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Biological adhesive

“SULFACRYLATE”

Antimicrobial and anti-flammatory adhesive composition

Manufacturer: JSC Federal Research and Production Center Altay
http: //www.sulfakrilat.ru

INSTRUCTIONS FOR USE IN SURGICAL FIELDS

Ministry of Healthcare
of the Russian Federation
Novosibirsk State Medical Academy

G.K. Boreskov Institute of Catalysis of the Siberian Branch of the Russian
Academy of Sciences

V.T. Marchenko, N.N. Prutovych, G.A. Tolstikov, A.G. Tolstikov

BIOLOGICAL ADHESIVE "SULFACRYLATE"

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V.T. Marchenko, N.N. Prutovych, G.A. Tolstikov, A.G. Tolstikov Biological adhesive Sulfacrylate Antimicrobial and anti-flammatory adhesive composition. Instructions for use in surgical fields. - Novosibirsk: 2013. - 80 p.

The book is concerned with the advantages of use of the medical adhesive Sulfacrylate in various surgical fields. The observation of effects of the adhesive on the tissues of parenchymal and hollow organs are presented. The recommendations for surgeons are provided to help more successfully apply the adhesive composition during the various operations. The book is intended for surgeons, residents, senior students of medical IHL.

CONTENTS

1. USE OF SULFACRYLATE ADHESIVE IN SURGERY

One of the ways to improve surgical technologies is a conceptually new form of connection and sealing of sutures in the local area of surgical intervention using Sulfacrylate biological adhesive compositions.

The chemical compounds based on alpha-cyanoacrylates find the widest application and have the widest use in the group of modern biological adhesives in medical practice. Synthetic adhesives based on esters of alpha-cyanoacrylic acid significantly contributed to the development of the latest surgical technologies, occupied a prominent place on the world market, surpassed the commercial success of biological sealants based on fibrin and collagen.

Use of Sulfacrylate biological adhesive improves effectiveness of surgery and reduces the incidence of postoperative complications in severe diseases of the abdominal and thoracic cavity organs complicated by pyoinflammatory process.

New adhesive technology with the use of new Sulfacrylate adhesive provide highly effective less traumatic connection and hemostasis of the tissues of parenchymal organs and intestines during surgical interventions that allows to perform reconstructive surgery associated with a high risk of development of postoperative bleeding and septic complications both in acute and cold surgery on the organs of abdominal and chest cavity, brain, in ophthalmology.

Use of Sulfacrylate allow to make prosthetics of peritoneal covers, make secure fixation of organ to the surrounding tissues, prevents infection of surgical intervention area.

Adhesive technology using Sulfacrylate can significantly reduce treatment costs by reducing the frequency of complications.

Use of Sulfacrylate eliminates the need for surgical interventions in several stages, limits the use of expensive antimicrobials, reduces the cost of treatment, reduces the stay of the patient in hospital after surgery.

Adhesive technology can be used in any age group of patients since neonatal period in surgery on lungs, diaphragm, liver, spleen, urinary tract organs and intestines irrespective of the aetiopathogenesis of the disease.

Implementation of a new type of adhesive composition Sulfacrylate in the clinic was preceded by a thorough morphological study in experiment in small and large laboratory animals. The effect of biological sealant on parenchymal tissue and hollow organs was studied. Portions of the study results are included in the sections of the instructions.

2. INDICATIONS FOR THE USE OF THE SULFACRYLATE ADHESIVE COMPOSITION

- In surgery of the gastrointestinal tract: for sealing seams and anastomoses;
- during surgical interventions for traumatic injuries of parenchymal organs: liver, kidneys, spleen, pancreas;
- during reconstructive surgery of the biliary tract;
- during reconstructive surgery of the urinary tract: pelvicaliceal system of kidney, ureter, bladder, urethra;
- in thoracic surgery for surgical interventions on the lung, bronchi, pleura, mediastinum organs, diaphragm plasty; repair of bronchopleural and thoracopleural fistulas.
- in cardiovascular surgery for sealing of vascular anastomoses;

- in obstetrics and gynecology during surgical interventions on the uterus, its appendages, vagina;
- in neurosurgery in removal of brain tumors and vascular abnormalities in the form of arteriovenous malformations - for embolization of vessels;
- during surgical interventions on the organs of pancreaticoduodenal area, for the pancreatic duct occlusion;
- closure of internal hernial orifice using a synthetic material, which is fixed with adhesive;
- for fixation of the mesh skin flaps during plastic surgery on the body surface;
- for bonding of polymeric materials or hemostatic sponge of the suture line for the purpose of hemostasis;
- for occlusion of fistulous tracts;
- for fixation of bone grafts;
- in plastic surgery and cosmetology to create a sutureless skin anastomoses;
- in the dental practice and otorhinolaryngology;
- in ophthalmology;
- in endoscopic surgery;
- in oncology.

3. CHARACTERIZATION OF SULFACRILATE ADHESIVE

The Sulfacrylate adhesive composition is based on α-cyanoacrylic acid ethyl ester, which polymerizes upon contact with liquid media containing water and transits from monomer to polymer.

Cyanoacrylate adhesive basis

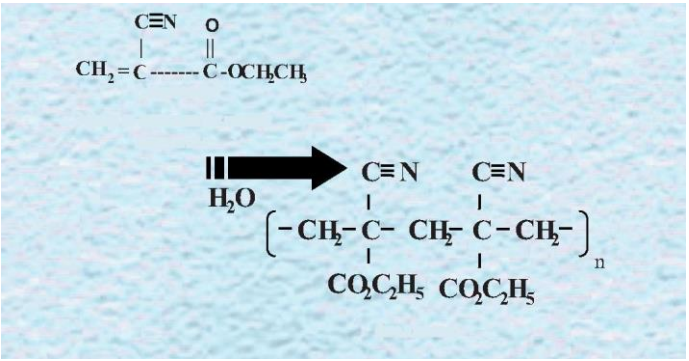
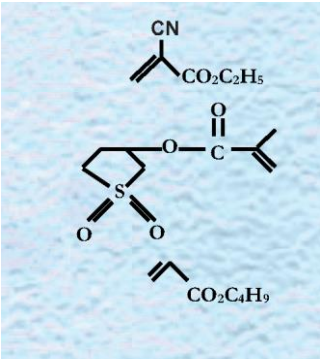


Fig. 1. *Scheme of polymerization of α-cyanoacrylic acid ester*

The Sulfacrylate adhesive consists of three components, the first being the ethyl ester of a-cyanoacrylic acid determines the ability of the composition when in contact with fluids containing water, to form a polymer, the first being the ethyl ester of α-cyanoacrylic acid determines the ability of the composition to form a polymer upon contact with media containing water. Second component is included in the copolymer imparting a plasticity to it. The third component, methacrylate-3-oxysulfolane has an antimicrobial activity, eliminate inflammation of tissues, promotes rapid wound healing. The adhesive is a colorless transparent liquid having a specific gravity of 1.05 to 1.07 п/cm^3 and a relative viscosity to water of 10 to 45; soluble in acetone, dimethyl-formalide, dimethylsulfoxide. The adhesive Sulfacrylate is produced in ready-to-use form in polyethylene ampule-tubes containing 1 ml of adhesive. The adhesive

is self-sterile. It polymerizes upon contact with water. When applying the adhesive to wet connected biological tissues, it firmly bonds them together to form a strong flexible film. The polymerization time is 10 to 120 seconds. The polymerization rate is dependent on the volume of adhesive and amount of the liquid medium, with which it is in contact. The adhesive composition has high adhesion properties. The polymerization of adhesive gives a small shrinkage bringing together the bonded fabric fragments more tightly. It has a specific smell.

Composition of the Sulfacrylate biological adhesive



1. Ethyl ester of α-cyanoacrylic acid
70 to 85 g

2. Sulfolane-methacrylate
7.5 to 15.0 g

3. Butylacrylate
5.5 to 15.0 g

Fig. 2*. The composition of Sulfacrylate adhesive composition*

The adhesive in the body is exposed to the gradual fragmentation and resorption.. The pores are formed in the low-molecular weight part of the adhesive, through which the connective tissue grows. Complete resorption of adhesive takes place 30 to 45 days from the date of its application to the tissue. The resorption process depends on the method of application of the adhesive composition, thickness of the applied adhesive film and the nature of the bonded surfaces.

Sulfacrylate has bactericidal activity against pathogens of surgical infections: Escherichia coli, Staphylococcus aureus, Proteus, Pseudomonas aeruginosa.

4. GENERAL PRINCIPLES OF THE USE OF ADHESIVE

For use in surgery, the Sulfacrylate adhesive composition is packaged in 1.0 to 2.0 ml disposable sterile syringes. Syringe tips are closed by Teflon tape gaskets and sealed by polypropylene cannulae for medical devices. Syringes with adhesive in individual packages are equipped with disposable injection needles packed in cardboard packs. Instructions for use are enclosed into each pack.

The adhesive is ready for use with no additional preparation.

The outer surface of the syringe with the adhesive is sterile. Before use, open an individual package, remove the cannula and gasket from the syringe tip, put the injection needle on the tip of the syringe. The adhesive is fluid and does not polymerize in a dry needle.

Depending on the purpose of the surgery, the adhesive can achieve different effects: to achieve hemostasis for moderate parenchymal bleeding, strengthen the suture line of created anastomosis, seal damage area, make the organ fixation, create a organoanastomosis, seal the fistula etc.

Before applying the adhesive, dry the wound surface with gauze, make legation of the major bleeding vessels if any.

The adhesive shall be applied to the wound surface, and it is necessary to achieve its uniform spreading on the treated area. Being applied in such a way, the thin layer of adhesive covers the wound surface and rapidly polymerizes to form a thin flexible film. This method allows precise dosing and targeted application of the adhesive composition. Polymerization proceeds for 10 to 120 seconds, thereby forming a flexible film ensuring a tightness of bonded surface connection or hemostasis of the wound surface.

Adhesive rate is about 0.03 ml (1 drop) per 1 cm^2 of the surface treated. When applying more adhesive, the polymerization proceeds for a longer period of time with the hard crust of polymerized adhesive formed on the wound surface. The excess of the applied adhesive reduces its effectiveness. In order to accelerate the polymerization, the surface of the adhesive film can be moisturized by saline or furacilin solution.

5. STUDY OF INFLUENCE OF SULFACRYLATE ADHESIVE ON PARENCHYMAL ORGANS IN EXPERIMENT

5.1. Study of influence of Sulfacrylate on regenerative processes in the liver during resection

The results of morphological study of the interaction of Sulfacrylate adhesive and liver tissue were carried out on the model of regeneration of the organ wound treated by biological adhesive. The photographic bar graphs of the following wound process durations are provided.

Immediately after resection of liver area, the wound surface was treated by the adhesive composition, an effective hemostasis was achieved with the formation of thin adhesive film on the wound surface.

hours after the resection, the appearance of leukocytes was observed on the wound surface. The fine-focal hemorrhages appeared in the liver, poor leukocyte infiltration in the tissue adjacent to the wound area. The hepatocytes with pyknotic nuclei were observed, their boundaries were more clear. Among hepatocytes with pyknotic nuclei, the necrotizing cells appeared located in small groups and mostly tiled. When applying the adhesive on

Glisson's capsule, the leukocyte infiltration was observed underneath. However, the changes in the subjacent tissues were not observed (Fig. 3).

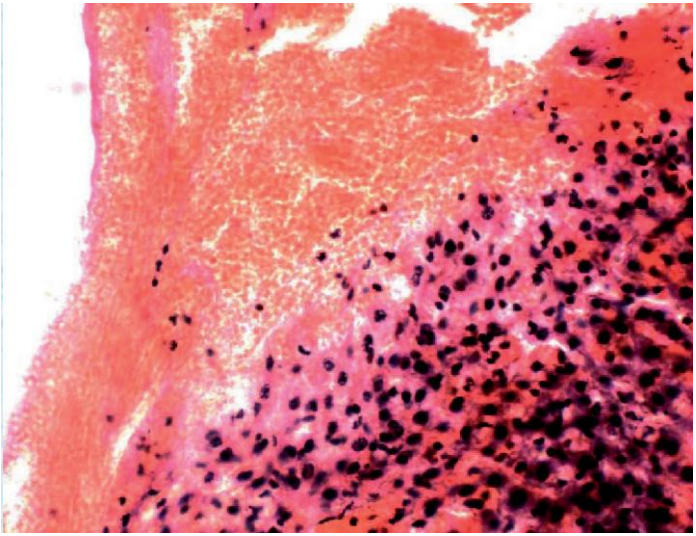


*Fig. **3.** Rat liver wound after treatment with adhesive (after 3 hours). Hematoxylin and eosin staining. The adhesive film on the blood clot surface. Magnification of 40x10*

One day after surgery, the necrotic zone clearly delimited from viable tissue was observed for animals in the area of resection. An abundant polymorphcellular inflammatory infiltration was observed in liver tissue adjacent to the adhesive layer. A large number of white blood cells have been destroyed, leukocyte reaction on the border with viable tissue was quite evident. An increased number of binucleate hepatocytes was observed in the area remote from the hepatocytes with necrotic changes (fig. 4).

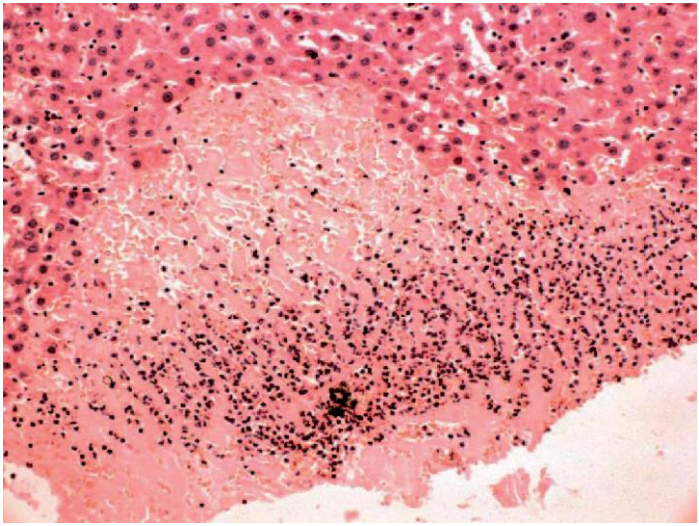


*Fig. **4.** Rat liver wound treated with Sulfacrylate adhesive after 1 day. Hematoxylin and eosin staining. Necrotic zone of hepatocytes with leukocyte infiltration on the wound surface.*
Magnification of 20x10

A week after the operation, a narrow necrotic zone is formed on the surface of the resected portion of the liver after applying the Sulfacrylate adhesive that is delimited from viable tissue, with initial signs of formation in the form of fibroplastic activity at the boundary. A polymorphcellular inflammatory infiltration is observed in liver tissue adjacent to the adhesive layer. In this time, the partial resorption of the adhesive is observed. It occurred only in certain macrophages or free in the scar in the form of small lumps.. The scar is represented as an immature fibrous tissue (Fig.. 5).

