New Technologies Making Use of Sulfacrylate in Pediatric Surgery

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Sulfacrylate glue composition was used in surgery for traumatic injuries to parenchymatous organs for attaining hemostasis and hermetic sealing of intestinal anastomoses and hollow organs, in cancer patients, in gynecological and thoracic surgery, and in correction of congenital defects. Glue composition ensures reliable intraoperative hemostasis, hermetic sealing of wounds in parenchymatous and hollow organs, prevents infection of the abdominal and thoracic cavities, thus reducing endotoxicosis and stimulating tissue regeneration. The use of Sulfacrylate optimized surgery, facilitated operative technology in difficult situations, and prevented the development of postoperative complications.

Key Words: *abdominal and thoracic surgery; urgent and planned surgery; new surgical technologies*

Biological glue compositions now used in medicine as biological glues play an important role in the development of new surgical technologies. Previously synthesized glue compositions (PECL, MC type glues, *etc.*) were experimentally and clinically tested and recommended for clinical practice [1-4]. Unfortunately, these glue compositions cannot be widely used because of side effects associated with some of their chemical and physical characteristics. Some of these glues caused inflammatory process in adjacent tissues, others created a fragile insufficiently elastic film, were too rapidly hardened, some did not ensure mechanical strength and hermetic sealing in the anastomosis zone [5,8]. The search for and development of more effective glue compositions are in progress.

Sulfacrylate-1, Sulfacrylate-2, and Silacrylate belong to a perspective group of glue compositions; the above-mentioned shortcomings can be partially solved by using these compositions. Now some experience is accumulated in using new glue composition in surgery and the indications for the use of this composition in various branches of medicine are defined [6,9-13].

This study was aimed at testing and introduction into clinical practice of a new glue composition (third-generation Sulfacrylate), optimization of currently used and creation of new gluing technologies for surgery on tissues and organs.

MATERIALS AND METHODS

Sulfacrylate bioglue synthesized at G. K. Boreskov Institute of Catalysis, Siberian Division of Russian Academy of Sciences, was tested in pediatric surgical clinic. The new glue composition is improved: it ensures high elasticity of the glue film and is characterized by high antiinflammatory effect. The film formed on the surface under the effect of liquid medium is not broken, deformed, does not shrink, and remains unchanged within 10-15 days. The glue is characterized by good adhesion and is completely resolved within 30-40 days [14]. Bacteriological studies of Sulfacrylate with *S. aureus* and *E. coli* cultures showed that the glue composition suppressed bacterial growth.

Sulfacrylate was used in 165 patients (0-14 years) divided into 4 groups, depending on the type of intervention: 1) urgent abdominal surgery (n=115); 2) tho-

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racic surgery (n=10); 3) planned surgery (n=24); and 4) surgery for congenital developmental defects (n=16). Control group consisted of 147 patients with similar diseases, of similar age, subjected to similar interventions without using the glue.

The patients' status was evaluated using severity score based on International Mannheim Index of Peritonitis (MIP). The score varied from 4 to 33. In addition, the postoperative status of the patients was evaluated by traditional clinical, laboratory, and instrumental methods (X-ray examination, ultrasonic imaging, laparoscopy, *etc.*), parameters of cell and humoral immunity, and estimation of the integral endotoxicosis index. Quantitative data were statistically processed using computer software.

RESULTS

The group of urgent abdominal surgery included mainly patients with blunt and perforating injuries to the abdominal and retroperitoneal organs, purulent peritonitis of different genesis and dissemination, and urgent gynecology.

Traumatic injuries to abdominal organs in children rank first among other injuries [7]. The spleen, liver, kidneys, and pancreas are most often damaged. The victims were hospitalized with extremely severe condition (severity score up to 31); 50% had combined injuries. Many patients were in a state of traumatic and hemorrhagic shock.

In patients with surface injuries of parenchymatous organs and parenchymatous hemorrhage Sulfacrylate was used as the main hemostatic means for bleeding arrest. Glue hemostasis was carried out in cases of parenchymatous organ removal, when it was difficult to determine the source of bleeding against the background of tissue imbibed with blood.

In cases with subserous hematomas of the liver or gallbladder bed the hematomas were opened, emptied, revision of the hematoma area was carried out, the organ tissue was treated with the glue, the surface was peritonized with the Glisson capsule by gluing and pressing to the organ surface.

