EXPERIMENTAL METHODS FOR CLINICAL PRACTICE

Plastic Repair of the Deferent Duct with a Silicone Tubular Prosthesis under Conditions of a Chronic Experiment on Laboratory Animals

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A connective tissue capsule consisting of a thin layer of the connective tissue envelopes the prosthesis by the end of week 1 after replacement of a part of the deferent duct with a silicone tubular prosthesis under conditions of a chronic experiment. By days 17-20 postoperation, two layers are clearly differentiated in the capsule: the outer layer consisted of a thin layer of connective tissue and the inner one consisted of compact connective tissue. The space between the silicone prosthesis and the connective tissue capsule is filled with the seminal fluid. Obturation of the deferent duct forms because of formation of internal spermatogranulomas and atypical growth of the deferent duct epithelium adhering to the prosthesis wall.

Key Words: *deferent duct plasty; silicone tubular prosthesis; spermatogranuloma; anastomosis; obturation*

Chronic experimental replacement of a part of the deferent duct (DD) with an autovenous prosthesis showed negative results: secondary obturation of DD developed as a result of formation of internal spermatogranulomas (SG), primarily in the epididymal anastomosis (EA) zone [2]. Hence, the search for plastic material for replacement of extensive defects of DD remains an important problem, and further basic studies in this field are needed.

We studied canine DD after plastic repair with a silicone tubular prosthesis.

MATERIALS AND METHODS

Experiments were carried out on healthy dogs weighing 6-24 kg after a 2-week quarantine in a vivarium. The animals were subcutaneously injected with promedole (0.5 mg/kg, 2% solution) 30-45 min before surgery.

The dogs were narcotized with 2.5% hexenal or sodium thiopental. The skin and subcutaneous fat in the inguinal area was dissected with a vertical incision (5-6 cm). The spermatic cord was mobilized at a length of 5-6 cm and brought into the operation wound. The membranes of the spermatic cord were opened longitudinally on the anterior surface. The DD was mobilized at a length of 5-6 cm, a 3-4-cm fragment was cut with a microsurgical scalpel or razor, the duct vessels were ligated and crossed at the ends of the fragment; thorough hemostasis was carried out.

The DD defect was replaced with standard silicone prosthesis (a tube with an outer diameter of 4.5 mm and inner diameter 1.5 mm). Hence, the inner diameter of the prosthesis was significantly

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greater that the diameter of DD lumen. Anastomoses between the ends of the duct and prosthesis were sutured with atraumatic monofilament thread (7/0) by 6 nodular sutures through all layers of the plastic material and the adventitial muscular part of the DD wall. Tantalum wire was used for more convenient suturing of anastomoses; it was removed directly after formation of both anastomoses. The membranes of the spermatic cord were restored with nodular capron sutures. The operation wound was sutured completely layer-by-layer and treated with antiseptic solutions.

A total of 30 chronic experiments were carried out, 6 per period: days 5-7, 10, 17-20, 60-120 postoperation.

The following methods were used: chromoductography, X-ray contrast ductography (injection of methylene blue or triatomic X-ray contrast agent into the DD and neoduct cavity). The macroscopic picture of the operation area, including the anastomoses and prosthesis, was described, with a detailed protocol; histological study of the neoduct and anastomosis zones was carried out on serial sections (7-8-μ) stained with hematoxylin and eosin, picrofuchsin after van Gieson, and with resorcin-fuchsin after Weigert.

The animals were sacrificed by toxic doses of hexenal or sodium thiopental.

RESULTS

The animals rapidly recovered after the intervention: on the next day they exhibited good appetite and vivid reactions. Minor edema of the scrotum disappeared on days 2-3.

On days 5-7, the diameters of the vesical and epididymal portions of the DD coincided in all cases, no outer deformation of the anastomoses was seen. In 3 cases, multiple foci of SG more than 2 mm in size were detected in the EA zone (Table 1). Both anastomoses were patent. A fine connective tissue capsule enveloped the silicone prosthesis. The testis and epididymis remained unchanged in all experiments.

The capsule enveloping the silicone tube consisted of fibrous connective tissue. The structure of the DD wall in the anastomosis zone was in general retained, the lumen of the DD channel had usual size. The ductal epithelial cells were vacuolated and did not migrate to the surface of the duct facing the alloprosthesis. In few cases, suturing threads came through the duct wall into the lumen, and foci of necrosis were discerned between them. Foci of SG were detected in the EA zone under the DD adventitial membrane in 3 cases (Fig. 1).

On day 10, the diameters of the epididymal and vesical areas of the DD coincided in all cases. Bending deformation of the vesicular anastomosis (VA) zone was observed in 3 cases (Fig. 2, *a*), numerous small SG foci (no more than 0.3×0.8 mm) were seen in the EA zone. All VA and EA were patent (Table 1). The silicone prosthesis was enveloped with a connective tissue capsule, the space between the prosthesis and capsule was filled with seminal fluid.