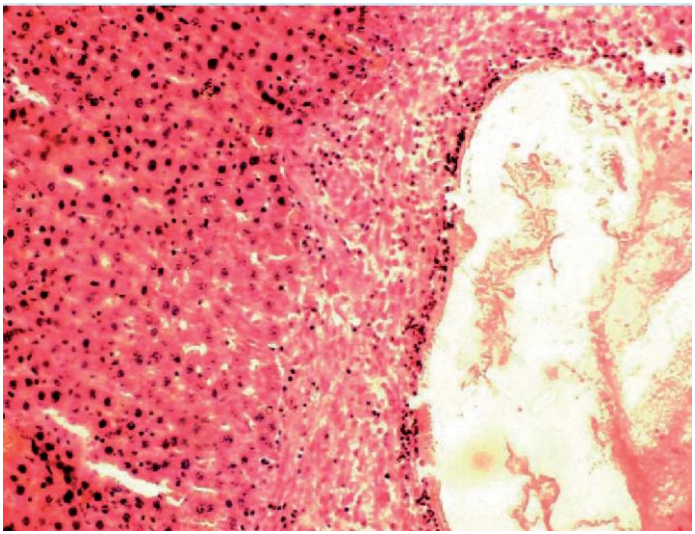


Fig. 5. Rat liver wound treated with Sulfacrylate adhesive after 1 week. Hematoxylin and eosin staining. Magnification of 20x10

1 month after surgery with the use of the Sulfacrylate adhesive, the necrotic zone was formed. The coagulation necrosis focus was delimited from the rest of liver tissue by the granulation tissue changing into the mature fibrous tissue with lymphohysteocytic infiltration on the periphery, with admixture of neutrophils. The infiltrate includes a large number of macrophages, giant cells - cells of foreign bodies, cytoplasm of which contains the adhesive inclusions. Small necrotic patches are completely resorbed by this time. Young scar tissue containing multinucleated cells of foreign bodies with adhesive in the cytoplasm forms the newly formed organ capsule (Fig. 6).

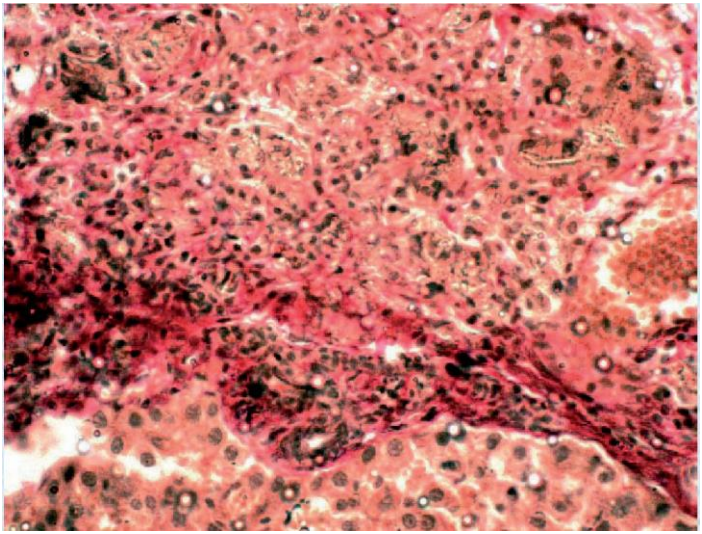


Fig. 6. Rat liver in a month after resection using Sulfacrylate. The scar tissue formed on the boundary with the liver parenchyma. Van Gieson's staining. Magnification of 40x10

Studies undertaken have shown that Sulfacrylate has a local toxic effect on the liver tissue limited by the surgical trauma area. The wound healing process proceeds through the phases of formation of necrotic patches with signs of aseptic inflammation.. The adhesive begins to be resorbed by the end of the first week after the operational period remaining as inclusions in macrophages in a young scar tissue on the wound surface.. Changing of the hepatocytes out of surgery area were expressed in the increasing of the number of binuclear and mononuclear large polyploid cells. The process of tissue repair in the surgery area in the control proceeded similarly but distinguished by that it passed through a phase of purulent inflammation with the formation of microabscesses, perifocal purulent process around foci of necrosis.

5.2. Study of influence of Sulfacrylate on regenerative processes in the spleen during resection

Immediately after application of the Sulfacrylate adhesive composition, the polymeric film formed on the wound surface. The Sulfacrylate partially dissolved during preparation and appeared in specimens as a narrow layer of homogeneous, mildly oxyphilic mass. No reactive changes from tissue side of spleen on the use of Sulfacrylate observed.

3 hours after the operation with the use of Sulfacrylate, the white blood cells and red blood cells appeared on the wound surface. The necrotic zone and reactive reaction were formed from tissue side of spleen appearing as small focal hemorrhages. When adhesive was applied to the capsule, the leukocyte infiltration of subjacent tissues appeared. The sharply expanded venous sinuses, focal hemorrhages in the red pulp was observed in them (Fig. 7).

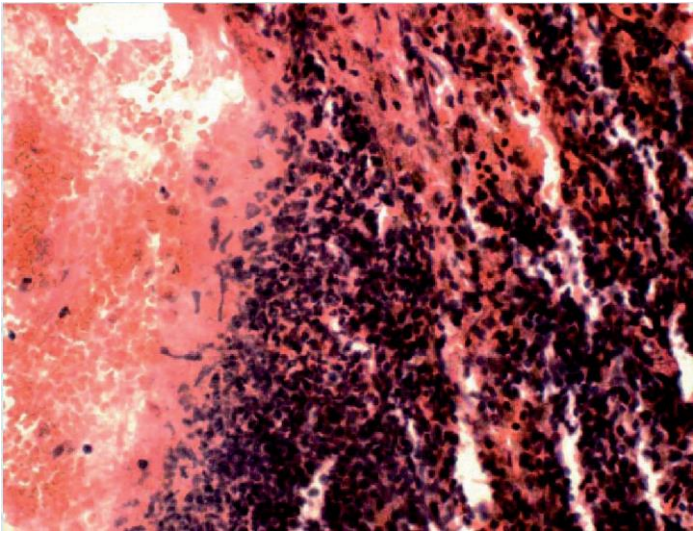


Fig. 7. *Rat spleen 3 hours after the resection and treatment of wound surface with Sulfacrylate. Hematoxylin and eosin staining. Magnification of 40x10*

1 day after surgery, the necrotic zone was clearly delimited from viable tissue, a poor polymorphcellular inflammatory infiltration was observed in spleen tissue adjacent to the adhesive layer. The hemorrhage area occurred on the boundary with viable tissue. The follicles in the necrotic zone were represented by a reduced number of cellular elements and mature white blood cells.. Follicles out of contact with the necrotic zone had the signs of hyperplasia (layered structure due to immature elements). The necrotic zone is formed in the subcapsular layer, in place of the adhesive contact with capsule similar to wound but smaller in width (Fig. 8).

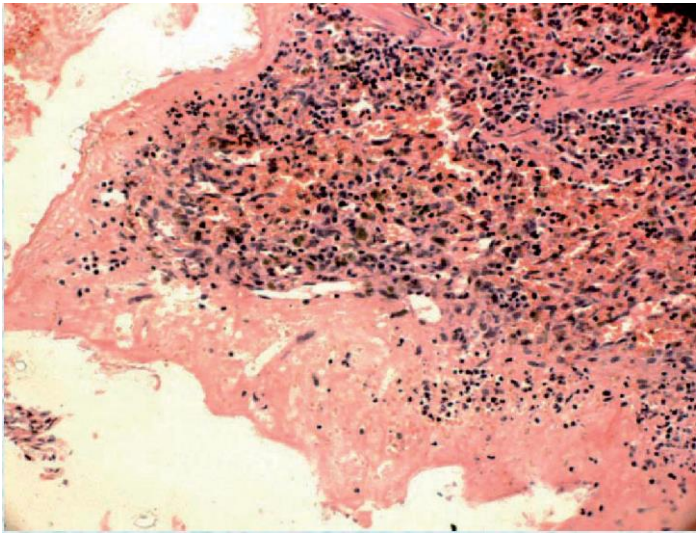


*Fig. **8.** Spleen tissue near the surgery area in a day after resection and treatment by Sulfacrylate.*
Hematoxylin and eosin staining. Magnification of 20x10

A week later, the specimens of experimental group using Sulfacrylate showed the initial signs of formation in the form of fibroplastic activity at the boundary of necrotic zone and viable tissue. The adjacent wound surface and adhesive in the spleen tissue had an abundant polymorphcellular inflammatory

infiltration. The large number of destroyed white blood cells were among the infiltrate cells.. Follicles were represented mostly by young lymphocytic series cells. The partial resorption of the adhesive occurred at this period of observation (Fig. 9).

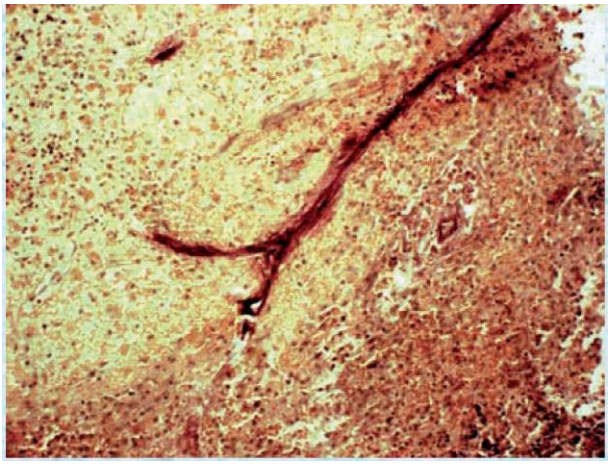


*Fig. **9.** Rat spleen 1 week after resection and treatment by Sulfacrylate. Van Gieson's staining. Magnification of 10x10*

A month later, the specimens of experimental group of animals showed the complete replacement of the necrotic zone by the fibrous tissue with the formation of scar tissue.. Lymphoid follicles were of normal structure (Fig. 10).

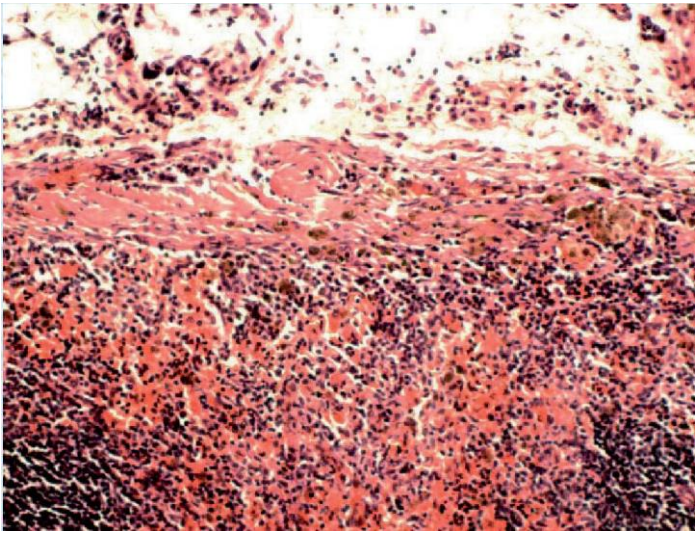


Fig. 10. *Rat spleen 1 month after resection and treatment by the Sulfacrylate adhesive. Hematoxylin and eosin staining. Magnification of 20x10*

Thus, the wound healing process after resection with the use of the Sulfacrylate adhesive and traditional suturing was accompanied by the scar formation. However the healing process in the control groups of animals passed through the stage of purulent inflammation microabscess formation..

5.3. Study of influence of Sulfacrylate on regenerative processes in the kidney during resection

The Sulfacrylate partially dissolved and appeared in specimens as a narrow layer of homogeneous, mildly oxyphilic mass, sometimes with an addition of unchanged red blood cells. No reactive changes from nephritic tissue side on the use of Sulfacrylate observed (Fig. 11).

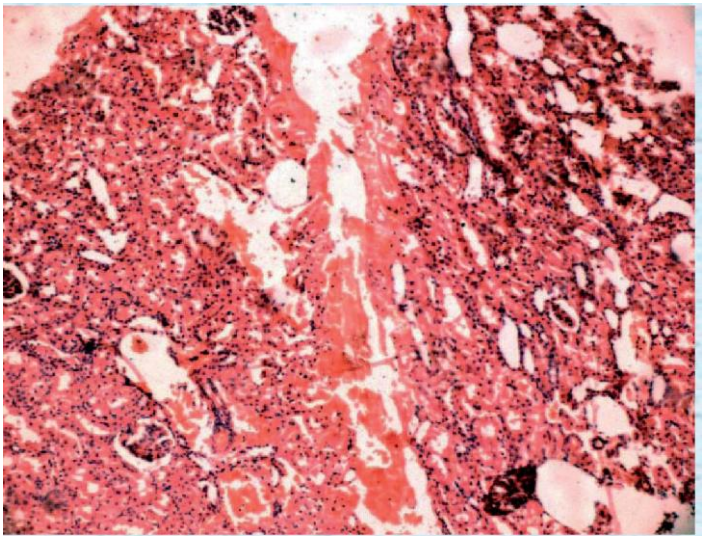


*Fig. **11.** Rat kidney tissue after dissection and bonding with the use of Sulfacrylate 0 hours Hematoxylin and eosin staining. Magnification of 10x10*

After 6 hours, the area of hydropic degeneration of the epithelial cells of excretory tubules is formed in the kidney tissue adjacent to the wound. Poor leukocyte infiltration is observed in the area of application of the adhesive. In some places, the adipose tissue is adjacent to the adhesive surface. The glomeruli and epithelium of the excretory tubules in the areas remote from the wound with signs of congestion (Fig. 12).

1 day after partial organ resection. The necrotic zone formed in the specimens of the experimental animals and delimited from the rest of tissue. The moderate polymorphcellular inflammatory infiltration was determined there in intratubular spaces. Glomeruli generally retained their structure.. Leukocyte infiltration at the boundary with the unchanged tissue is weak (Fig. 13).

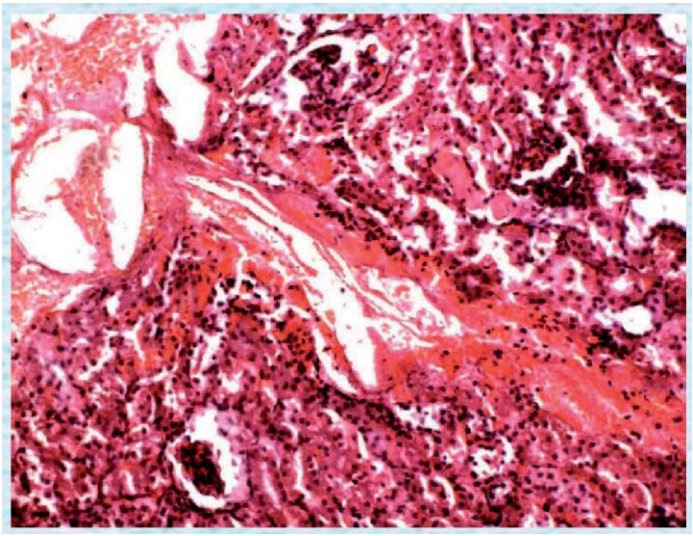


*Fig. **12.** Rat kidney tissue after dissection and bonding with the use of Sulfacrylate after 6 hours. Hematoxylin and eosin staining. Magnification of 20x10*

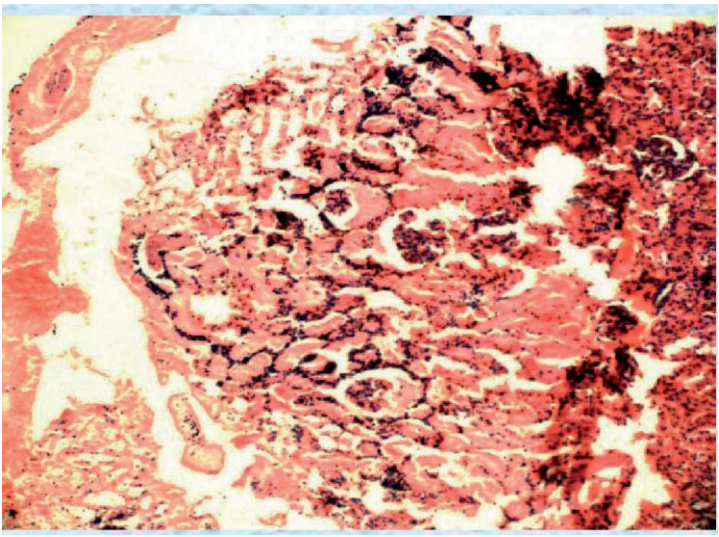


*Fig. **13.** Rat kidney after dissection and bonding with the use of Sulfacrylate after 24 hours. Necrotic zone at the surgery site. Hematoxylin and eosin staining. Magnification of 10x10*

A week later, the necrotic zone was more clearly delimited from the viable tissue. There were initial signs of the formation in the form of fibroplastic activity on the boundary of the damaged and normal tissue.. The partial resorption of the adhesive occurred. The adipose tissue adjacent to the wound, along with leukocyte infiltration, had a fibroplastic reaction with the proliferation of capillaries (Fig. 14).

