its loop. The peritoneum was separated from the testicular vessels. The testicular vessels were separated from surrounding tissues bluntly by index finger, which made it possible to shift them medially and to straighten their path to the testicle in a shortest way. Changes pathway of the ductus deferens and testicular vessels led to their newest location relatively to the inferior adrenal artery and vein. Angle of the apex in Davis triangle is unfolded. The part of testicular vessels which was not related to the peritoneum extended. Additionally, testicle mobilization in the first stage was performed depending on the length of testicular vessels without fixation of the testicle or spermatic cord to the surrounding tissues. Vaginal process of the peritoneum was revealed on the anterior surface of a spermatic cord to the deep inguinal ring without its longitudinal direction. The entry to the peritoneal cavity was liquidated by imposing an internal purse suture over parietal peritoneal membrane on the level of deep inguinal ring. The testicle mobilized such way was left on the level to which it could be lowered (more often in area of upper third of a scrotum). The posterior wall of the inguinal canal was sutured. The plastic of aponeurosis an external oblique abdominal muscle was performed by Bobrov and suture of the anterior abdominal wall was stitched. In the second stage, the testicle was removed into scrotum after 14-16 months and fixed to the tunica dartos and a scrotum bottom in the membranes, directly under skin on the side of intervention.

In cryptorchidism ultrasound examination of the testicles gave a different picture depending on the type of cryptorchidism and age of the child. Thus, in IGC showed increased echogenicity of the parenchyma. In the older children it was more permanent and significant, compared with children less than 5 years. In ABC echogenicity of the testicle parenchyma was inversely reduced, which may be the result of impaired lymphatic drainage from the testicle and presence of a long-term edema. Compared to the ultrasound examination of the testes in children from control group it was shown that testes have contours and a homogeneous structure. It should be noted that with age (in children older than 11 years), there is a normal increase in echogenicity of the testicles.

In the dystopic testes in children older than 5 years, heterogenecity structure of parenchyma was observed both in IGC and in ABC. Such changes in the ultrasound pattern of pathologically located testicles are most likely related to the occurrence of sclerosis foci. There are many prerequisites for this. These are mechanical trauma, fever, underdevelopment of blood vessels, reduction of blood vessels of a microcirculatory bed – they can cause hypoxia, and therefore sclerosis.

In 24 months after surgical intervention with different methods of surgical treatment of cryptorchidism (traditional methods and after second stage of surgery by own method) in the testicular artery was revealed improvement of a blood flow compared to the condition before surgery: decreasing of the resistance index (0.607–0.600), increasing a blood flow velocity (11.0–13.0 cm/s) and final diastolic blood flow velocity (4.2–5.3 cm/s). Moreover, when performing a two-stage orchiopexia according to own method, all changes of indicators were significant ($p<0.05$) and values of the parameters approached to the corresponding levels in healthy children.

Analysis results of the color duplex angiomapping and energy dopplerography of the capsular testicular artery before and after surgery indicates that a steady increase of a peak systolic blood flow velocity and decrease of the resistance index in this vessel is a prognostically unfavorable sign of decreasing the arterial blood flow. In such conditions, regardless of the state cardiac and respiratory systems, the testicle is subjected to a high blood pressure on the type of "local hypertension", which leads to plasmorrhagia, development of hyalinosis in the arterioles walls and to atrophy of tortuous seminiferous tubules.

Changes in the circulation of testes in the early postoperative period are caused by operative trauma, compensatory increase of inflow due to trauma of the spermatic cord, lack of regulating mechanisms of cremaster reflex and others.

Presence of not identical, but permanent deviations of a peak systolic blood flow velocity and index of resistance in the capsular testicular artery was found in 6 months after operations performed by both methods, indicates insufficient regeneration of the blood vessels in the displaced organ and incomplete restoration of normal organ.

When changing position of the body from vertical to horizontal it is shown decreases a peak systolic blood flow rate and increases the resistance index of vessels, which must be taken into account in the postoperative curation of children with cryptorchidism. It should be prescribe bed regime and antispasmodics.

Thus, presence of latent circulatory abnormalities in the testes, which are not detected by conventional methods in the late (after 6 months) observation period carried out necessitate of dispensary supervision with repeated ultrasounds and doppler ultrasound of the postoperative testes in children operated from cryptorchidism.

In general, the systematic approach to study cryptorchidism on experimental and clinical material using adequate clinical, morphological and modern highly informative methods of research has allowed us to establish a number of new facts and patterns.

According to the results of palpation examination the reduced testicles in 6 months after surgery, normal consistency of the parenchyma was observed in

51 (92.8%) patients after surgery by own method against 24 (44.4%) patients operated in the traditional way ($p<0.05$). Softening of the parenchyma in reduced testes was noted after surgical correction in 3 (5.4%) patients, by the traditional way – in 24 cases (44.4%), $p <0.05$.

