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ИССЛЕДОВАНИЕ ФИЗИКО-МЕХАНИЧЕСКИХ ХАРАКТЕРИСТИК ШОВНОГО МАТЕРИАЛА В ЭКСПЕРИМЕНТЕ ПРИ ОПЕРАЦИЯХ НА ПЕЧЕНИ

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Принимая во внимание особенности кровоснабжения печени и структуру ее паренхимы, а вследствие этого и значительные трудности в достижении надежного гемостаза без дополнительной травматизации, хирургу необходимо быть осторожным при проведении оперативного пособия. Несмотря на большое количество современных методов достижения остановки паренхиматозного кровотечения многие практикующие специалисты отдают предпочтение классическим методам гемостаза, в т.ч. лигированию кровоточащих сосудов в толще органа при помощи специализированных швов. Одним из тяжелейших осложнений применения шовного материала является прорезывание ткани органа, что приводит к усилению кровотечения и расширению области повреждения. В настоящий момент тактика выбора шовного материала для выполнения оперативного пособия носит эмпирический характер. В связи с этим, цель данного исследования заключалась в проведении оценки физико-механических свойств шовного материала в зависимости от его структуры, а также разработке критерия выбора хирургических нитей для оперативного пособия. Для исследования производилось изъятие печени трупов лиц мужского пола от 35 до 40 лет, после чего из нее выделялись отдельные участки размерами 7,5×7×4 см. Затем наносили рану длиной 3 см, глубиной 2 см. Рану ушивали простым узловым швом, который не затягивали, а накладывали один простой полуузел. Для ушивания применяли кетгут, капрон крученый и нить полиглликолидную. Обращали внимание на максимальное усилие на момент прорезывания (Fmax) и степень вытяжения нити на момент прорезывания (Lu). Анализ полученных данных проводился на основе сравнения показателей Fmax и Lu. Использование этого метода позволяет отказаться от эмпирического подхода к выбору шовного материала при операциях на печени, а также разработать критерий выбора хирургических нитей.

Ключевые слова: *гемостаз; печень; шовный материал; физико-механические свойства.*

RESEARCH OF PHYSICAL AND MECHANICAL CHARACTERISTICS OF SUTURE MATERIAL IN EXPERIMENT IN OPERATIONS ON LIVER

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Taking into account the peculiarities of the blood supply to the liver and the structure of its parenchyma, and, as a result, considerable difficulties in providing reliable hemostasis without additional traumatization, a surgeon needs to be careful when performing a surgical manipulation. Despite a large number of modern methods for stopping parenchymal bleeding, many practitioners

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give preference to classic methods of hemostasis, including ligation of bleeding vessels in the bulk of the organ using specialized sutures. One of the most serious complications of the use of suture material is cutting of organ tissue, which leads to enhanced bleeding and expansion of the area of damage. At the moment, the tactics of choosing suture material for surgical procedures is empirical. In this context, the aim of this study was to assess the physico-mechanical properties of suture material regarding its structure, and to develop a criterion for choosing surgical sutures for surgical procedures. For the study, the liver was removed out of corpses of males of 35 to 40 years of age, after which separate sections of 7.5×7×4 cm in size were obtained from it. Then a wound 3 cm long and 2 cm deep was made. The wound was sutured with a simple interrupted suture without tightening, but with application of one simple half-node. For suturing, catgut, twisted capron and polyglycolide thread were used. Attention was paid to the maximal force applied at the moment of cutting (Fmax) and the degree of pulling the thread at the moment of cutting (Lu). The analysis of the data was based on comparison of Fmax and Lu parameters. This method permits to refuse from the empirical approach to the choice of suture material for operations on the liver, and to develop a criterion for choosing surgical sutures.

Keywords: *hemostasis; liver; suture material; physical and mechanical properties.*

Organ-saving operations present an important problem in modern abdominal surgery [1]. For example, trauma of the liver is one of most severe in the course and most difficult in the diagnosis abdominal damages that makes 30% of traumas of the abdominal organs. Taking into account peculiarities of the blood supply to the liver, its wounds are associated with massive parenchymal bleeding [2-3]. To evaluate the extent of traumatization of the organ, different scales are used. Members of the Department of Operative Surgery and Topographic Anatomy of Kursk State Medical University proposed their own classification of liver damages:

I. Without breakage of integrity of the capsule;

II. With breakage of integrity of the capsule;

III. Damage to the ligamentous apparatus;

IV. Damage to extrahepatic vessels [4].

In treatment of trauma of the liver both conservative and surgical methods are used. Surgical manipulations include ligation of the large hepatic vessels, resection of the damaged part of parenchyma, application of a hemostatic sponge, etc. However, all the described methods imply use of surgical sutures. Among several classification categories of suture materials of highest scientific interest is the structure of threads [5].

There exist two large groups of sutures differing in the texture: monofilament and polyfilament. The latter includes twisted and braided suture material. Of no less importance are such properties of surgical sutures as elasticity and biological inactivity [6-9].

However, in Russian and international scientific literature there is no information about investigation of physico-mechanical characteristics of suture material for use on the biological objects, and tightening of the node is evaluated only subjectively [10-11].

The *aim* of the study is evaluation of physico-mechanical characteristics of suture material of different structure and elaboration of the criterion for selection of surgical sutures for surgical treatment.