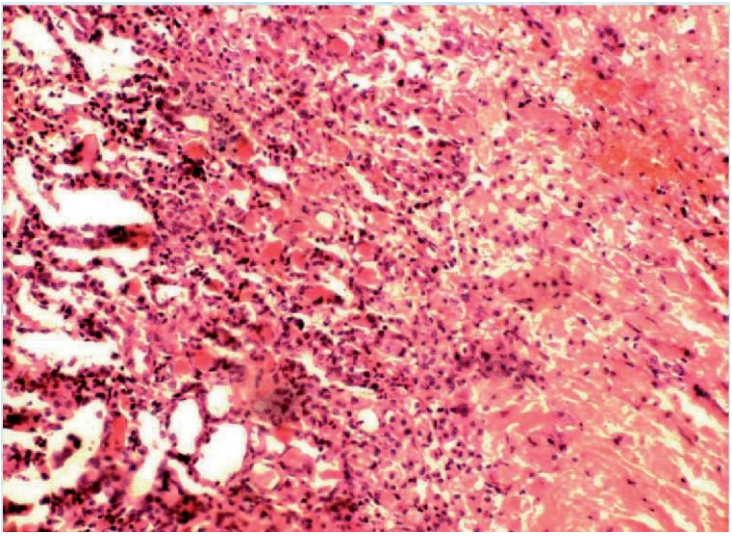


*Fig. **14.** Rat kidney after dissection and bonding with the use of Sulfacrylate in a week. Hematoxylin and eosin staining. Magnification of 20x10*

A month later, the wound area of the kidney with the use of the Sulfacrylate adhesive underwent fibrosis, the complete resorption of the adhesive occurred (Fig. 15).

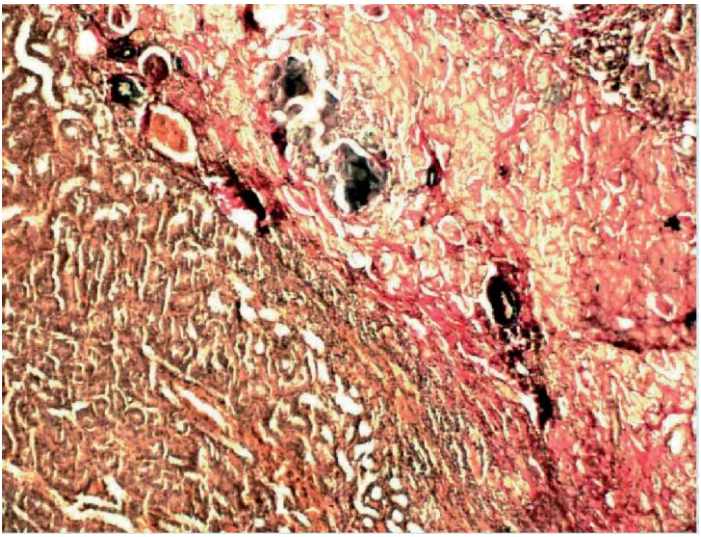


Fig. 15*. Rat kidney after dissection and bonding with the use of Sulfacrylate after 1 month. Van Gieson's staining. Magnification of 10x10*

5.4. The effectiveness of Sulfacrylate adhesive composition on the tissue in experiment for damaged parenchymal organs

The Sulfacrylate adhesive has good adhesion properties, is fixed to the wound surface in the form of a polymer film playing the protective and hemostatic role. The coagulation necrotic and aseptic inflammation zone is formed on the first day (from 3 hours). Coagulation nature of the necrosis prevents the development of secondary hemorrhages. Formation of the necrotic zone is due to a cytotoxic effect of Sulfacrylate and aseptic nature of inflammation is due to its aseptic properties. In the first week, the delimitation of the necrotic zone from the intact tissue occurred with a formation of fibrous scar, the final formation of which is completed by 1 month.

Injuries of parenchyma of the organs that were not treated by Sulfacrylate heal either without necrotic area or with necrotic area that subsequently heals through the purulence stage.

Benefits of Sulfacrylate use:

1. Fast and efficient primary hemostasis is achieved by formation of a polymer film on the wound surface..
2. The film has a protective function.
3. Restores the integrity of the damaged organ capsule properties by the adhesion properties of the adhesive film..
4. Performs the secondary hemorrhage prevention due to the coagulation nature of the necrosis of treated wound surface tissue.
5. Sulfacrylate having antiseptic properties provides an aseptic nature of the inflammatory response in the damage area.

6. USE OF SULFACRYLATE ADHESIVE COMPOSITION IN URGENT ABDOMINAL SURGERY TO ACHIEVE HEMOSTASIS OF WOUNDS OF PARENCHYMAL ORGANS IN CLINIC

6.1. Technique for the control of bleeding from liver wounds

Technique for the control of bleeding from the parenchymal organs consists of two stages: short-term crossclamping of afferent blood vessels or the local tissue compression allowing to provide a temporary control of bleeding from the wound surface. Then after draining a wound, a thin layer of the adhesive composition shall be applied for the shallow traumatic injuries up to 0.5 to 1.0 directly on the wound surface, at the same time the wound edges shall be quickly drawn together by the surgeon fingers and held in this position for 1.5 to 2.0 minutes. During this time, the vessel thrombosing in the damage area occurs, bleeding stops and the wound edges are bonded together tightly (Fig. 16).

*Fig. **16.** Treatment of shallow wounds of liver*

For the deeper injures when the large vessels and ducts are injured, the adhesive composition is used as an addition to hemostasis, which is achieved after the suturing and ligation of large vessels. Before ligature tying, the adhesive composition shall be applied to the surface of parenchymal organ along the wounds on Glisson's capsule. The film is formed on the surface of the Glisson's capsule of the liver, which prevents the filament cutting out when closing the wound edges. If necessary, an additional treatment of suture lines and puncture holes is performed by the biological sealant with an application of a thin film. This allows to create hermeticism along the suture line and prevent bleeding from the puncture holes (Fig. 17).

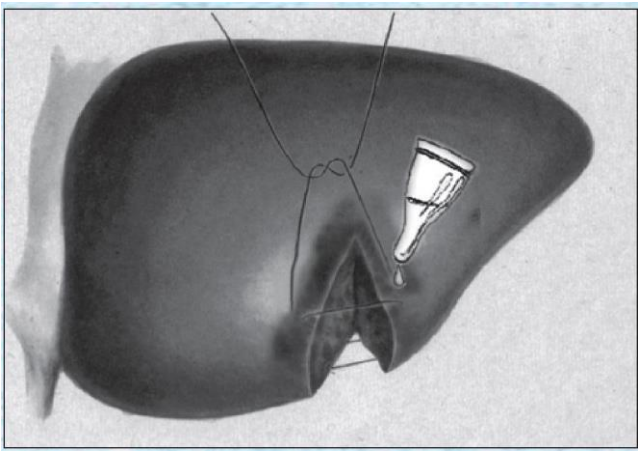


*Fig. **17.** Application of the adhesive composition on the Glisson's capsule of the liver to strengthen and seal the wound edges*

If necessary, the greater omentum strand shall be fixed to the wound surface area, i.e. the omentopexy is performed (Fig. 18).

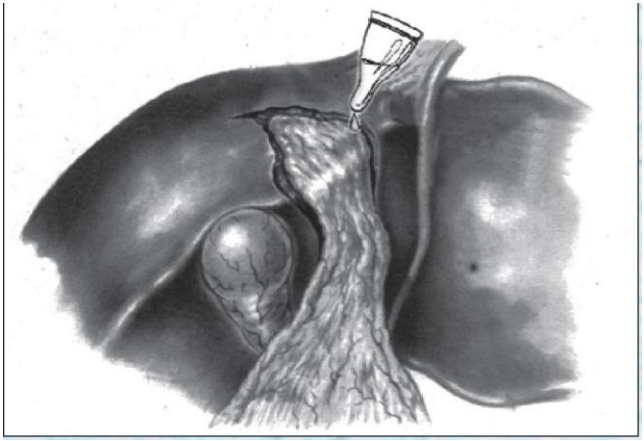


*Fig. **18.** The greater omentum strand is fixed in the wound surface area of the liver with the adhesive*

6.2. Hemostasis adhesive technology in liver wound suturing

In case of kidney traumatic injuries, the technique of use of the Sulfacrylate adhesive composition is identical to that used for traumatic injuries of the liver. The temporary hemostasis of kidney shall be carried out by crossclamping of the vessels near kidney pedicle.. The strand of greater omentum shall be fixed to strand of omentum the wound surface after bonding of organ fragments.. In case of extensive traumatic injuries of the organ when there is damage to the kidney cavity of superimposed stitches securing the edges of the wound, stitches processed line adhesive, when there is damage to the pelvicaliceal system of kidney, the sutures shall be put fixing the wound edges, the suture line shall be treated by the adhesive. The adhesive composition polymerizes to form a thin flexible film on the organ surface (Fig. 19).

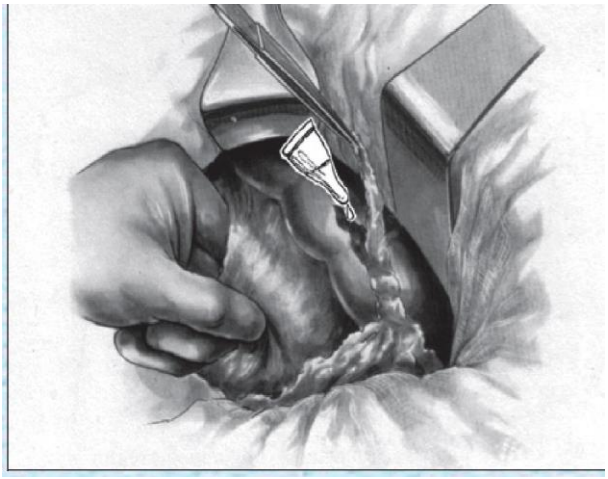


Fig. 19. *Treatment of the kidney wound with omentum fixation to its surface using the adhesive*

6.3. Adhesive technology used in the evacuation of subcapsular hematomas of parenchymal organs

6.3.1 Adhesive technology of the evacuation of subcapsular hematomas is performed in two ways.. In the presence of large opened subserous hematomas of the liver, gallbladder bed, spleen, kidney after revision of the hematoma area, an organ tissue in the treated area

shall be treated by the adhesive. It also fixes the some parts of the serous covering to the organ tissue.. Thus, the capillary hemostasis is achieved and the organ capsule is recovered.

6.3.2. In the presence of subcapsular hematoma, its puncture shall be performed, blood shall be evacuated and the adhesive shall be injected under the organ capsule. By compression of the capsule, the capsule shall be firmly fixed to the organ parenchyma by the swab. This technology prevents the secondary bleeding, bile oozing, purulence.

6.4. Adhesive hemostasis in the removal of parenchymal organs

The final control of bleeding within the bed of the removed organs in some cases is associated with technical difficulties due to the presence of capillary bleeding. The most typical is an option of the injured spleen removal, when there was a hematoma in the area of the portal and bleeding, which arose in case of exposure and intersection of ligamentous apparatus. The adhesive composition shall be applied drop by drop from the tube to the bleeding areas within: cupula of the diaphragm, spleen bed and hilum, on the tail of pancreas area. The reliable hemostasis occurs within 1-2 minutes.

6.5 Adhesive sealing of small pancreatic ducts

The technique is used in patients undergoing surgery for damage of the body and tail of pancreas. In the hematoma area, the posterior peritoneum shall be incised, the blood and accumulated fluid shall be evacuated. In case of visible tear of the gland parenchyma, an individual sutures shall be put by atraumatic needle with a thread of 3/0, 4/0, the wound shall be dried by drape and then the adhesive shall be applied on the suture area and wound surface that polymerizes after penetrating into the damaged ducts with a creation of a flexible film over the damage area. The adhesive omentopexy with a free omentum flap is effective in case of gland capsule defect. Using a similar procedure it is possible to bond hermetically the small pancreatic ducts of the pancreas of up to0, 5 mm (Fig. 20).

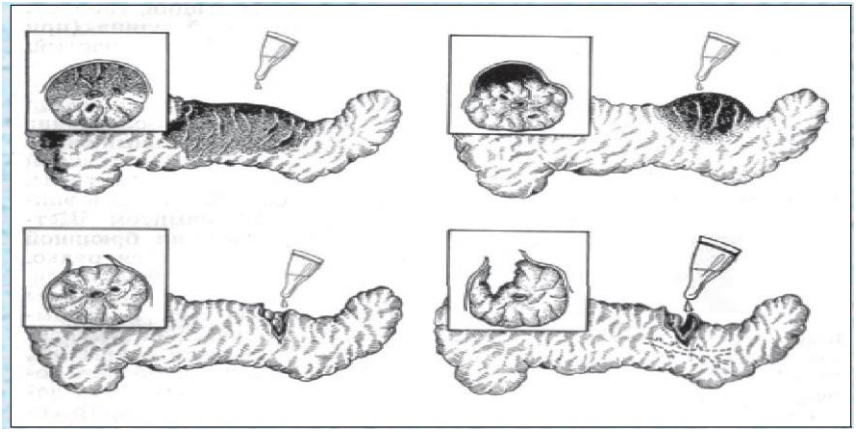


Fig. 20. *Hemostasis and sealing of the small pancreatic ducts in different damage options*

7. USE OF NEW SULFACRYLATE ADHESIVE COMPOSITION IN ABDOMINAL SURGERY FOR OPERATIONS ON HOLLOW ORGANS

7.1. Biological model of sutureless connection of intestinal loops with the use of Sulfacrylate

• The cross-section specimens of the bonded small intestine loops of the rat were studied immediately after treatment by the adhesive and fixation of bonded surfaces with an immediate and long-term follow-up.. When applying the adhesive composition to the bonding serous covering, a thin flexible film was formed. At the initial stage of the experiment, the edema was found in the serous membranes of the combined intestine loops after bonding with the Sulfacrylate adhesive, between the sheets of mesothelium on the background of delicate basophilic reticulated substance of fibrin strands. The intestine loops were securely fixed to each other.

After three hours, the changes appeared in the serous membranes of the intestinal loops corresponding to the early stage of exudation phase: plasmorrhagia and loosening of mesothelial cover, appearance of single lymphocytes and plasma cells. The individual

specimens noted the emerging division of the modified serous membrane into layers with directly contacting surfaces. These layers were thicker and optically more dense.. The concentration of cellular elements in them was higher than in a loose layer located closer to the muscular layer (Fig. 21).