The histological picture was the same in all cases. The DD walls in the EA zone had foci of necroses, blood vessels were detected in the adventitial membrane. The lumen of the duct channel was intact and contained spermatozoa. Epithelial cells were flat, did not migrate to the duct surface facing the alloprosthesis. Focal SG was detected between the tube and duct wall. The site of anastomosis was presented by granulation tissue with few cells of different kinds and fine vessels. The cells accumulated mainly around the suture threads; giant cells of foreign bodies were detected in these accumulations. The neocapsule consisted of a fine layer of loosely interwoven connective tissue fibers. Capillaries and small arteries were detected in the outer layer, elastic fibers were seen in the neocapsule and walls of new vessels (Fig. 3, *a*). Sper-

TABLE 1. The DD Anastomoses with Silicone Tubular Prostheses (*n*=6)

Day of observation	EA				VA			
	patent	obstructed	spermatogranuloma		patent	obstructed	spermatogranuloma	
			outside	inside			outside	inside
5-7	6	—	3	—	6	—	—	—
10	4	—	3	—	4	2	—	—
17-20	4	2	2	—	6	—	—	—
30	2	4	2	—	6	—	4	—
60-120	2	1	—	1	6	—	—	—

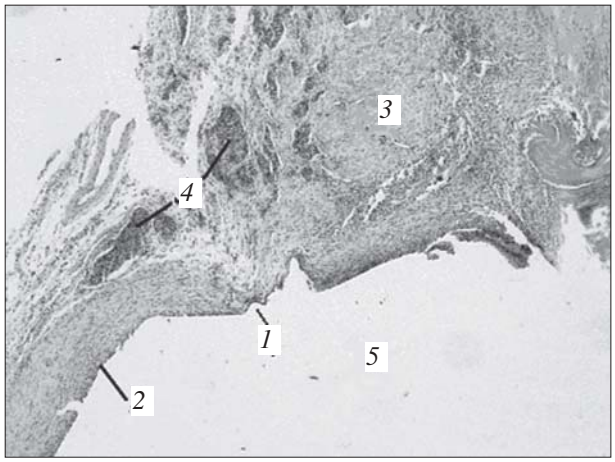

Fig. 1. The DD EA zone with silicone tubular prosthesis on day 7 postoperation. Spermatozoa and forming SG (*4*) at the site of EA (*1*), on outer walls of the prosthesis (*2*) and DD (*3*); neoduct lumen (*5*). Hematoxylin and eosin staining, ×105.

matozoa were located on the inner surface of the capsule. In contrast to EA, the DD epithelium migrated onto the duct surface facing the alloduct. The rest was identical to the histological picture on days 5-7 postoperation.

On days 17-20 postoperation the diameters of the epididymal and vesical sections of DD coincided in all cases. The EA was patent in 4 cases (Table 1). Bending deformation was observed in 1 case. Spermatogranulomas presenting as patches were detected in 2 EA. Vesical anastomoses were patent in 5 cases, in 2 only in the retrograde direction (methylene blue solution was injected into the vesical segment of DD and diffused into the alloprosthesis). Bending deformation of VA was detected in 1 of these 5 anastomoses. Vesical anastomosis was obstructed in 1 case, without apparent changes in the anastomosis zone. Silicone prosthesis was enveloped with a connective tissue capsule in all experiments, its channel was filled with seminal fluid.

The structure of the DD wall in the EA zone was intact, the lumen of the duct channel was wide and optically empty. A suture thread was seen in the lumen of the duct channel in 1 of 4 functioning anastomoses. The ductal epithelium was intact, migrated onto the duct surface facing the alloprosthesis, where it formed "pads". In 2 cases with obstructed anastomoses the lumen of the duct channel was significantly stenosed and the epithelial "pads" narrowed its lumen in the anastomosis zone. The EA zone was presented by mature fibrous connective tissue with foci of SG inside, which in 2 cases were discernible in the muscular wall of the duct wall and under the adventitium.

The DD wall retained its common structure in the VA zone; the DD channel was intact. In 5 cases, the ductal epithelium lined the duct channel and migrated to the duct surface, facing the alloprosthesis, where it formed "pads". In 2 cases with just retrograde patency of the anastomosis and in 1 case with obstructed VA the lumen of the duct channel was stenosed in the anastomosis zone, one of the causes of stenosis being accumulation of epithelial cells, grouped in 3-4 rows. The anastomosis zone was presented by mature fibrous connective tissue. A fine capsule enveloping the alloprosthesis consisted of 2 layers: loose fibrous connective tissue from the outside and well-formed connective tissue inside. An appreciable number of blood vessels of different diameters were detected in the outer layer of the capsule in all cases. Spermatozoa forming a thin layer or lumps were detected

