EFFECTIVENESS OF BLOODSTOP IN OPTIMIZING UTERINE SCAR REPAIR AFTER CESAREAN SECTION

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Abstract.
The aim of this study was to clinically and experimentally evaluate the effect of the BloodStop hemostatic agent on myometrial repair and uterine scar formation during cesarean section. Patients were divided into three groups: control, conventional hemostatic gels, and BloodStop. The results of ultrasound and morphological analyses showed that the use of BloodStop accelerated uterine involution, increased scar thickness and strength, and reduced myometrial thinning. In experimental studies, this agent provided optimal reparative processes characterized by minimal inflammatory reactions and low levels of fibrosis. The results obtained confirm the high efficacy of BloodStop and its importance in improving the functional recovery of the myometrium.

Keywords:cesarean section, BloodStop, myometrium, hemostatic agent, uterine scar, repair, ultrasound, morphological analysis, fibrosis, regeneration.

Cesarean section is one of the most commonly performed surgical interventions in obstetric practice, and its share has been steadily increasing worldwide in recent years. However, the morphological and functional incomplete formation of the postoperative uterine scar, the prevalence of fibroid remodeling processes in the myometrium, and the poor course of reparative processes increase the risk of serious complications in subsequent pregnancy and childbirth (2,5,8).

It is known that poor scar formation after cesarean section is associated with uterine wall thinning, scar insufficiency, the need for repeat cesarean section, and even the risk of uterine rupture. Therefore, optimizing myometrial repair and ensuring physiological regeneration is one of the urgent problems in obstetrics and gynecology (3,9,10).

Although topical hemostatic agents are widely used today, most of them do not completely eliminate inflammatory-dystrophic changes and in many cases cannot limit

the processes of fibrotic remodeling. This determines the need for the use of new, biocompatible and modern hemostatic materials that physiologically direct reparative processes (1,7).

The use of oxidized cellulose-based collagen membranes, such as BloodStop, may reduce the inflammatory response in the myometrium, improve microcirculation, and redirect regeneration processes from a fibrotic direction toward physiological recovery. However, the effect of this agent on myometrial repair after cesarean section, its morphological and morphometric characteristics, has not been sufficiently studied (4,6).

From this perspective, this study aims to clinically and experimentally evaluate the use of the BloodStop hemostatic agent in cesarean section, to determine its effect on myometrial repair and uterine scar formation, and is of significant scientific and practical importance for modern obstetric practice.

This research work describes the characteristics of the clinical and experimental material, as well as the morphological, ultrasound and statistical research methods used. The clinical part of the research work was carried out on the basis of the Interdistrict Perinatal Center No. 9 of Tashkent city and the Syrdarya regional branch of the state institution "Republican Specialized Scientific and Practical Medical Center for Maternal and Child Health".

The study included patients undergoing cesarean section and was divided into three groups: the main group (using the Blood Stop hemostatic agent), the comparison group (using conventional local hemostatic gels), and the control group (without the use of local hemostatic agents).

Assessment of myometrial status and postoperative scar formation was performed using ultrasound, Doppler ultrasound of uterine blood flow, and analysis of uterine linear parameters at early and long-term follow-up. Scar thickness and exostructure, radial artery status, peripheral vascular resistance, and microcirculation characteristics in the surgical area were studied.

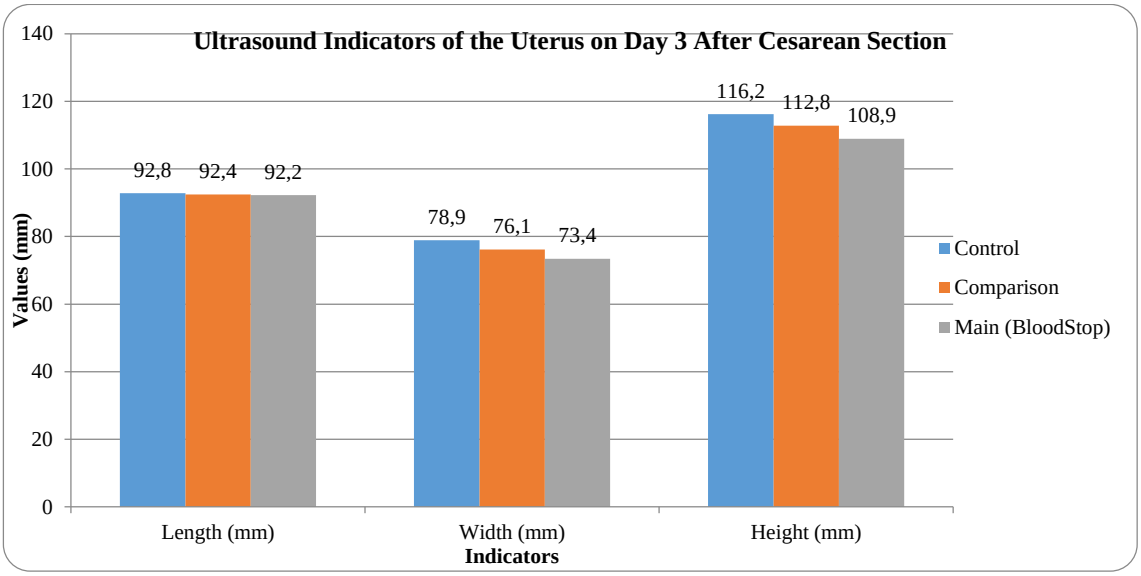
The experimental part of the study was carried out in laboratory animals by modeling surgical damage to the myometrium and the subsequent use of various hemostatic agents. Morphological examination included light microscopy stained with hematoxylin and eosin, assessing the severity of the inflammatory reaction, the degree