Six hours after the start of experiment, almost all fragments studied in the thickened serous membrane noted the fibrin fiber orientation in the plane corresponding to the longitudinal axis of the intestine (possibly connected to, among other, the artificial changes). In some fields of view, the synechiae or intersections were observed formed between the serose sheets and bridged one intestinal wall with other that consisted of delicate collagen fibers, fibrin, fibrocytes, small number of histoid cells scattered between them (Fig. 22).

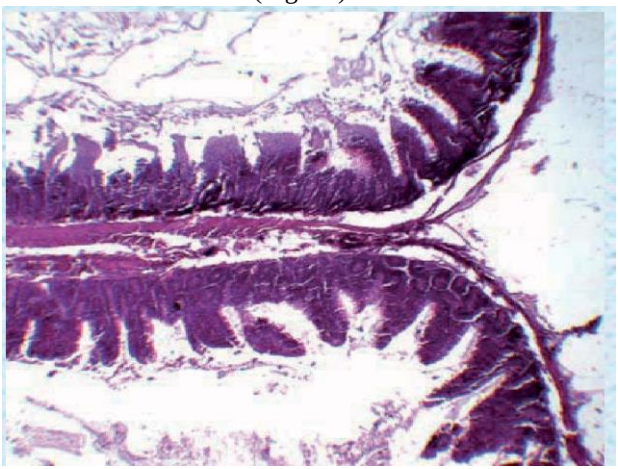


*Fig. **21.** Bonded rat intestine loops after 3 hours. Hematoxylin and eosin staining. Magnification of 10x10 **

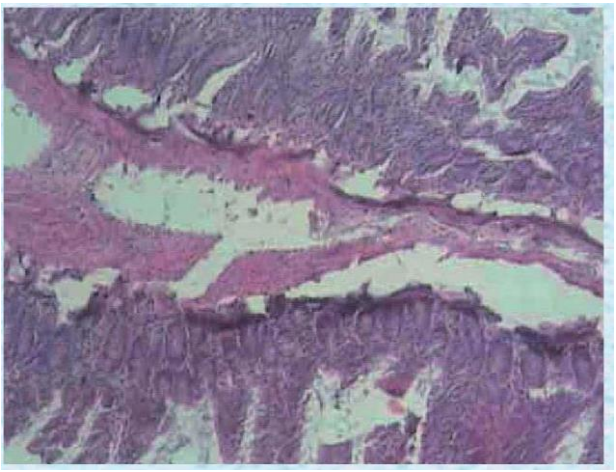


*Fig. **22.** Bonded intestine loops 6 after an application of the Sulfacrylate adhesive. Hematoxylin and eosin staining. Magnification of 10x10*

After 24 hours, more pronounced collagen structures appeared between the sheets of serous covering. The intersections between the sheets noted previously compacted gradually bringing together the fragments of the intestine (Fig. 23).

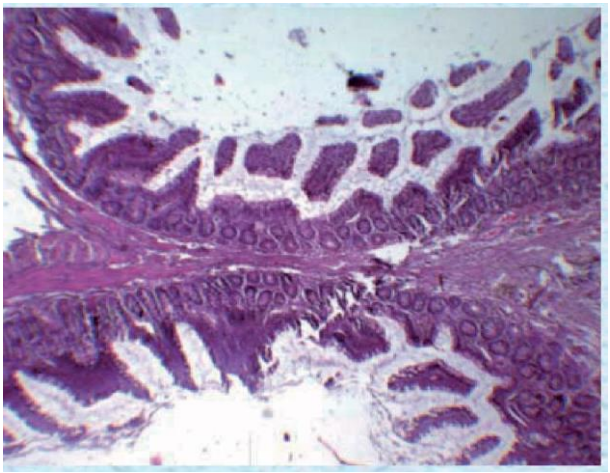


*Fig. **23.** Bonded intestine loops after 24 hours. Hematoxylin and eosin staining. Magnification of 20x10*

A week after the start of experiment, the adhesive application area had the quite dense connective tissue fibers.. The bonding zone edges of intestine loops noted the presence of granulation mass with the formation of blood vessels.. The structure of granulation tissue had a large amount of macrophages with vacuolated cytoplasm, which absorbed the adhesive mass. Well-shaped capsule is visible on top of granulation tissue (Fig. 24).

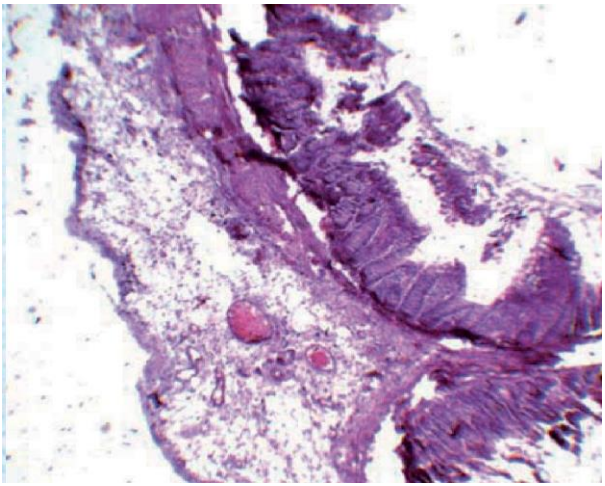


*Fig. **24.** Intestinal loops bonded together a week later.. Hematoxylin and eosin staining. Magnification of 20x10*

Three months after the start of experiment, the intestine function was preserved in all cases, no macroscopic changes (abnormalities of lumen diameter, wall thickness, nature of the mucous membrane) were found. Complete closure of the intestine loop surfaces was determined in the test material with an intestine wall thickness tending to a single value of each of them. Serous membrane in the area of adhesion of intestinal loops was not found.. Lithesome cover in the corners between adjacent portions of the intestine forms a callous, excessive proliferation of loose connective tissue with newly formed blood vessels, scattered lymphoid and histoid cells,

macrophages. Macrophages were intensely filled with small basophilic granules that were also found extracellularly. They were diffusely scattered in the newly formed connective tissue (Fig. 25).

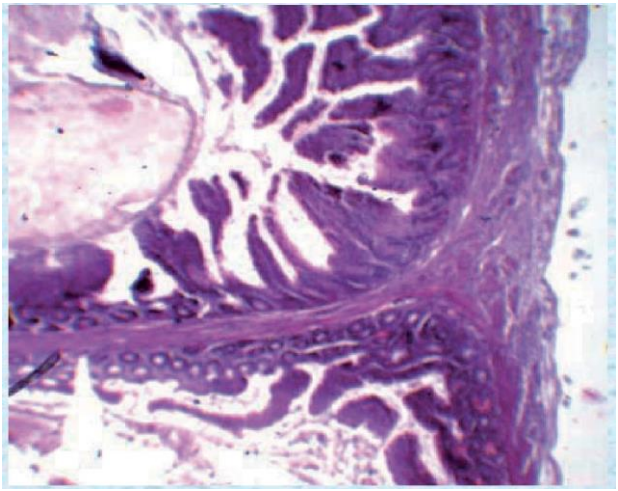


Fig. 25. *Bonded intestine loops 3 months after the start of experiment. Hematoxylin and eosin staining. Magnification of 20x10*

The visible features of the inflammatory reaction in the small intestine were caused by visible physical and chemical properties of the adhesive composition: active chemical adhesive agent and bactericide additives. The duration of chemical attack was limited to the time of polymerization of the adhesive and therefore the changes in the intestinal wall are located only in the serous membrane.. The duration and severity of the phases of inflammation were determined by the scale of destruction process after occurrence of a chemical burn during that short period

7.2. Morphological study of intestinal anastomoses using the Sulfacrylate adhesive in experiment

The use of the adhesive composition Sulfacrylate adhesive composition has made it possible to create a tight closure of the cut edges of the intestine wall, fast deployment

and special progress of the exudative inflammation phase, no expression of alternative reaction of muscle and serous layers of the intestinal wall. At this stage of the experiment, the robust biological sealing of the intestinal suture was achieved: no symptoms of peritonitis, adhesions, and synechiae with adjacent organs. Microscopic examination revealed no signs of a significant hemorrhagic impregnation of tissue as the consequences of post-operative trauma. The lumen of blood vessels was narrowed lymphatic vessels were not visible. Non-uniform density of the tissue structures was observed: their compression and flattening around the suture material, some looseness of free fragments of the intestinal wall (Fig. 26).

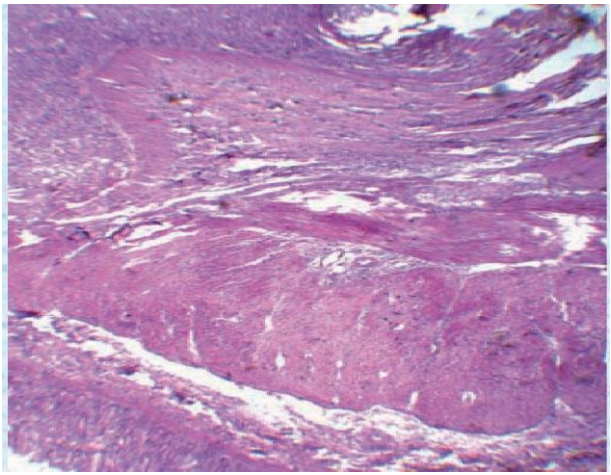


*Fig. **26.** Intestinal anastomosis with the use of an adhesive after 12 hours Hematoxylin and eosin staining. Magnification of 10x10*

On the sixth day of the experiment, the intestine edges were still tightly connected, the uniform diffusive loosening of muscle fibers was observed in a muscle layers due to both accumulation of interstitial fluid and the extended lymphatic and small venous vessels; small clusters of red blood cells around venules and small veins. The neutrophilic

were observed in tissue, the infiltration was insignificant, diffuse. The mucous membrane of that period had no expressed necrobiotic changes , with slightly more loose stroma, shorter fibers.. Serous membrane was thickened due to edema and dilated lymphatic vessels.. The stasis of blood in the capillaries and venules near the areas of injury by suture material. The macrophages and histiocytes appeared in the connective tissue (stroma of mucosa, submucosa of intermembrane interlayers) (Fig. 27).

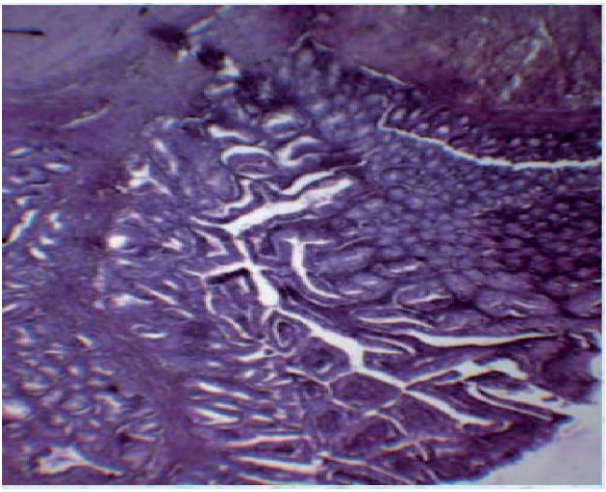


*Fig. **27.** Intestinal anastomosis with the use of an adhesive after 12 hours . Hematoxylin and eosin staining. Magnification of 10x10*

On 30 day, there was no sign of damage to the intestinal wall, all its layers were clearly traced. Focal lymphohysteocytic infiltration preserved, mainly between the layers and near the suture material. Subperitoneal layer had granulation tissue between the preserved tissue of intestinal wall that was presented by the newly formed vessels in very loose, small cell stroma (Fig. 28).

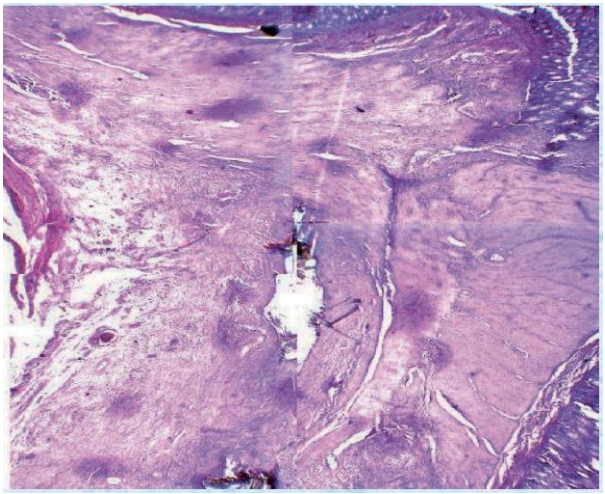


Fig. 28. *Anastomosis on day 30 of the experiment when using suture-adhesive bonding. Hematoxylin and eosin staining. Magnification of 10x10*

7.3 Study of the strength of intestinal anastomoses in experiment

An example of the strength of intestinal anastomoses is the experiment that made it possible to determine the tightness of the different options of anastomosis.

Table 1

"Strength" parameters of the different options of intestinal anastomosis in experiment

No.	**Options of intestinal anastomosis**	n	**M±m**	P			
				P1-P2	P1-P2	P2-P4	P3-P4
1	End-to-end, single-row suture, + adhesive film	5	44.0±1.9	<0.01	<0.001	<0.001	<0.01
2	End-to-end, single-row suture, + no adhesive	5	37.6±1.1				
3	End-to-end, double-row suture, + adhesive film	5	73.8±3.1				
4	End-to-end, double-row suture, + no adhesive		66.0±2.0				

The highest strength margin was noted for the two-row suture anastomosis with the adhesive composition.. The value difference was highly significant indicators both for the control (P3-P4 < 0.01), and or the anastomosis made by the one-row suture with an adhesive coating (P1-P3 < 0.001). The Sulfacrylate adhesive composition strengthened single-row suture anastomosis as evidenced by the difference between the experiment and control (P1-P2 < 0.01) creating the hermeticism in the anastomosis area.

8. USE OF NEW SULFACRYLATE ADHESIVE COMPOSITION IN CLINICAL PRACTICE IN ABDOMINAL SURGERY

The indication for the use of biological adhesives for the injury of hollow organs can be a damage of small and large intestine, stomach, bladder, urethra. A special feature of the hollow organ damage is a formation of defects with zones of primary and secondary traumatic necrosis.. Wound area have in this case the nature of lacerated, tear-contused wounds for a blunt trauma and slash wound for stab wounds. The pathological process during abdominal injuries of the hollow organs usually proceeds under conditions of peritonitis, so the thread itself is exposed to infection during suturing creating the conditions for an inflammatory process, possible cutting of the sutured organ wall and suture failure. This situation deprives the surgeon 100% confidence in the primary healing of the damage area. Adhesive technology allows to avoid such complications. Sulfacrylate substantially prevents the trophic disorders in the damage area due to its physical and chemical properties.

Enterocleisis during the intestine resection and anastomosis creation with no peritonitis poses a hazard and facilitates an infection of the peritoneum in the surgery area because the organ lumen is opened. Suturing through all layers of the intestinal wall

infects the thread and therefore the whole wound tract, through which it passes during the tissue suturing. Moreover, it is particularly pronounced in conditions of peritonitis: a surgeon operates continuously in an infected field, aseptic thread is infected during use. Sealing of the suture line and puncture holes by the adhesive composition makes it possible to prevent such complication.. It should be noted that the options of the anastomosis sealing of intestine and perforated hole suturing portions with the use of a biological adhesives are used as a prevention of suture line disruption and formation of adhesive process in this area because the film isolates the suture area and make prosthetic appliance for pathologically changed serous covering of the peritoneum.