Glue hemostasis was used for fortification of sutures of the wounds in parenchymatous organs. In this case the glue composition fixed on the organ surface ensured (in addition to the hemostatic effect) closer contact of the wound edges, preventing perforation of sutures in the parenchyma and promoting complete hemostasis.

In cases with extensive lesions of the liver, spleen, and kidneys the wounds were sutured, the vessels were ligated in the zone of traumatic injury, and the glue was used at the final stage of the surgery for hermetic sealing of the wound by the glue film. This technology prevented secondary bleeding, suppuration, and penetration of the bile through the bladder wall and wound surface.

The wound process in abdominal injuries of hollow organs is as a rule associated with peritonitis. Wound suturing involves infection of the thread, this creating conditions for failure of the sutures, when the surgeon cannot be completely sure in primary healing of the wound. Use of the glue composition creates hermetic full-value intestinal anastomosis. In order to fortify the intestinal anastomosis, the glue was applied after double-row suture directly onto the fissure of sutured wound and 1.0-1.5 cm around it for complete sealing of the needle holes with consideration for tissue incompetence in hollow organs at the site of injury (Fig. 1, *a*). The glue effectively prevented suture incompetence in case of large infiltrative zone around perforative holes (Fig. 1, *b*).

For peritonization of the defects in the parietal and visceral peritoneal leaflets, glue film was used as applications to deserosed areas and sites of nonperforating intestinal injuries. This created optimal conditions for tissue regeneration, prevented inflammatory process in the wall of hollow organ or promoted liquidation of this process and prevented adhesion formation.

In thoracic surgery the new-generation glue was used in urgent and planned surgery in patients with cancer, pyoinflammatory diseases of the lungs and pleura, gunshot wounds of the lung and diaphragm, *etc.* Sulfacrylate was used in extraordinary situations, in pronounced pathological changes in remaining tissues, as a method for preventing suture incompetence for final hemostasis and aerostasis.

The operations were technologically difficult because of abundance of dense adhesions of pleural leaflets, sclerotic and inflammatory changes in tissues and main vessels. In such cases the glue technologies were used for hemostasis and hermetic sealing of surfaces, divided adhesions, hermetic sealing of the lumen and stump of ligated vessels and bronchial sutures. The use of the glue facilitated the intervention, prevented injuries to lung parenchyma and air release from bronchial stumps and damaged lung tissue, promoted bleeding arrest from ligated vessels.

The glue film formed on the surface of lung tissue was elastic, did not cause lung deformations, did not impede lung ventilation, and the lung was well spread. Due to Sulfacrylate the wounds in the lung and pleura were hermetically closed (Fig. 2, *a*). Filling of vascular and bronchial stumps with the glue composition prevented intra- and postoperative complications and reduced blood loss. The glue composition was effectively used for hermetic closure of the bronchus during bronchotomy for removal of a foreign body.

The group of patients subjected to planned surgery included patients with various diseases: hepato-