of dystrophic changes, the nature of fibrotic remodeling, and the preservation of the architectonics of the muscle layer.

The obtained data were analyzed morphometrically and statistically using generally accepted methods of variational statistics. The reliability of differences was assessed using parametric and nonparametric criteria with a statistical significance level of $p<0.05$.

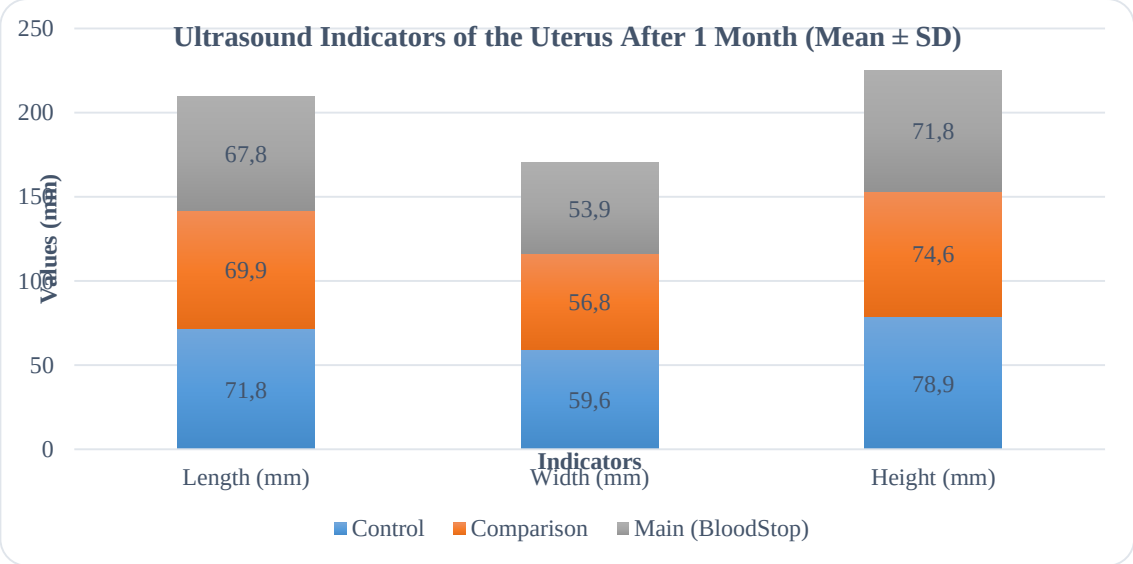
Results Patients were divided into three groups: control group (n=10) - without the use of local hemostatic agents; comparison group (n=12) - using standard hemostatic gels; main group (n=12) - using BloodStop collagen membrane based on modified oxidized cellulose. In all cases, the operation was performed using a single method through a transverse section of the lower uterine segment. The duration of the intervention did not differ statistically between the groups and was approximately 50 minutes on average ($r>0.05$). On the 3rd postoperative day, the length of the uterus did not differ significantly between the groups ($r>0.05$), while the width and height showed intergroup differences. The largest values of width and height were recorded in the control group, and the minimum values were recorded in the main group (Fig. 1).

Fig. 1. Ultrasound parameters of the uterus on the 3rd day after cesarean section (M ± SD)



After 1 month, a clear involution of the uterus was noted in all groups, but the most significant decrease in linear parameters was observed in the main group (Fig. 2).