8.1. Use of adhesive technology during bowel resection

This surgery is usually performed for intestinal obstruction complicated by loop necrosis, necrotizing enterocolitis, destructive diverticulitis and ileal duplication cyst in most cases complicated by purulent peritonitis, which greatly increase the weight of the postoperative period due to severe microcirculatory disturbances in the intestinal wall and body intoxication. In this situation, there is a high risk of anastomotic leak.. Using the adhesive technology it is possible to reduce significantly the incidence of complications during surgery on the intestine, in particular during suturing of perforated holes and enteroenterostomy for the intestinal anastomosis. The use of adhesive technology allows to achieve an intestinal anastomosis in two options (Fig. 29 A and B).

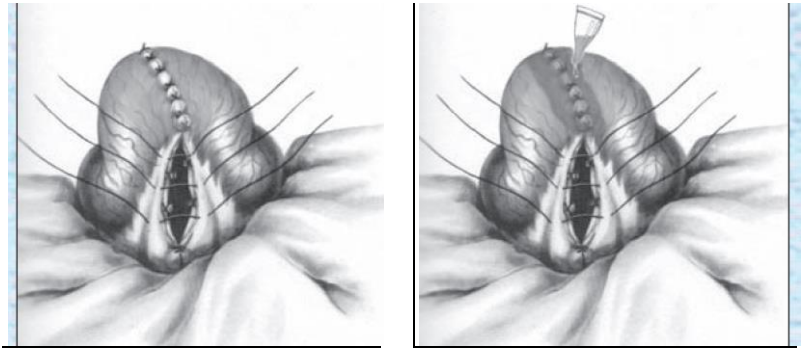


*Fig. **29.** Stages of double layer anastomosis using adhesive*

8.1.1. If edema or inflammatory changes occur in the intestine beyond the resected area in the zone of normal tissue after the creation of the end-to-end anastomosis by two-row suture, the adhesive composition is applied in the form of a thin strip that covers the serous intestinal covering proximal and distal of anastomosis in the range of 1.5 to 2 cm. This facilitates not only sealing of the sutures and puncture holes contacting with the bowel lumen but the prosthetics of changed serous peritoneum covering in the area of anastomosis. The adhesive film strengthen the anastomosis area and bactericidal properties of the adhesive can reduce the inflammatory response (Fig. 30).

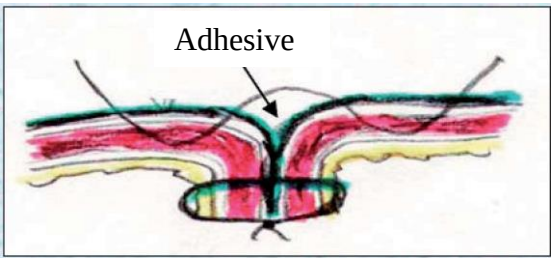
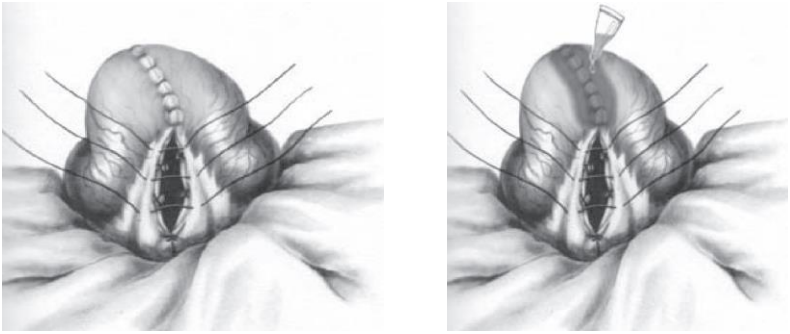


*Fig. **30.** Scheme of application of the Sulfacrylate adhesive composition in the area of double layer intestinal anastomosis*

8.12. The second method is used for less expressed changes of anastomosed bowel segments.. In this case, the adhesive was applied only along the anastomosis line to seal the gap between the segments of the intestine and puncture holes.

Both options provide the tightness of the anastomosis created by filling with adhesive the narrow space between the walls of the anastomosed loop and puncture channels and holes. Clinical data confirm the reliability of sealing of the created anastomosis.

Reliable fixation and quality sealing of intestinal anastomoses make it possible to achieve successfully single-layer intestinal anastomoses in patients of different age groups, including infants (Fig. 31, 32).



1 **B**

*Fig. **31.** Steps for single-layer anastomosis using adhesive. A: single-layer intestinal anastomosis is created. B: use of the Sulfacrylate adhesive composition to seal and strengthen the anastomosis*

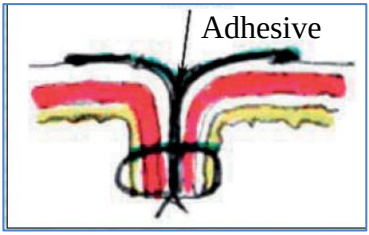


*Fig. **32.** Scheme of distribution of the Sulfacrylate adhesive composition applied in the area of single-layer intestinal anastomosis*

8.2. Use of adhesive technology for Peritonization of defects of parietal and visceral peritoneum

This method is used mostly during decollement surgery when deseroused areas of the intestine loops occurs. The adhesive composition is used in deseroused areas, of the intestine loops to strengthen its walls in the form of application of the adhesive film applied in a thin layer on the surface of intestinal deseroused areas. This creates the optimal conditions for tissue regeneration, prevents the possibility of failure of the intestinal wall and promotes, through the inclusion of the anti-flammatory components, the elimination of the inflammatory process in the wall of the hollow organ and provides the prevention of adhesion formation (Fig. 33).

Fig. 33*. Treatment of the intestine deseroused areas by adhesive*

8.3. Use of adhesive technology for suturing suturing of the perforated ulcer of the stomach and duodenum

Suturing of perforated holes in the stomach in the presence of the expressed perifocal inflammation and infiltration of the wall creates certain technical difficulties in suturing. It creates a high risk of suture failure development.. Due to the rigidity

of tissues, there is not possible to provide a reliable sealed closure of edges and the suture cutting out occurs during ligature tying. It is particularly difficult for the localization of ulcers in the pyloric segment area since the cicatrical stenosis may develop in double-row suturing of perforated hole. This process is exacerbated by trophic disturbances in the ulcer area due to microcirculation disturbances that can also lead to the suture failure. The presence of peritonitis creates a number of problems during surgery. In this case, the adhesive (Fig. 34.) is used to prevent suture failure due to presence of a large infiltration area around the perforated hole. The proximity of the pylorus create a hazard of the pyloric stenosis development. In addition, the complexity of the sealed seam is associated with a small tissue volume, especially in young children.

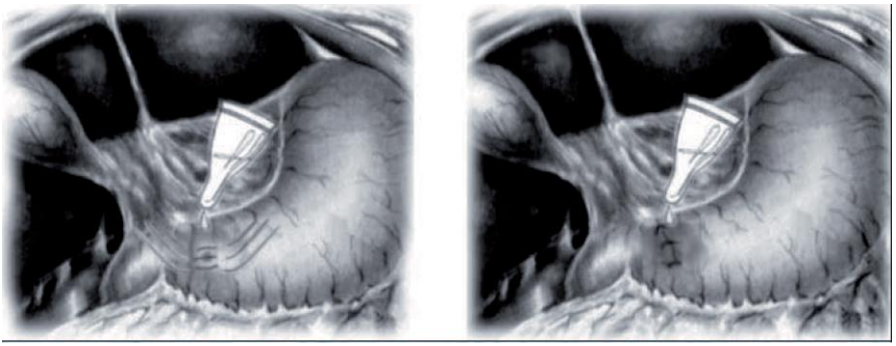


*Fig. **34.** Options of the adhesive use for suturing of the perforated ulcer of the stomach. . A: the adhesive is used to strengthen the wound edges in the presence of expressed infiltration.. B: adhesive treatment of the suture line*

8.3.1. Method of peritoneum adhesive treatment to strengthen the ulcer edges. Film formation prevents the cutting out of infiltrated tissue (Fig. 34 - A).

8.3.2. The method of suture strengthening and additional sealing in the suturing area. The adhesive composition is applied in the suture area after ligature tying that creates a protective film (Fig. 34 - B).

8.4. Use of Sulfacrylate adhesive composition during appendectomy surgery for complications of acute appendicitis

The application of the Sulfacrylate adhesive composition is reasonable to use in a typical appendectomy when the surgeon has difficulty with dipping of necrotizing vermiform appendix stump in the purse-string suture, or the presence of perforated hole at its base. It occurs in infiltrative or phlegmonous typhlitis. Such changes do not guarantee a smooth postoperative course. The following adhesive technology is used for the prevention of postoperative complications.

8.4.1. Creation of the hermeticism of the vermiform appendix stump and its dipping area in the purse-string suture with the use of adhesive

After an appendectomy and vermiform appendix stump formations, a drop of adhesive is introduced into the stump lumen (Fig. 35).

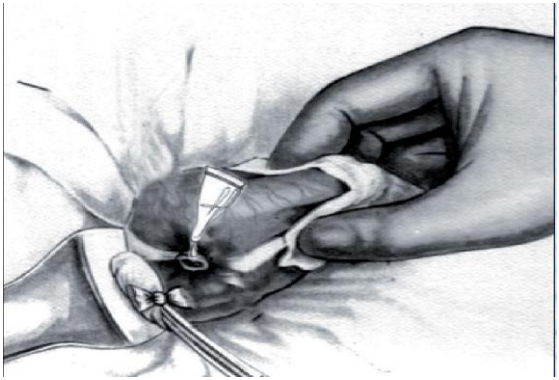


*Fig. **35.** Adhesive treatment of the vermiform appendix stump*

8.4.2. In case of perforation of the appendix at the base, the latter is cut off, its anastomosis with the intestine anastomosis and perforation area

are sutured with a double-row suture followed by adhesive treatment of serous covering along the suture line.

8.4.3. In the presence of abscess typhlitis, the adhesive is applied on most damaged areas of the blind colon to create a delicate aseptic protective film.

8.4.4. If there are areas suspicious for the possibility of abscess formation or necrosis then they are sutured with a seromuscular sutures followed by treatment with an adhesive.

8.4.5. If there is no confidence in purse-string suture due to the expressed inflammatory process in the head of blind colon, the adhesive composition is applied as a thin adhesive film on the head of blind colon after tying the purse-string suture (Fig. 36).

Fig. 36. Treatment of the head of blind colon after applying the purse-string suture

Adhesive technology can achieve sealing of suture on the hollow organ of the gastrointestinal tract, thereby isolating the source of microflora from the free abdominal cavity. In addition, the adhesive area creates an aseptic environment taking into account its antimicrobial properties and prevents the development of adhesive process.

8.5. Use of adhesive in the surgery for strangulated inguinal hernia

Indications for the use of adhesive is the large diameter of the hernia sac neck, inflammatory changes of the sac itself and the surrounding tissue during prolonged period of strangulation. In these cases, the adhesive is applied to the hernia sac neck ligation area for complete hermeticism or on the parietal peritoneum suture line if it was dissected for herniolaparotomy (Fig. 37).

Fig. 37. The use of the adhesive composition for herniotomy to strengthen the sutures

8.6. Use of adhesive technology in plication of small intestinum

Bonding of peritoneal sheets on a large surface. This adhesive technology is used, if necessary, to fix the fragments of the intestine to the parietal peritoneum in case of displacement of organs of the abdominal cavity. For example, for Ladd's syndrome, mobile cecum, for exteriorization of the fistula-bearing intestine segment, when there is a need to fix the intestine loops and protect the abdominal cavity from the effused intestinal

contents. In addition, the fixation of intestinal loops together or with parietal peritoneum is used in the separation of large mass of adhesions or for plication of small intestinum (Fig. 38).

*Fig. **38.** Option of intestinal loop bonding together*

In this case, after obtaining the desired anatomical position of organs in the abdominal cavity, the adhesive is applied in the form of a thin spreading film to the peritoneal covering in the area of necessary fixing. 1-1.5 minutes later, the intestinal loops are tightly fixed together by the peritoneal covering.

8.7. Adhesive technology for treatment of stump cut in omentum resection

The indication for the omentum resection can be a destructive omentitis. The remaining stumps create a risk of continuation of the destructive process and can serve as a mass of adhesions place of formation. Taking into account the features of the adhesive composition, the following technology is used to prevent these complications: a strand of omentum is ligated by thin ligature with one knot, the omentum stump is treated with an adhesive, then the strand end is screwed with the strand cut inward and ligated again with the same ligature (Fig. 39).

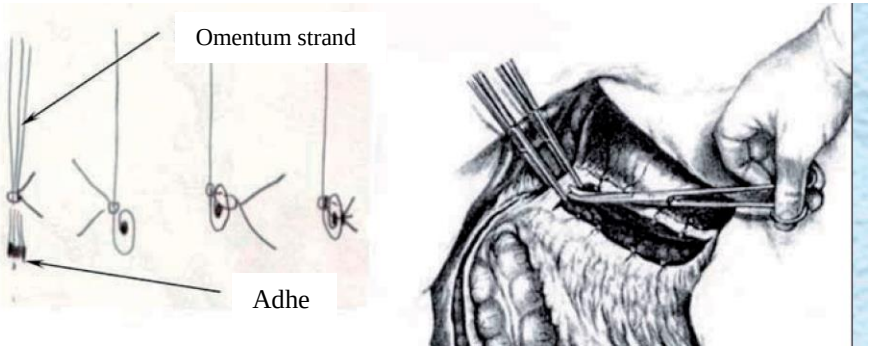


Fig. 39. *Methods of omentum strand treatment during the omentum resection under a destructive omentitis. A: surgery technique, B: result of the use of adhesive technology.*

8.8. Use of adhesive technology in reconstructive surgery of the biliary tracts

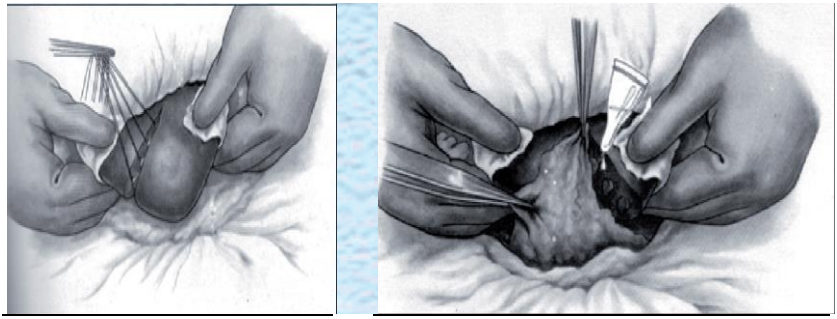
When performing reconstructive surgical interventions on the biliary ducts, it is very important to ensure a reliable seal of anastomosis areas due to the anatomical complexity and inconsistency of diameter of the sutured anatomical structures and small diameter of ducts.. In some cases, the anatomic features do not allow to create a double-layer anastomosis because of the possibility of stenosis development. The use of the adhesive composition allows to create a reliable hermeticism in the anastomosis area with a single-row suture. Such surgical interventions are possible only when performing reconstructive surgery of the biliary tracts: choledochotomy, various kinds cholangiojejunal and choledochojejunal anastomoses. The use of adhesive avoids setting drainage systems, facilitates care for patients in the postoperative period, reduces the duration of hospital stay.