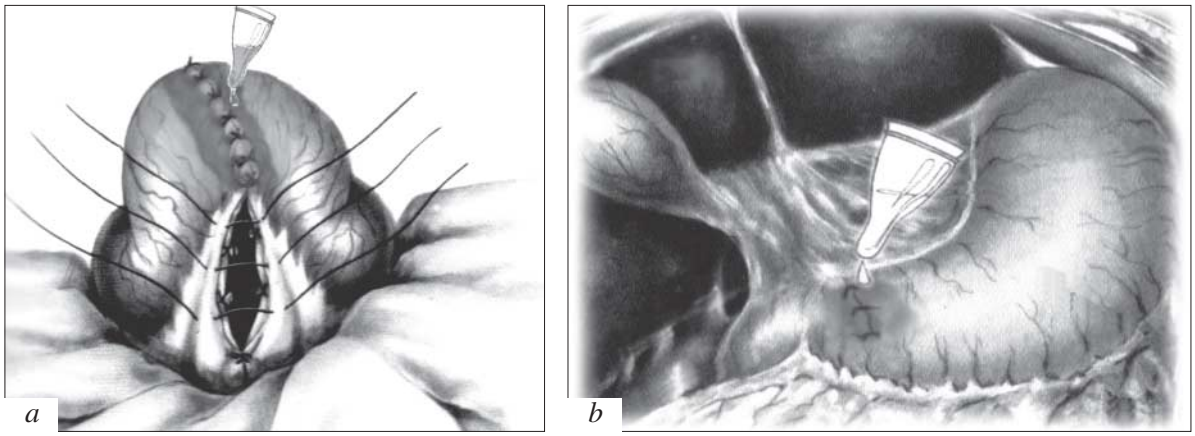

Fig. 1. Use of glue technologies in abdominal surgery. *a*) application of glue film during creation of intestinal anastomosis; *b*) hermetic sealing of sutures with glue after suturing perforated wounds in the stomach in diffuse purulent peritonitis.

biliary diseases, chronic duodenal ileus, congenital gastric abnormalities, hematological diseases, and cancer. Sulfacrylate was used in planned operations for improving the efficiency of treatment in the most intricate cases (tissue degeneration and defects, operations with high risk of complications) and for creating ideal hemostasis. Hemostasis was attained by creating a glue film and obturation of small vessels; the hernial sac neck was treated with the glue in case of wide communication with the abdominal cavity; anastomoses, sutures, *etc.* were hermetically sealed by means of the glue.

Glue technologies were used in operations performed in patients with congenital abnormalities of the esophagus, intestine, biliary duct atresia, diaphragmatic hernias, congenital agangliosis of the intestine; use of these technologies optimized the results of surgery.

The use of the glue promoted hermetic sealing and fortification of anastomosis sutures, created favorable conditions for their healing (Fig. 2, *b*, *c*). Due to gluing technology, the abdominal cavity was reliably protected from translocation of bacteria from the intestine and favorable conditions for patient's recovery were