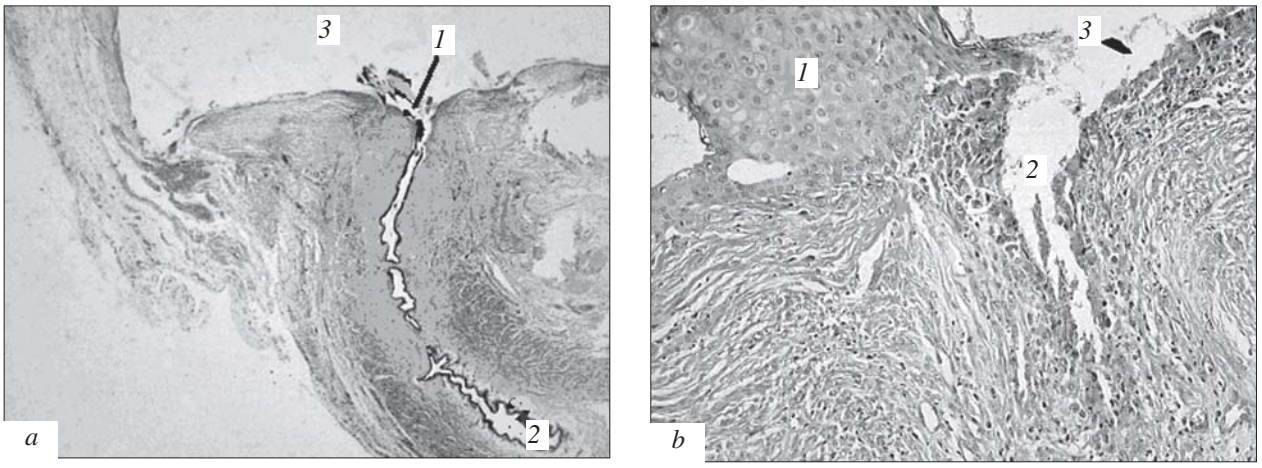

Fig. 2. The VA zone with silicone tubular prosthesis on days 10 (*a*) and 30 (*b*) postoperation. *a*: *1*) direct migration of epithelium from DD to the inner wall of the prosthesis; *2*) DD lumen; *3*) neoduct lumen; *b*: *1*) epithelium from DD crawls onto the prosthesis wall and forms a sort of a "pad" from round (flat) cells on the left; *2*) DD lumen; *3*) neoduct lumen. Hematoxylin and eosin staining; ×52 (*a*), ×420 (*b*).

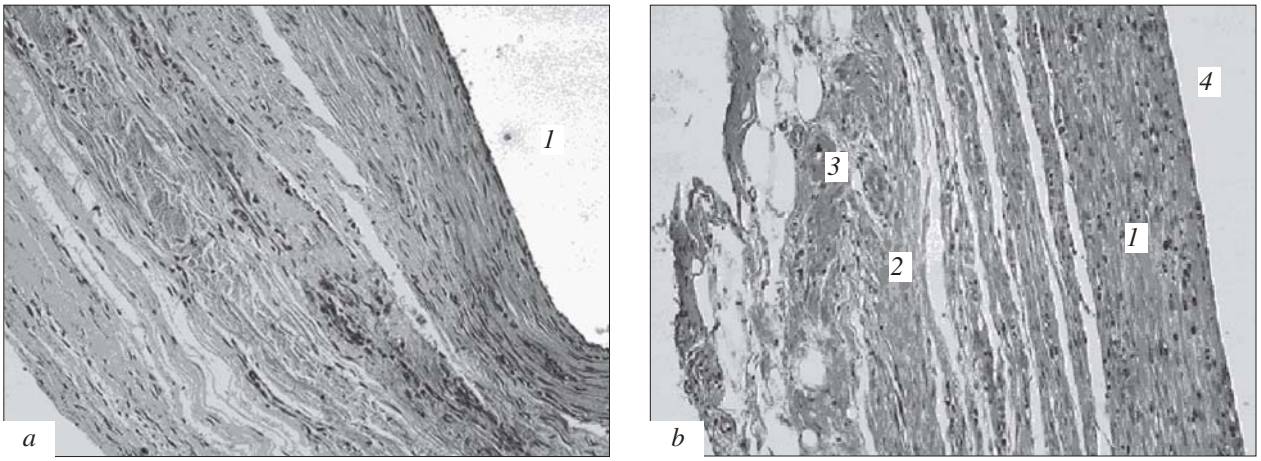

Fig. 3. Connective tissue duct wall on day 10 (*a*) and neoduct wall structure on day 30 (*b*) after surgery. *a*: the wall consists of connective tissue fibers; blood capillaries are discernible; neoduct lumen (*1*); *b*: inner layer of the wall at an appreciable distance from the anastomosis consists from compact connective tissue (*1*), outer layer is more loose (*2*); blood vessels (*3*), neoduct lumen (*4*). Hematoxylin and eosin staining, ×420.

on the inner surface of the neocapsule in 4 cases with patent EA. Elastic fibers were detected in the outer layer of the capsule in 3 cases and in the walls of new vessels in all cases.