The method of application is similar to the use for intestinal anastomoses. The adhesive composition is applied in the form of drop on the anastomosis area. When spreading the adhesive on the surface along the anastomosis line,

the adhesive polymerization proceeds forming a thin flexible film, which is firmly fixed to the tissue, securely closing the puncture holes and anastomosis line.

8.9. Use of adhesive technology during hepatic resection

Liver resection is mostly performed for the parasitic, neoplastic diseases, cirrhosis of the liver. During the organ resection, the surgeon comes in contact with the major blood and biliary vessels, the control of bleeding and bile leak from which is carried out by ligation. But there are still small vessels, creating the effect of capillary bleeding and capillary outflow of bile. In this situation, the application of the adhesive composition on the wound surface allows to stop capillary bleeding and biliary drainage. The use of the adhesive eliminate the necessity to use the tampons and drains. The postoperative period proceeds more favorably. The patient hospital stay is reduced (Fig. 40, 41).



1 **B**

Fig. 40. *A: phase of ligation of large vessels in the liver resection.*
B: treatment of wound surface by adhesive for capillary bleeding control and omentum fixation

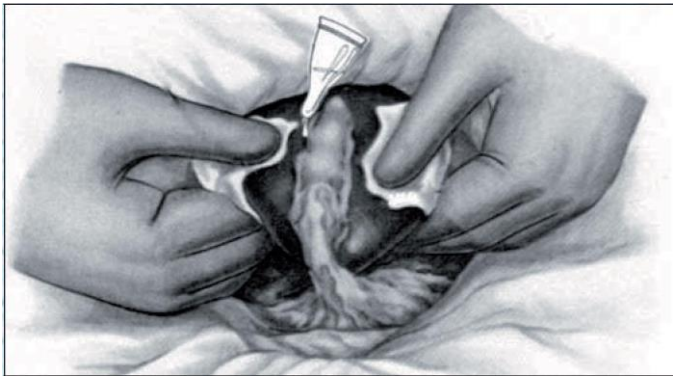


Fig. 41. *Omentum fixation to the Glisson's capsule*

8.10. Use of adhesive technology during cholecystectomy

During cholecystectomy, loose type of blood supply to the gallbladder and abnormally located small biliary ducts coming off into the lumen of the gallbladder directly from the liver create some difficulties for the surgeon. Hemostasis and ligation of vessels in the area of gallbladder bed may be not sufficiently effective. The use of the Sulfacrylate adhesive composition after draining gallbladder bed by applying a thin layer of biological sealant creates a reliable hemostasis and stops bile leak. The use of adhesive technology ensures not only the reliable final hemostasis but its use is related with a reliable obturation of abnormally located small biliary ducts, it allows to complete the surgery without setting drains, greatly facilitates the condition of patients in the postoperative period, reduces the treatment period (Fig. 42).

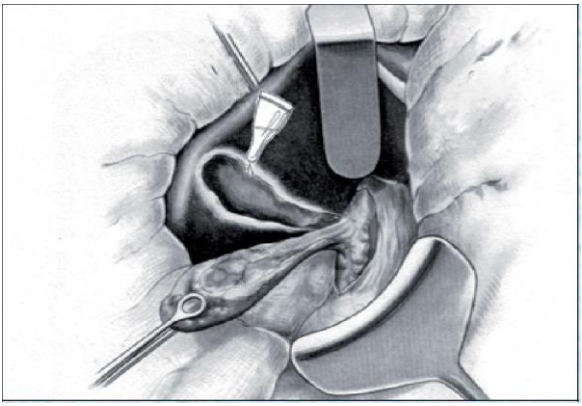


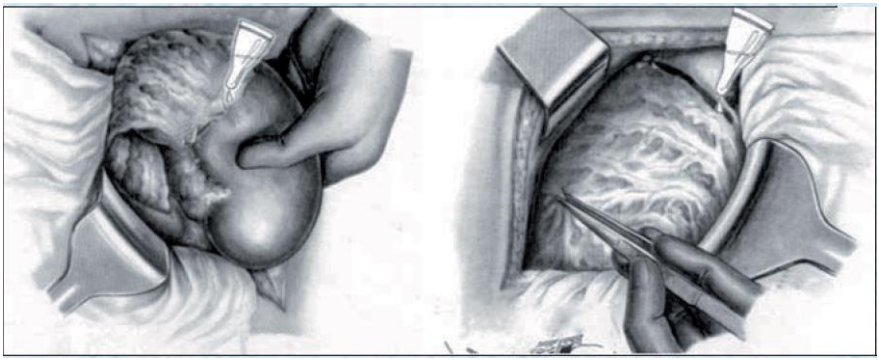
Fig. 42. *Application of the adhesive in cholecystectomy for the treatment of gallbladder bed.*

8.11. Use of adhesive technology in splenectomy

During splenectomy, especially in the presence of the expressed perisplenitis when the organ is closely matted with the posterolateral surface of the parietal peritoneum and the tail of pancreas is located in the splenic hilum, the removal of the latter may be accompanied by significant bleeding. If the electric coagulation and ligature hemostasis are ineffective, then the application of the adhesive composition by means of application of the biological adhesive Sulfacrylate on bleeding sites allows to achieve complete hemostasis.

8.12. Use of adhesive technology in removing non-parasitic cysts of parenchymal organs

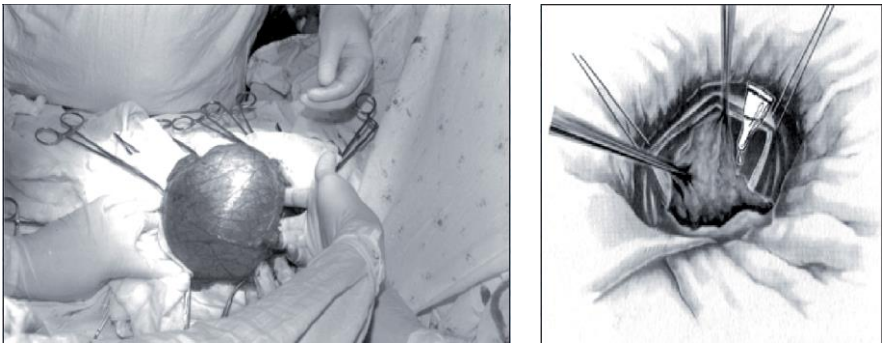
It is advisable to perform conservative surgery for this category o the patients. The use of adhesive technology for the cysts of kidneys, spleen makes it possible to perform successfully the surgery with additional omentorenopexy, omentosplenopexy, omentohepatopexy. Omentopexy leads eventually to the formation of omentoorganoanastomoses improving the blood circulation in the surgically operated organs (Fig. 43).



1 B

*Fig. **43.** A: adhesive omentorenopexy. B: adhesive omentohepatopexy*

The contents is removed after opening of the cystic cavities. Bleeding sites are treated with adhesive, the hemostasis is performed. Then the cyst cavity is lined by the strand of the greater omentum, which is fixed with adhesive to the inner walls of the cyst and then to the capsule of the operated organ. During the omentopexy, the adhesive shall be applied between the omentum and organ batchwise for adhesive spreading in a thin layer without repository formation. In this case, the reliable fixation of the omentum is achieved (Fig. 44).



1 **B**

*Fig. **44.** The use of adhesive technology in the removal of the spleen cyst*

8.13. Use of adhesive composition in surgery for Wilkie disease

There are several options of adhesive technology.

8.13.1. - for sealing duodenojejunal anastomosis sutured with a, single-row suture;

8.13.2. - for the adhesive fixation of adducting jejunum above anastomosis to the wall of the duodenum, for the prevention of intestinal loop kink in Robinson surgery;

8.13.3. - for treatment of stumps of the dissected dense, well vascularized adhesions;

8.13.4. - adhesive of pulled-through duodenojejunal kink to the subjacent tissues during Strong operation.

The use of Sulfacrylate achieves an absolute hermeticism in the anastomosis area with minimal edema and small manifestations of inflammatory tissue reaction.

The treatment of dissected adhesion stumps provides good hemostasis..

Adhesive fixation of the intestinal loop make it possible to avoid secondary organ displacement.

8.14. Use of adhesive composition during stomach surgery

Adhesive technologies are successfully used in the gastric resection by different methods with the creation of gastrojejunal anastomoses and performance of gastrotomy.

8.14.1. Technology of the stomach wall suturing with the use of adhesive: First option: - subserous suturing of the mucosa, submucosal and muscle layers by interrupted sutures with knots inward the hollow organ, the suture line is treated with adhesive. Then the serous membrane is sutured by interrupted sutures with a non-traumatic thread.. Thereafter,

a thin adhesive layer is applied by spreading a drop; this creates a flexible adhesive film from the serous covering reliably preserving the hermeticism in the suture area.

Second option: - stomach wall suturing is performed by creating of a first continuous suture line, then the adhesive composition is applied on the suture line with making interrupted seromuscular sutures.

Third option of the stomach wall suturing is possible in application of the adhesive composition just over the second suture line.

8.14.2. The use of adhesive technology during surgery on the stomach wall (subserous cysts)

The cyst is enucleated after dissection of serous covering of the muscular layer without breaking the submucosal and mucosal layers. The sutures were put on muscles and serose without tying after its removal to eliminate the residual cavity. Then the adhesive composition is applied to this area, the sutures are tied. The residual cavity is not formed according to this method. The edges of the wound are well matched. If necessary, it is possible to apply the adhesive on the suture line (Fig. 45).

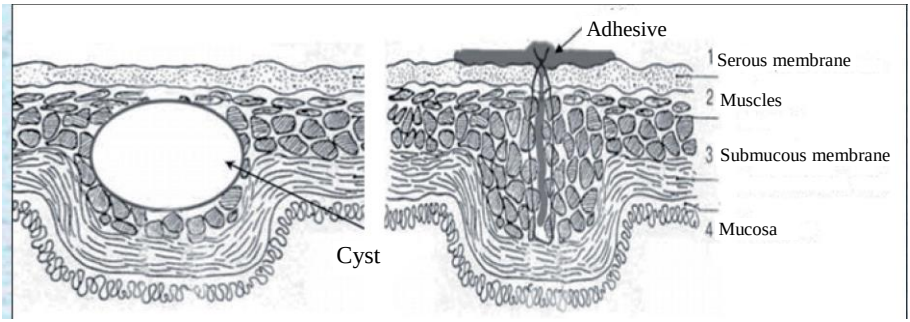


*Fig. **45.** Scheme of surgery for removal of the stomach subserous cyst*

8.15. Use of adhesive technology during biopsy of tumors and soft tissues

During the open biopsy of tumors, especially of a malignant one, it is a risk of bleeding during its invasion into the surrounding tissues. In some cases, the surgeon meets a difficult situation where the tumor tissue is in a state of decay and wound suturing is significantly hampered. Treatment of the wound surface area of the tumor with an adhesive make it possible to create the capillary hemostasis.. Furthermore, the adhesive film formed on the wound surface prevent the suture cutting off and expansion of tumor cells into the surrounding tissues from the biopsy focus.

9. USE OF ADHESIVE COMPOSITION IN THORACIC SURGERY

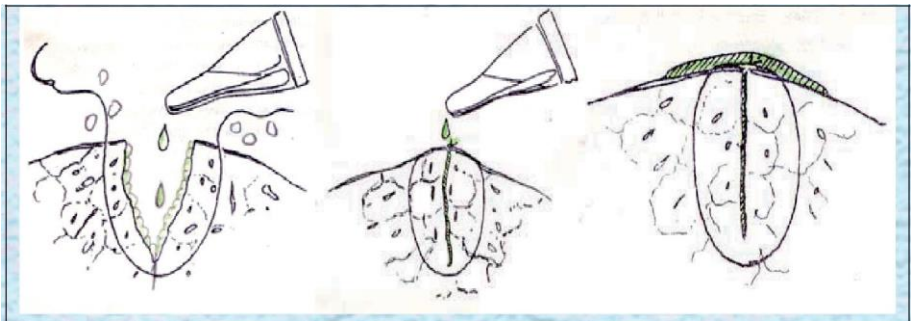
Adhesive technology with the use of the Sulfacrylate adhesive composition have been widely used in thoracic surgery both in emergency situations and in the implementation of elective surgical interventions for chronic pyoinflammatory processes, malignant tumors, foreign bodies in bronchi, congenital malformations. Use of the Sulfacrylate adhesive optimizes the surgical interventions of various kinds. Application of adhesive technology in unusual situations, for expressed pathological changes in remaining tissues avoids a number of complications, is a method of preventing suture disruption, provides the final hemostasis, allows to quickly create hermeticism of the lung tissue.

9.1. Use of Sulfacrylate adhesive for traumatic lung injuries

The traumatic lung injury is accompanied by imbibition of tissue around the wound by blood, which does not make it possible to achieve a reliable hermeticism and complete hemostasis. In spite of the sutures of lung

tissue, the air release may continue, including from the puncture holes. The sealing of lung tissue using the Sulfacrylate adhesive allows to create a complete hemostasis and provide a reliable hermeticism of the lung wound..

After suturing of lung tissue, the adhesive composition is applied before ligature tying on the wound surface, after which the suture is tied. This method provides a hemostasis. If it becomes necessary to further strengthen the suture line the adhesive is applied as a thin strip on a wound projection along the ligation line(Fig. 46).



• ***Fig. 46.*** *The use of adhesive for hemostasis and sealing of the lung tissue during wound suturing*

The adhesive film does not break lung tissue excursions, prevents infection of the wound channel and pleural cavity.

9.2. Use of Sulfacrylate adhesive for decortication of lung

The long current chronic inflammatory process in the lung leads to the formation of the dense adhesions on the visceral pleura, the separation of which is associated with the certain technical difficulties. During lung decortication, its tissue is injured, the areas appear, through which an air is released, the

excessive capillary bleeding is possible. The application of the adhesive composition on these areas allows no additional through-out suturing of the lung tissue to create a reliable hemostasis and aerostasis.. Application of this technology allows to implement good lung ventilation during surgery, spread atelectated areas of the lung occurred during surgery and avoid the necessity of setting drains into the pleural cavity.

9.3. Use of Sulfacrylate adhesive during lung resection

9.3.1 During the pulmonary lobectomy for multiple bronchiectasis, congenital malformations of lung during surgery, the surgeon is faced with an expressed adhesive process and in the root of lung area with the inflammatory-changed lymph node conglomerate. The afferent bronchus and vessels may be matted in such conglomerate. In this case, the separate ligation of vessels is difficult and does not guarantee the reliable hemostasis. The bleeding in bronchiectasis may arise from submucosal layer of the bronchi and the system of bronchial arteries, the diameter of which increases with the progression of the disease as a manifestation of local hypertension.. In this case, the arteries at the level of subsegmental bronchi form plexuses anastomosing with the pulmonary artery. Therefore, the careful hemostasis is an important part of surgical treatment. In this option, the additional treatment of bronchial stump and vessels is performed after the through-out suturing by the lung root suturing appliance (UKL) in the area of resection by sealing with the adhesive of the open lumens of vessels and bronchial stumps (Fig. 47).

The application of the Sulfacrylate adhesive composition allows to provide the hemostasis and aerostasis of lung tissue. Using adhesive sealing of the sutures of bronchi, stumps of vessels the postoperative bleeding and suture failure can be completely eliminated.

9.3.2. Prosthetics of the pleura defects with an adhesive by creating an adhesive film and bonding of free fragments

of parietal pleura to places of bronchi suturing significantly improves the surgery technique, excludes the possibility of bleeding, has a positive effect on the outcome of the surgery.