Materials and Methods

The base for the given study was laboratory of experimental surgery and oncology of Research Institute of Experimental Medicine (LESO RIEM) of Kursk State Medical University of Healthcare Ministry of Russia.

The object of study was portions of the diaphragmal surface of the right lobe of the liver of corpses of males 35-40 years old taken in the Office of the Chief Medical Examiner of Kursk. Taking out and use of the biological material were permitted by Regional Ethic

Committee within the frames of the RF Government Decree of 21.07.2012 №750 (ed. of 17.12.2016) «On approval of regulations of transfer of non-claimed body, organs and tissues of a dead person for use for medical, scientific and educational purposes and also of use of non-claimed body, organs and tissues of a dead person for the mentioned purposes».

One of the main criteria for selection of the biological material was the absence of any macroscopic pathological alterations, and also the absence of hepatic diseases in history. The time interval between taking out of the organ and its use was not more than 4 hours to minimize the negative influence of autolysis on the reliability of the obtained results.

For examination a part of parenchyma 7.5×7×4 cm in size was separated from the organ. The next step was making a wound on the isolated part of the organ 3 cm long, 2 cm deep. The wound was sutured with simple interrupted stitches without tightening, with application of one simple half-node. For ligation, a piece of suture material was used 50 cm in length. Such length of thread is optimal for further work on the test bed. Monofilament (catgut), twisted (twisted capron) and braided (polyglycolide) suture materials of the same thickness (3/0 by USP) were used. After modeling and ligation of the wound the studied part of the organ was placed on the device for examination of the physico-mechanical characteristics of the sutures and suture material, of the extent of deformation of the parenchyma of the organs (patent №184617). The device was designed on the base of LESO RIEM of Kursk State Medical University [12].

An additional equipment was universal testing electromechanical machine РЭМ–0,2-1 (ООО Metrotrest, Neftekamsk, Republic of Bashkortostan) equipped with a dynamometer and a display showing changes in the pulling of the suture material in the graphic form. Maximal effort (Fmax) applied before cutting of the organ parenchyma and/or rupture of suture material was analyzed, and also the extent of pulling of the thread (Lu). For the study 3 groups of 60 samples in each were formed with different structure of the used suture material. The obtained results were interpreted using methods of statistical processing (calculation of the arithmetic mean, the average error of mean, of 25^{th} and 75^{th} percentiles). Statistical significance of comparisons was determined using Mann-Whitney test with $p \leq 0.05$ admissible for biomedical studies. As software for statistical processing, license versions of Statistica programs were used (version 10.0, Stat Soft Inc., USA) and Excel 2013 spreadsheet program (Microsoft Office, USA).

Results and Discussion

According to the results of study (Tables 1,

Table 1

Fmax (H) Parameters of Studied Groups

Parameter	Suture Material		
	monofilament	twisted	braided
M	65.20	88.68	78.01
m	0.059	0.64	0.083
Me	65.21	81.24	78.02
25^{th} percentile	65.23	81.34	78.9
75^{th} percentile	65.31	89.93	79.56
p	***≤ 0.05	**≥ 0.05	*≤ 0.05

Note: * – comparison of the mean Fmax values of samples sutured with braided suture material with samples sutured with monofilament threads; ** – comparison of the mean Fmax values of samples sutured with twisted material with samples sutured with braided surgical threads; *** – comparison of mean Fmax values sutured with monofilament material with samples sutures with twisted threads

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Table 2

Lu Parameters (mm) of Studied Groups

Parameter	Suture Material		
	monofilament	twisted	braided
M	54.31	72.75	63.64
m	0.057	0.68	0.1
Me	54.41	72.54	63.77
25^{th} percentile	54.4	71.11	64.36
75^{th} percentile	54.43	74.26	64.83
p	***≤ 0.05	**≥ 0.05	*≤ 0.05

Note: * – comparison of the mean Lu values of samples sutured with braided material with samples sutured with monofilament threads; ** – comparison of mean Lu values of samples sutured with twisted material with samples sutured with braided surgical threads; *** – comparison of mean Lu values of samples sutured with monofilament material with samples sutured with twisted threads

2), the mean Fmax in use of monofilament suture material at which cutting of parenchyma took place, was 65.20 H, with the medium pulling of thread 54.31 mm, that was the lowest value in three groups.

The obtained results permit to state that the least preferable suture material in operations on the liver is monofilament. However, there exists practical necessity in the introduction and evaluation of the coefficient that can help standardize and scientifically substantiate selection of suture material for certain kinds of surgical manipulations.

The authors propose to introduce *cutting coefficient (Cc) calculated as the ratio of Fmax to Lu (the value that should be ≥1).* This is associated with the fact that during tightening of the node the Lu parameter increases while the cross section area of the thread and the area of its contact with the bulk of parenchyma decreases which increases the risk of cutting. Therefore, *in operations on the liver the suture material should be used that can withstand high axial load with insignificant stretch.*

Conclusion

Thus, the conducted study permitted to identify statistically significant differences between monofilament and twisted/braided suture material and put into a question the reasonability of using monofibers in operations on the liver.

The proposed cutting coefficient will permit to gradually refuse from the empiric approach to selection of suture material.

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