On day 30, the diameters of the epididymal and vesical fragments of DD coincided in 4 cases. In one case the diameter of the epididymal part of DD was greater, in 2 cases it had bending deformation. Spermatogranulomas (patches 0.2×0.6 mm) were detected in the EA zone on the outer surface of DD in 2 of 3 cases (Table 1). Four VA were patent, in 2 patency was detected only by antegrade chromoductography. Spermatogranulomas in the anastomosis zone were detected in 4 cases, in 1 case they were combined with the anastomosis obstruction. All sutures in the EA and VA zones were intact. No macroscopic changes in the testis and epididymis were detected (4 cases), signs of DD obstruction were clearly seen in 3 cases. The epididymis was enlarged, its tubule was dilated: microscopic examination of its contents showed modified spermatozoa. The silicone tube was surrounded with the connective tissue capsule consisting of 2 layers (loose outer layer and more compact inner layer) in all cases.

The histological picture of serial sections through the anastomoses (Fig. 2, *b*) and the neoduct (Fig. 3, *b*) in general corresponded to the morphological picture 17-20 days after the intervention.

On days 60-120, the diameters of the epididymal and vesical parts of DD coincided in 3 cases, with bending deformation of EA in 1 case. The sutures were intact. The testis and epididymis were macroscopically modified in 4 cases. About 2-3 ml hydropic fluid was released from a testis after the testicular membranes were opened; the testis shrank, dilated lymph vessels were seen along the spermatic cord.

In 1 case the epididymal fragment of DD was wider than the vesical one, its channel was dilated and filled with thick crumbly mass. The epididymis in this case was enlarged, its tubule was dilated, and thick creamy mass was released from it if injured; macroscopic study of this mass showed detritus.

Compact connective tissue capsule was detected around the silicone prosthesis in all cases. No SG foci were detected in the anastomosis zones.

Antegrade ductography with methylene blue showed free passage of the dye through EA, after which the dye filled the lumen of the allogenic tube and the space between the tube and the connective tissue capsule in 2 cases, and passage of the dye (under slight pressure) into the vesical fragment of the duct in 1 case (Table 1). Antegrade ductography was impossible in 1 case because of EA obstruction (DD channel and EA zone were tightly packed with crumbly SG). Retrograde injection of the dye into the lumen of the vesical fragment of the duct showed that all VA were patent.

The EA and VA zones were presented by mature connective tissue with few fibroblasts. DD in the EA and VA zones retained its common structure in all cases. The channel of the duct was lined with epithelium, which in all cases "crawled" onto the duct surface facing the alloprosthesis, where it formed "pads".

The duct lumen had usual size and was optically empty in 3 VA and in 2 EA.

Fine-wall blood vessels adhering to the epithelium were well discernible in all cases. The neocapsule consisted of mature connective tissue. Numerous arterial blood vessels and large arteries were detected

in the loose connective tissue layer from the outside. Elastic fibers in the capsular wall were detected in only new vessels.

No relationship between the presence of SG in the anastomosis zone and its patency was detected in the overwhelming majority of cases. For example, SG was detected on the surface of EA in 10 of 30 cases and in just 1 case inside the DD channel (SG was undetectable on the anastomosis surface in this case). SG was detected on VA surface in 4 cases, but in none of the cases in the duct channel. Hence, SG were inessential for the development of secondary obturation of DD in plastic repair of DD with silicone tubes.

In some cases, VA patency was detected only by retrograde chromoductography, and the histological picture of serial sections through the anastomoses was similar. The DD epithelium in the anastomosis zone "crawled" onto the ductal surface facing the alloprosthesis, where it formed foci of 3-4 layers of cells ("pads"). The area of the cells dissemination promoted shrinkage of the transverse section area in the alloprosthesis. The rest part of the duct surface facing the allotube was covered (starting from days 17-20 postoperation) by well-formed fibrous connective tissue unfit for maintaining the viability of epithelial cells.

Hence, the presence of a silicone prosthesis promoted the formation of fibrous connective tissue on the DD surface in the anastomosis zone, prevented further migration of epithelial cells, promoted epithelial growth. This growth narrowed the lumen of the duct channel, obstructed the passage of seminal fluid, and in some cases promoted secondary obstruction of DD. In 1 case, the lymph flow from the testis was impaired 4 months after the intervention. It seems that lymphostasis is a result of damage to the lymph collector of DD by ligature of the duct walls during resection of its fragment.

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