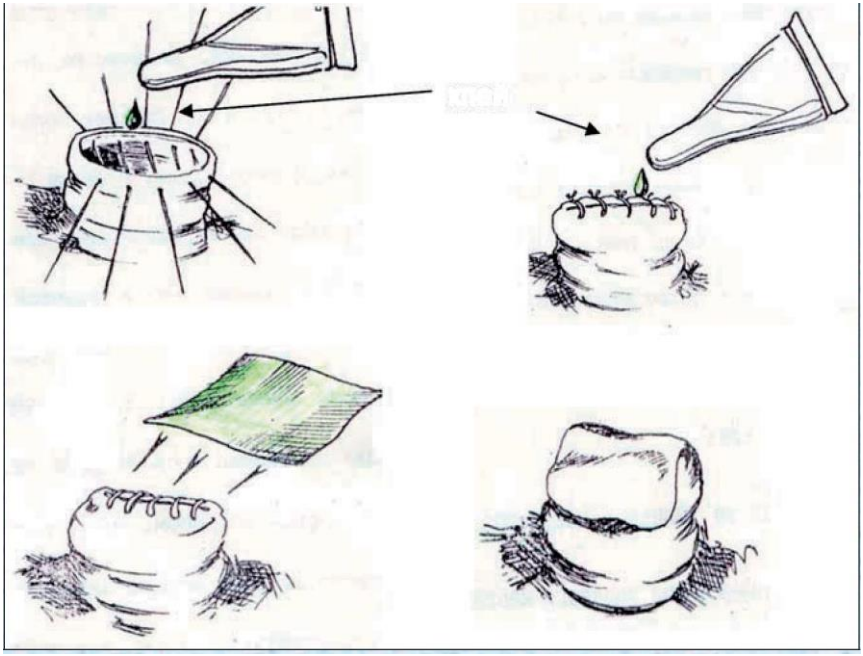


Fig. 47. Sealing of bronchial stump with the Sulfacrylate and sealing of bronchus suture line with the free segment of parietal pleura

10. USE OF SULFACRYLATE ADHESIVE COMPOSITION IN VASCULAR SURGERY

10.1. Use of Sulfacrylate adhesive composition in the treatment of congenital arteriovenous malformations of cerebral vessels

Removal of extensive vascular tumors of the brain is very difficult because of the vast areas of blood supply of such vascular collectors posing a great danger due to the possible bleeding. Application of the adhesive composition

in the surgical treatment of extensive vascular malformations allows to perform such interventions. Introduction of the adhesive composition with the dye to the arteriovenous malformation allows to reveal the major vessels feeding this collector and clear boundaries of the affected area of the brain tissue. The adhesive polymerization results in thrombosing of afferent vessels and exclusion of this vascular collector from the blood circulation. As a result, the boundaries of the affected and normal tissue are well differentiated. This makes possible a total removal of the vascular malformation only within the affected area with the minimum trauma to adjacent brain structures. The adhesive technology allows to perform the quality surgical intervention and avoid the enormous blood loss that occurs during surgery using conventional techniques.

10.2. Use of Sulfacrylate adhesive composition in treatment of cavernous hemangioma

The use of the Sulfacrylate adhesive composition in the treatment of hemangiomas in difficult to access for surgery areas is based on the chemical and biological properties of the drug. When puncture introducing the adhesive in the hemangioma cavity it is polymerized in the form of small fragments. Fragments of the polymerized adhesive in the hemangioma cavity causes an aseptic inflammatory reaction of the vessel intima.. The tissue fibrosis develops in the hemangioma cavities. The hemangioma gradually decreases in size and becomes easier to remove surgically. In some cases, hemangioma may disappear completely.

11. USE OF THE ADHESIVE SULFACRYLATE IN THE GROUP OF NEWBORNS IN TREATMENT OF CONGENITAL MALFORMATIONS

11.1. Use of Sulfacrylate adhesive composition in correction of congenital esophageal malformations

Performing of the surgical interventions in newborns with congenital esophageal malformations is associated with technical difficulties due to the lack of plastic tissue for the implementation of direct anastomosis, morphological immature of tissues. The resulted tension of the suture line in the anastomosis area of the esophagus parts leads to its failure even with a small tension.. Sealing of anastomosis suture line with a biological adhesive creates the favorable conditions for healing and prevents the recanalization in separation of tracheoesophageal fistula (Fig. 48).

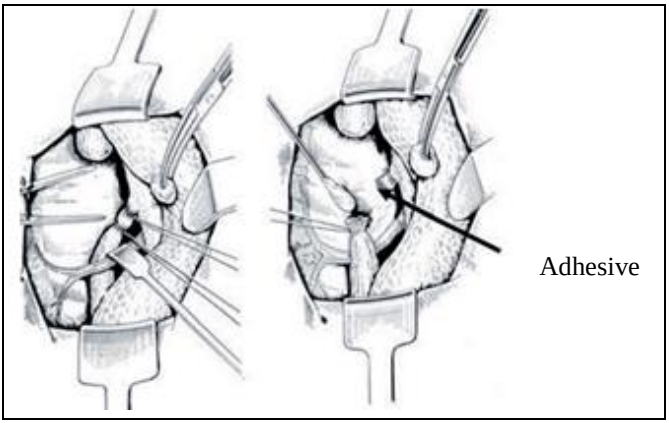


*Fig. **48.** The use of the adhesive composition in separation of the tracheoesophageal fistula*

The difficulty in performing the sealed anastomosis is associated with immature anatomical structures, arising tension of all anastomosed parts due to the tissue deficiency. The proposed adhesive composition allows to reduce the tension in suture areas, avoid thread cutting off and provide hermeticism in the anastomosis area (Fig. 49).

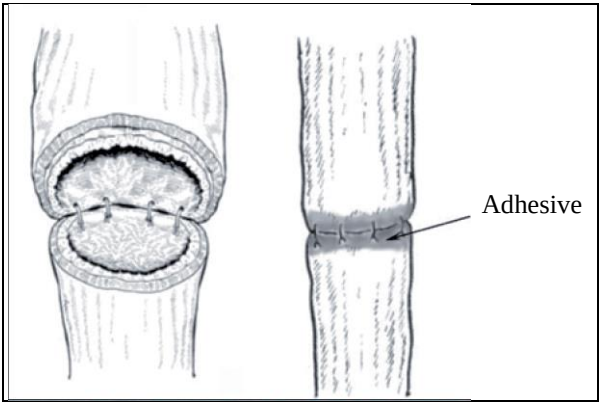


*Fig. **49.** Sealing of the esophago-esophagoanastomosis area with the adhesive*

11.2. Use of Sulfacrylate adhesive composition in correction of congenital intestinal malformations

When performing surgical interventions on the intestine of the newborn, the surgeon meets with immature tissues. It is necessary to perform an intestinal anastomosis on hollow organs of different diameters with a very thin wall. In addition, the anatomical immaturity very often leads to functional inferiority of the intestinal wall due to organ innervation pathology. Therefore, a reliable hermeticism of sutured parts of intestinal loops is of great importance..

Technology of enteroenteroanastomosis is identical to the described above. The single-layer intestinal anastomosis is performed as interrupted sutures, then the adhesive drop is applied on the suture line that, spreading, covers an area of anastomosis. The thin flexible film is formed on the surface after polymerization that reliably protects the area of anastomosis, provides hermeticism, prevents intestinal anastomosis suture failure (Fig. 50).

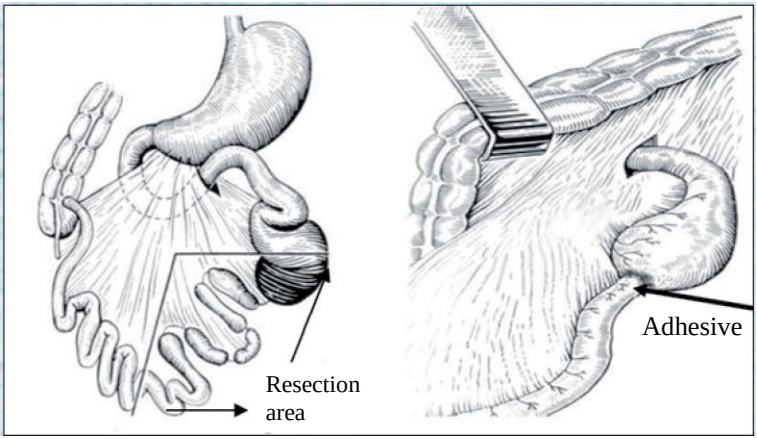


Fig. 50. *Resection of the inperforate small intestine and strengthening of the suture line of the anastomosis with an adhesive*

11.3. Use of adhesive technology for surgical interventions on the diaphragm

Application of adhesive technologies for surgical interventions in the relaxation of the diaphragm and true hernias allows to create a reliable reduplication from its tissue. Later the connective tissue adhesions develop in the fixed fold that reliably strengthen the cupula of diaphragm, preventing the relaxation effect and recurrence of the hernia.

The adhesive technique is applied in the form of two options:

11.3.1. Mattress sutures are put on the cupula of diaphragm. At the stage of tying of these sutures, the adhesive composition is applied in the formed folds, which polymerizing creates a flexible adhesive bond between the reduplications.. The applied adhesive composition does not affect the diaphragm excursion. The cupula shape is normalized.

11.3.2. The reduplications are created of an excess of hyperinflate diaphragm tissue layers, with or without dissection dissection of the into 2 parts, between which the adhesive composition is applied. Further, the adhesions are formed between the sheets of pleura along the diaphragmatic surface (Fig. 51).

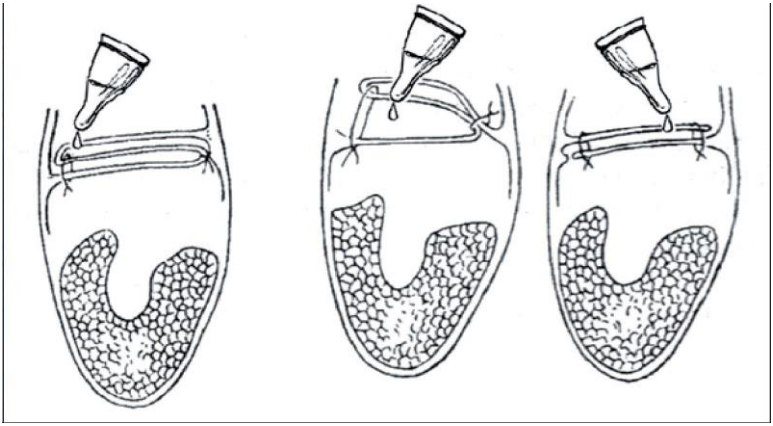


Fig. 51. *Option for the diaphragm strengthening with an adhesive*

11.4. Use of Sulfacrylate adhesive composition in abdominoperineal proctoplasty by Soave for congenital megacolon

Use of the adhesive allows to create a sutureless anastomosis in the demucosated area of the bowel and proximal large intestine pulled-through into its lumen (Fig. 52, 53). The mobilized proximal large intestine is pulled-through ampulla lumen after the mobilization of the distal rectum, its demucosation and the proximal large intestine fixed to the skin of the anus by apposition sutures. The adhesive is injected circularly in a thin layer between demucosated wall of the rectum and serous covering of the passed-through intestine with a syringe with round tip cap. Spreading, the adhesive composition reliably fixes the pulled-through bowel part in the muscular coat of rectum.. Sealing of the pelvic peritoneum is carried out by loose apposition sutures, along the line of which the adhesive is applied. This technology eliminates the failure in the area of the anastomosis, and penetration of infection along the area of the wound channel..

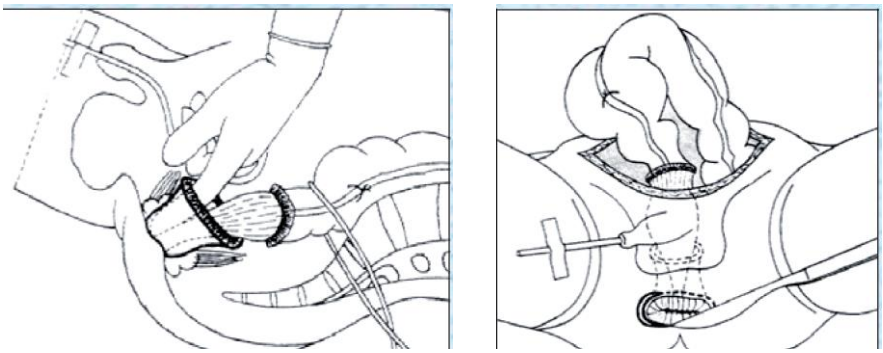


Fig. 52. Steps for the rectum demucosation and pull-through.
A: separation of mucosal and submucosal layers of the muscular coat of the rectum. B: pull-through of the proximal part of the intestine to the muscular coat of the rectum

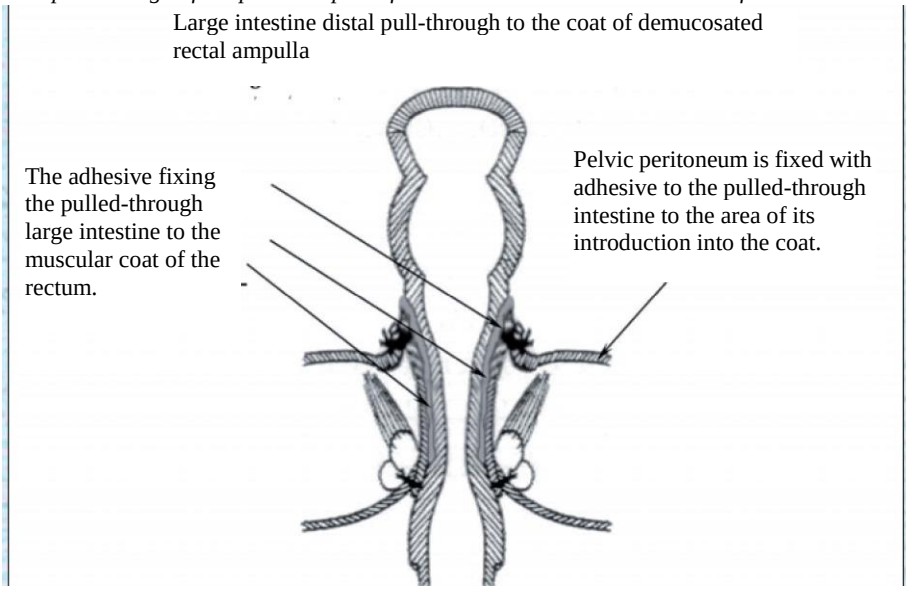


Fig. 53. Scheme of surgery for creating the sutureless anastomosis with the adhesive

12. USE OF SULFACRYLATE FOR SURGICAL INTERVENTIONS ON THE BONE TISSUES

12.1. Use of adhesive technology for the fixation of bone grafts during trepanation of the skull bones

Sulfacrylate is successfully used for fixation of bone grafts at the closure of skull defects.. Using the adhesive composition, it is possible to provide the cancellous bone hemostasis and bone fragment reliable fixation. The adhesive use eliminates the need to use metal structures for fixation of bone fragments. It is cost-efficient, convenient and reliable method of fixation. The method is easy to use. The adhesive is applied to the cancellous bone and the graft is set on this place, after 1 minute, the graft is firmly fixed to the bone tissue.