Compaction parenchyma of the testes in 6 months after application its own method of testicular descent was detected in ABC at 1 patient, while in the traditional approach – at 5 patients (9.3%). It should be noted that in the abdominal forms of cryptorchidism, normal consistency of the testes was observed in 42 (76.4%) patients operated by own method. Only in 24 (44.4%) patients with ABC after traditionally performed operation testicle has normal consistency ($p<0.05$). In 1 (1.9%) patient with IGC after traditional treatment was noted development of testicular atrophy. In children operated by own technique, testicular atrophy was not observed.

The results of clinical and morphological studies conducted in the experiment indicate presence in a spermatic cord of the adaptation - compensatory possibilities in relation to the regeneration of blood vessels and anastomoses between them. We have taken this into account when developing a new method of improving blood supply in the reduced testis by maintaining vascular anastomoses between vaginal process of peritoneum and other elements of a spermatic cord in surgical treatment of cryptorchidism in children, whose long-term results are better than using traditional method of mobilizing elements of a spermatic cord with complete crossing a cremaster muscle and vaginal process of peritoneum.

CONCLUSIONS

The monograph presents experimental substantiation and practical solution of actual scientific problem, which consists in the development and introduction of a new method of step-by-step surgical treatment of cryptorchidism in children, which allows preserving blood supply of testes in the postoperative period and decreased development of atrophy in the reduced testis.

1. An ultrasound examination using doppler technology is a highly effective way of assessing both anatomical parameters regarding a size of the testicle, blood vessels, parenchyma status, and functional indicators of blood flow in the genital gland. Doppler ultrasound revealed that in all cases of cryptorchidism, regardless of the age of children, there was shown decreased blood flow in the testicular artery, which was reflected in increasing of the resistance index (RI), a significant decrease of a peak systolic blood flow velocity (Ps) and final diastolic blood flow (Md) ($p < 0.05$) compared with healthy children. The most significant circulatory disorders were observed in patients older than 12 years. The maximum systolic and final diastolic blood flow rates were in 1.9-2.1 and 3.2-3.3 times lower than in healthy children of appropriate age.

2. Using of laparoscopy at the diagnosis abdominal forms of cryptorchidism in children allows not only to clarify localization of the testicle, but also to assess its condition, which affects the subsequent tactics of treatment. In the structure of cryptorchidism, according to the diagnostic laparoscopy, abdominal form occurred in 22 cases (95.7%), a "high" inguinal form – in 1 child (4.3%). In 21 cases, the testes were hypoplasic (91.3%) and in 2 patients (8.7%) were diagnosed aplasia of testicle. Two-stage orchiopexia with treatment a vascular bundle of the testicle was performed by Fowler–Stephens in a case of cryptorchidism in 21 boys (91.3%). Atrophy of the reduced testicle in the postoperative period was not observed.

3. Injury of vascular anastomoses at a complete cross section vaginal process of peritoneum in the experiment carried out on rats led to the disturbance of blood supply in a testicle with development of stagnant plethora, swelling of tissue. There was a reliable ($p < 0.05$) decrease in diameter of tortuous semiferous tubules on 180.21±0.77 μcm and volume of Leydig cell nucleus on 76.78 ± 0.37 μcm^3, which led to the negative impact of intervention on general condition of the testicle.

4. Proposed method of step-by-step surgical treatment of abdominal forms of cryptorchidism is characterized by decreasing a vascular traction, absence of injury vascular anastomoses between a vaginal process of peritoneum and other elements of a spermatic cord, improves testicular blood circulation and reduces the blood flow after postoperative period. The two stage in the treatment of abdominal forms of cryptorchidism allows the reduced testicle to gradually adapt to a new condition. Disease recurrence and atrophy of the testicles were not observed after surgery by own technique.

5. Effectiveness a new method of stepwise surgical correction abdominal forms of cryptorchidism in children has been confirmed in the experiment and clinical studies, according to the ultrasound and doppler examination. It has been proved that in the testicular artery, using different methods of surgical treatment of cryptorchidism (traditional methods and after second stage of surgery by own technique), in 24 months after intervention, was shown improvement of circulatory indices compared to the condition before surgery: decreasing of the resistance index (0.607–0.600), increasing of a peak systolic blood circulation rate (11.0–13.0 cm /s) and final diastolic blood circulation rate (4.2–5.3 cm/s). Moreover, performing a two-stage orchiopexia by own methods carried out to the corresponding levels of the given results and values of parameters, which were observed in healthy children.

PRACTICAL RECOMMENDATIONS

1. One of the main conditions for preventing negative consequences of surgery in the treatment of cryptorchidism in children should be performed only in specialized centers by pediatric surgeons and urologists who have some experience.

2. Implementations into general practice of own method step-by-step surgical reduction of testis in "high" forms of cryptorchidism in children allows improving testicular circulation in the retentate testicle during surgery and after its descent by reducing traction of vessels and gradual adaptation circulation of testes to the new conditions.

3. We propose to use our own method of gradual surgical correction of cryptorchidism in children from 3 years in the cases when correction of defect in one stage is impossible without a complete crossing of cremaster muscle and vaginal process of the peritoneum.

4. Children who have been operated in cryptorchidism should be monitored to the puberty period and methodologically undergo doppler ultrasound study of testicular circulation for the early detection and correction of impaired development in the testes.

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