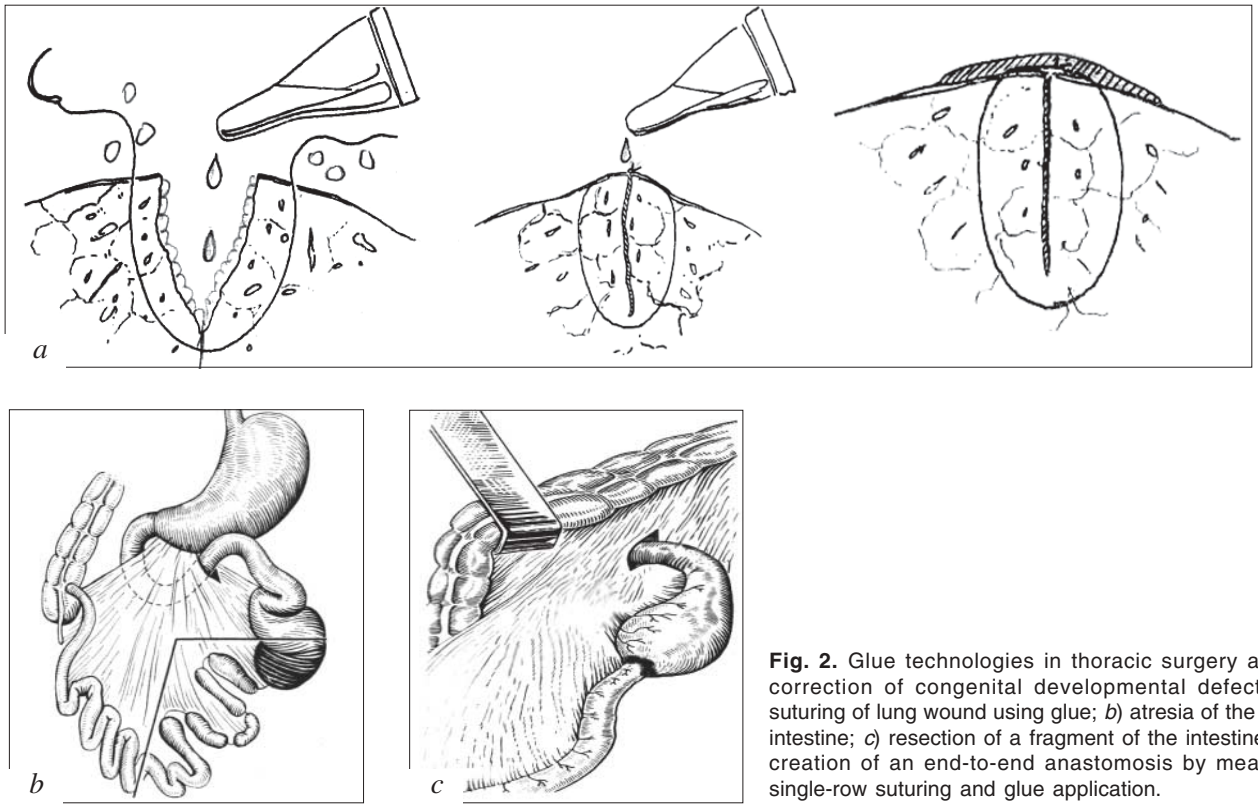

Fig. 2. Glue technologies in thoracic surgery and in correction of congenital developmental defects. *a*) suturing of lung wound using glue; *b*) atresia of the small intestine; *c*) resection of a fragment of the intestine with creation of an end-to-end anastomosis by means of single-row suturing and glue application.

TABLE 1. Laboratory Parameters of Hepatorenal Function in Patients on Day 3 after Surgery (*M*±*m*)

Parameter	Normal value	Glue technologies	Traditional technologies
Uncomplicated abdominal disease			
albumin, g/liter	23.0-46.1	28.00±0.02*	29.00±0.15
bilirubin, μmol/liter	3.4-13.7	6.2±0.3*	8.70±0.02
ALT, μmol/liter	0.1-0.6	0.42±0.03*	0.85±0.20
AST, μmol/liter	0.10-0.45	0.32±0.04	0.28±0.05
fibrinogen, g/liter	2.0-4.0	4.20±0.05*	4.90±0.02
prothrombin index, %	80-100	89.3±0.5	87.7±0.8
creatinine, μmol/liter	0.076-0.114	0.12±0.02	0.13±0.03
urea, μmol/liter	4.3-6.8	6.5±1.2	7.8±0.2
Peritonitis			
albumin, g/liter	23.0-46.1	20.00±0.09*	19.10±0.08
bilirubin, μmol/liter	3.4-13.7	13.5±0.1*	14.20±0.08
ALT, μmol/liter	0.1-0.6	0.71±0.03	0.68±0.15
AST, μmol/liter	0.10-0.45	0.22±0.12*	0.71±0.06
fibrinogen, g/liter	2.0-4.0	4.70±0.05	4.65±0.20
prothrombin index, %	80-100	92.4±0.3*	83.50±0.09
creatinine, μmol/liter	0.076-0.114	0.13±0.04	0.16±0.07
urea, μmol/liter	4.3-6.8	9.2±0.6*	11.3±0.1

Note. *$p<0.001$compared to traditional technologies.

created. Uneventful course of the postoperative period prevented, among other things, the formation of coarse cicatrices and narrowing of newly formed rectal ampoule. Treatment of the diaphragmatic surface with the glue after the first line of fixing suturing (and later after the second line) promoted high-quality plasty of the diaphragm.

Analysis of the postoperative period in comparison with the control group (clinical, laboratory, biochemical tests, integral index of endotoxicosis and parameters of cell immunity) demonstrated the advantages of the glue technologies over traditional surgical methods (Table 1). More pronounced increase in the levels of ALT, fibrinogen and urea, reflecting strained hepatorenal function, was observed in children operated with traditional methods, for example, for uncomplicated abdominal diseases, in comparison with the postoperative period in the control. Glue application arrested superinfection in the abdominal cavity from the pathological focus, which was hermetically isolated from the intestinal cavity. Cleansing of the abdominal cavity and detoxication were more rapid, regeneration was more effective.

Hence, the new glue composition is characterized by positive effects: it is nontoxic, bactericidal, forms a plastic film on tissue. The use of the glue films in pediatric surgery ensures reliable hemostasis, hermetic sealing of sutures, wounds, and anastomosis zones, permits gluing tissues of different nature, promotes an uneventful course of the postoperative period and a favorable outcome during the immediate and remote periods after the intervention, creates conditions for more rapid recovery. The proposed methods making use of a new biological hermetic Sulfacrylate can optimize typical and atypical operations irrespective of the type of the disease.

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