13. USE OF ADHESIVE TECHNOLOGY IN OBSTETRICS AND GYNECOLOGY

The Sulfacrylate adhesive is used in the following situations: sealing of uterine sutures in wedge excision of the fallopian tube, in putting the meticulous sutures on the ovary to preserve the maximum volume of functioning tissue; elimination of defects in the ovary tissue tear and removal of ovarian benign cysts.

13.1. Use of adhesive technology during fallopian tube resection

When performing the wedge excision of the fallopian tube at the time of the uterus tissue suturing, the ligatures often cut off, it is accompanied by excessive bleeding from the puncture holes. The adhesive technology is as follows: the wound surface is treated with an adhesive. The adhesive film is formed on the wound surface, which has a hemostatic effect and strengthens the edges of the wound. Then the wound defect is sutured with the interrupted sutures, on

which a thin layer of the adhesive composition is again applied. This technique provides a good hemostasis.

13.2. Use of adhesive technology in ovarian apoplexy

Two methods are used for this pathology:

13.2.1. The edges of the wound are treated, non-viable tissue is removed. Then, the adhesive is applied to the dry wound surface. Exposure during 1.5 to 2.0 minutes, closure of wound surfaces by the surgeon hand allows to make a good approximation of the tissue, hemostasis and avoid the need for suturing (Fig. 54).

Fig. 54. *Adhesive use in ovarian apoplexy*

13.2.2. When suturing the torn ovarian tissue, the capillary bleeding may continue after suturing. In order to provide the final hemostasis, the adhesive composition is applied as a thin layer on the suture area, the reliable hemostasis is achieved.

13.3. Use of adhesive technology in ovarian biopsy

During ovarian tissue biopsy. After a wedge excision of ovarian tissue, the adhesive composition is applied on the dry wound surface

, the wound edges are tightly compressed by fingers for 1.0 to 2.0 minutes. The complete hemostasis is achieved in this period(Fig. 55).

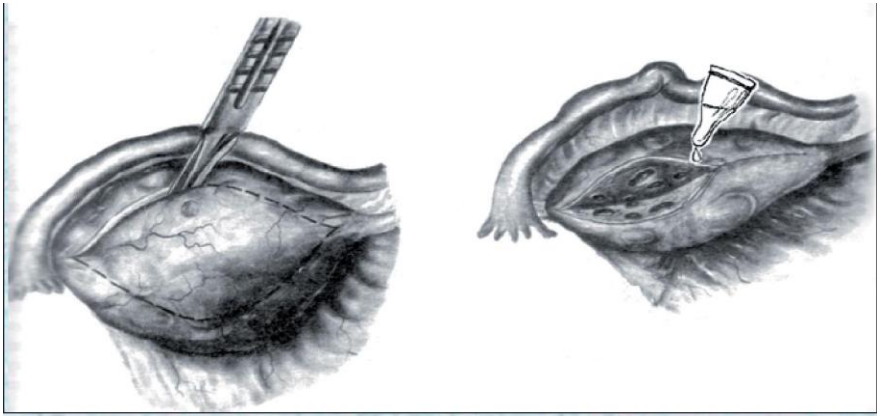
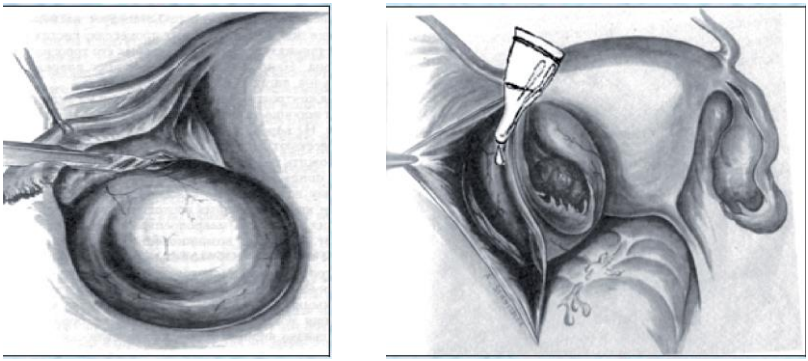


Fig. 55. Use of adhesive in ovarian biopsy

13.4. Use of adhesive composition in removal of ovary benign cysts

Use of adhesive technology in removal of ovary benign cysts. During enucleation, the cyst bed continues diapedetic bleeding. To provide the permanent hemostasis, the dry cyst bed is treated with an adhesive. The adhesive is polymerized in a thin flexible film and no additional hemostasis is required (Fig. 56).



1 **B**

Fig. 56. Cyst bed treatment to achieve hemostasis

13.5. Use of Sulfacrylate adhesive composition during plastic surgery on the vagina and perineum

Synthesis of continuity of the vagina and perineum using the Sulfacrylate adhesive composition in traumatic injuries can effectively eliminate the injuries and accelerate the healing process. The sequence of application of the adhesive composition for the vaginal birth injury when, along with damage to its walls, the muscles are damaged, is as follows: primarily, the muscles are sutured. For this purpose, the absorbable suture materials are used: catgut, vicryl etc. Then the vaginal mucous membrane edges are sutured with the continuous suture starting from the upper corner of the wound toward the perineum. The next stage is the suturing of the skin wound. After vagina drying with the drape, a thin adhesive composition is applied on the suture line with a width of 1.5 cm. The sutures in the area of the vaginal vestibule and the perineum are treated in a similar way.. The suture line becomes protected by the polymer film from exposure of the discharged vaginal secretion that provides optimum conditions for wound healing. If necessary, 4-5 after days, the adhesive film can be applied

again. Application of this method allows to avoid suture failure, reduce the frequency of wound healing by secondary tension. This prevents the development of the cicatrical deformities.

13.6. Suture-adhesive method for repair of laceration of cervix

Lacerations of cervix detected after birth are restored by double-row sutures with absorbable suture material. When suturing the laceration, the internal suture row is made first from the endocervix. Knots of individual sutures are faced to the cervical canal lumen. The distance between sutures is 0.7 to 1.0 cm. The outside suture row is put on from exocervix.. In this case, the outside sutures must be laid between the first row sutures. Knots of separate sutures of the second row are faced to the lumen of the vagina. The suture line is dried, and then the adhesive is applied along the suture line using a syringe with a needle. With adhesive and antimicrobial effect, the adhesive protects the sutures from the lochial discharge. After 4 to 5 days the adhesive is applied again due to the partial destruction of the film. Use of the adhesive technology avoids the suture failure and provides primary wound healing..

• The use of biological adhesives in surgery allows to avoid complications in the immediate and long-term postoperative periods arising from the use of standard and customized surgical technologies.

14. USE OF SULFACRYLATE ADHESIVE COMPOSITION IN ENDOSCOPIC SURGERY

The Sulfacrylate adhesive composition is used in endoscopic surgery for capillary hemostasis from the gallbladder during cholecystectomy, traumatic injuries of parenchymal organs, subcapsular hematomas, for hemostasis in ovarian

apoplexy, additional strengthening of the vermiform appendix stump in the appendectomy, for sealing of hernial orifice, bonding of Nuck's diverticulum in Dupuytren's hydrocele, repair of bronchopleural fistula, treatment of the peritoneum deseroused areas. Laparoscopic hemostasis is achieved with the use of monopolar and bipolar coagulation but these options may result in a risk of uncontrolled coagulation effect on adjacent tissue through indirect contact of the tool and trocar of the upstream (non-working) part of the tool jaws with tissue. When controlling the parenchymal bleeding, the options of clipping and ligation of vessels are inconvenient.

When performing surgical interventions in endoscopic option, it is necessary to avoid contact of the catheter, through which the adhesive is supplied, with the liquid in free peritoneal or pleural cavity keeping in mind that the adhesive polymerizes in contact with the liquid. This is done by removing free liquid from the abdominal cavity by means of aquapurator.. The adhesive is applied to the surgical field in dosed manner with a syringe through the catheter at the final stage of the surgery.. The catheter must be dry. The adhesive is applied to the desired tissue site with the use of an endoscope..

14.1. Use of Sulfacrylate adhesive in appendectomy

14.1.1. Use of the Sulfacrylate adhesive composition in endoscopic appendectomy for the treatment of the vermiform appendix stump

After electrical coagulation of the mesentery of vermiform appendix, application and tightening of the Reder's loop, the bipolar coagulation and intersection of the vermiform appendix base is performed. The aspiration of the contents from the vermiform appendix stump is performed by means of the aquapurator.. The Sulfacrylate adhesive composition is applied on the vermiform appendix stump through the microirrigator

to form a thin bactericidal film reliably protecting the abdominal cavity from the infection. The vermiform appendix stump to be removed is treated in a similar way.. This prevents the liquid contents discharge from its lumen and infection of the abdominal cavity with the extraction through the umbilical trocar..

14.1.2. Method of adhesive occlusion of the perforated hole in the vermiform appendix under conditions of peritonitis

If, during the ongoing endoscopic surgery the peritonitis was diagnosed and the contents of vermiform appendix is effused from the perforated hole into the abdominal cavity, then before performing the endoscopic stages of an appendectomy, it is necessary to aspirate an effusion from the abdominal cavity by the aquapurator and treat the perforated hole with an adhesive with the use of an endoscope by means of microirrigator, introduced through a trocar. In this case, a thin flexible film is formed on the surface of the vermiform appendix and perforated hole area that prevents further contamination of the abdominal cavity. The remaining appendectomy steps are identical to the foregoing. When removing the vermiform appendix after appendectomy, the adhesive film applied in the perforation area does not prevent the removal of the vermiform appendix through the trocar. After removal of the vermiform appendix, a thorough sanitation of the abdominal cavity with antiseptic solutions is performed. If necessary, the drains shall be kept..

14.2. Use of Sulfacrylate adhesive composition in laparoscopic adhesiolysis and viscerolysis

The capillary bleeding takes place after separation of the adhesions due to formed abnormal vasculature during the laparoscopic adhesiotomy when intestinal loop fits tight to the parietal peritoneum or is firmly fixed to the suture area after the initial surgery penetrating into the soft tissue of the anterior abdominal wall

due to a previous suture failure. In this case, the surface of the visceral peritoneum after the separation of adhesions is locally treated by the Sulfacrylate adhesive composition under the control of the optical system. The treatment by adhesive allows to complete the quality final hemostasis taking into account the adhesion properties of the adhesive, make the prosthetics of the peritoneum portion.

14.3. Endoscopic resection of Meckel's diverticulum with prosthetics of peritoneum by the Sulfacrylate

An open portion of the mucosa remains during the Meckel's diverticulum resection performed using suturing appliances. In this case the edges of the mucous and muscular mass along the diverticulum dissection line are not closed by serous covering.. The infected area occurs in the suture line area, that may cause a local inflammatory process.

Adhesive treatment of the cut surface under the control of the optical system allows to create an additional hermeticism, to avoid infection of the surrounding tissues, creates a protection against the spread of infection from the intestinal mucosa along the abdominal cavity.

14.4. Use of Sulfacrylate adhesive for laparoscopic cholecystectomy

Method of adhesive technology is described above in detail, taking into account the features of laparoscopic approach, the Sulfacrylate is used in the final stages of the operation of cholecystectomy.

14.5. Use of Sulfacrylate adhesive for sealing of cystic duct stump

The Sulfacrylate adhesive is used for treatment and sealing of cystic duct stump. After the clipping of the cystic duct and its dissection, the drop of adhesive is applied

through a catheter on the proximal stump of the cystic duct under the control of an optical telescope. Spreading on the place of dissection, the drop reliably seals the lumen of the duct creating a thin flexible plug on the surface.

14.6. Use of Sulfacrylate adhesive for hemostasis in traumatic injury of parenchymal organs with the damage of organ capsule

During the diagnostic laparoscopy for the closed abdominal trauma and detection of shallow fissures, shallow tears of the liver or spleen parenchyma with the solution of continuity of the organ capsule, the endoscopic hemostasis is performed with the use of the Sulfacrylate adhesive. Veress needle is introduced to the abdominal cavity in the projection of the damaged organ. The inner cylinder of needle is replaced with a plastic catheter connected to a disposable syringe-tube containing the Sulfacrylate adhesive composition. The catheter is approached to the place of organ tear under the control of the video system. The adhesive is applied on the wound surface. The wound is preliminarily dried by the electric suction machine. Then, using the clamp arm, the tear is packed by the omentum strand.

14.7. Use of Sulfacrylate adhesive for hemostasis in the treatment of subcapsular hematomas in traumatic injuries of parenchymal organs

If the diagnostic laparoscopy revealed the tense subcapsular hematoma, then the hematoma puncture is performed under the control of video system. The blood is removed, and then the Sulfacrylate adhesive is introduced in the subcapsular space. The adhesive fills subcapsular space, provides hemostasis. Capsule is pressed to the body by an arm and tightly fixed..

14.8. Use of Sulfacrylate adhesive for laparoscopic excision of the spleen cyst

After the endoscopic revision of spleen, the topographic location of ganglion is examined by means of the endoscopic needle with an aspiration of the contents, then, after capturing the wall, the cyst is opened as widely as possible, its revision is performed to clarify the presence of internal partitions and additional cavities. After that, the cyst partitions and capsule are removed. The remaining cavity is dried by aspiration, irrigated by the Sulfacrylate adhesive through the catheter and packed by the omentum strand.

14.9. Use of Sulfacrylate adhesive during endoscopic surgical interventions in gynecological diseases

14.9.1. Use of Sulfacrylate adhesive during salpingostomy

Hysterosalpingostomy is carried out for relatively intact tube when it is possible to identify the bonded fimbriae covering the tube entrance. Using scissors, cut through the adhesions and up to opening of the lumen of the tube in its natural place. The edges of the fimbriae are turned out by atraumatic forceps. Pelvic cavity is thoroughly dried using electric suction machine.. Edges of the corpus fimbriatum is fixed as a mucous cuff outwardly with the use of the Sulfacrylate adhesive, which is applied through the catheter to a peritoneal covering in the tube zone with the fixation of fimbriae.

14.9.2. Use of the Sulfacrylate during salpingoneostomy

The surgery is performed to restore tubal patency in the ampullar segment. Crucial dissection of the terminal portion of the tube opposite to mesosalpinx is made along its axis for 1.5 cm. Hemostasis and fixation of dissected fragments are performed by the Sulfacrylate adhesive.

14.9.3. Use of Sulfacrylate adhesive during endoscopic ovaricystectomy

After the contents aspiration, the ovary is captured by two atraumatic forceps, the cyst capsule is dissected and peeled off the ovarian cyst and removed. In the presence of excessive bleeding, the monopolar electrical coagulation is performed, then the cavity is treated by adhesive through a catheter after drying using an electric suction machine, which allows to coagulate every smallest bleeding vessel without damaging the ovarian tissue.

CONCLUSION

The emergence of the new biological sealant Sulfacrylate in surgical practice can significantly improve the effectiveness of surgical treatment of patients with pathological processes of various origins and different localization.

The new generation of biological adhesives makes it possible to successfully perform the customized urgent and elective complex surgery in patients of any age including in newborns. Biocompatibility, non-toxicity, ability to perform the effective hemostasis and sealing of the wound surfaces, bactericidal action can achieve recovery after surgery with the use of the new generation Sulfacrylate in serious and complex patients, reduce the treatment time and are economically feasible.

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BIOLOGICAL ADHESIVE “SULFACRYLATE”

ANTIBACTERIAL AND ANTI-FLAMMATORY ADHESIVE COMPOSITION

INSTRUCTIONS FOR USE IN SURGICAL FIELDS

Manufacturer: JSC Federal
Research and Production Center Altay
http: // www.sulfakrilat.ru