Fig. 2. Ultrasound indicators of the uterus after 1 month (M ± SD)



By month 3, the trend was maintained: minimal uterine dimensions were noted in the main group, reflecting a more pronounced and consistent involution (Table 1).

Table 1. Ultrasound indicators of the uterus after 3 months (M ± SD)

Group	Length (mm)	Width (mm)	Height (mm)
Control	66.90 ± 1.40	56.80 ± 1.35	75.40 ± 1.45
Comparison	64.80 ± 1.35*	54.10 ± 1.30*	72.20 ± 1.40*
Home (BloodStop)	62.90 ± 1.30*	51.90 ± 1.25*	69.80 ± 1.35*

* r<0.05 compared to the control group.

On the 3rd day, the scar thickness in the control group was 4.1 ± 0.4 mm, in the comparison group - 4.8 ± 0.5 mm (r<0.05), in the main group - 5.6 ± 0.4 mm (r<0.05). The scar strength index was 0.42 ± 0.04; 0.50 ± 0.05 and 0.58 ± 0.04, respectively (r<0.05). The percentage of myometrial thinning was 58.3 ± 4.2%; after 1 month, the scar thickness increased to 5.6 ± 0.5 mm in the control group, 6.8 ± 0.4 mm in the comparison group and 7.9 ± 0.5 mm in the main group (r<0.05). The validity index reached 0.58 ± 0.05; 0.69 ± 0.04 and 0.80 ± 0.05. The percentage of thinning decreased to 42.1±3.6%; after 3 months, the scar thickness was 6.4±0.4 mm in the control group, 7.6±0.4 mm in the comparison group, and 8.8±0.3 mm in the main group (p<0.05). The significance index reached 0.66±0.04; 0.77±0.04 and 0.88±0.03, respectively. The minimum percentage of myometrial thinning was observed in the main group -

12.1±2.2%, in the control group - 33.7±3.0% ($p<0.05$). A statistically significant inverse correlation was found between scar thickness and uterine width ($r = -0.61$; $p<0.01$), as well as uterine height ($r = -0.58$; $p<0.01$). The scar strength index showed a more negative correlation with width ($r = -0.66$; $p<0.001$) and height ($r = -0.63$; $p<0.001$). The percentage of myometrial thinning was positively correlated with uterine width ($r = 0.69$; $p<0.001$) and height ($r = 0.65$; $p<0.001$). In addition, a strong positive correlation was found between scar thickness and its strength index ($r = 0.74$; $p<0.001$), as well as a significant negative correlation between scar thickness and percentage of myometrial thinning ($r = -0.78$; $p<0.001$). Thus, the use of BloodStop collagen membrane in cesarean section promotes the formation of a thicker, structurally organized and functionally strong scar, accelerates uterine involution and is associated with a minimal percentage of myometrial thinning. The obtained data confirm the morpho-functional advantages of this local hemostasis method in the early and long term after operative delivery.

The next part of our study was an experimental one, in which a comparative morphological assessment of reparative processes in the myometrium after cesarean section was carried out in three groups of animals: control (without local hemostatics), experimental (traditional hemostatic gels) and basic (BloodStop). The dynamics of changes was analyzed on days 7, 14, 21, 30 and 60 after surgery. The severity of morphological disorders was quantitatively assessed by calculating the total score according to the Perepelova TA scale (scatter of smooth muscle bundles, disorganization, hydropic dystrophy, isolation of myocytes). The lack of a local hemostatic effect was accompanied by a poor outcome with a predominance of inflammatory-dystrophic and fibrotic processes. On the 7th day, a pronounced inflammatory reaction (hyperemia, vascular congestion), interstitial edema, and a violation of the architectonics of the muscle layer were detected in the incision area (Fig. 1). Dystrophic changes in smooth muscle cells were mainly expressed by moderate and high-grade hydropic (vacuolar) dystrophy, which reflected a violation of intracellular homeostasis and a decrease in the functional capacity of myocytes. By day 14, a massive increase in connective tissue with the formation of intertwining layers and separation of smooth muscle bundles was noted, inflammatory infiltration (mainly macrophages and lymphocytes) remained, which indicated early activation of the fibroblastic repair pathway and a tendency to a fibrotic type of endometrium (Fig. 2).

By day 21, signs of disorganization of the myometrium and activation of the fibroblastic pathway in the suture area increased in 30% of animals: dense fibrous areas were formed that partially squeezed out muscle fibers; In a number of cases, a cell capsule was formed around the suture material with the participation of fibroblasts and macrophages, which corresponded to a prolonged inflammatory-proliferative process. By day 30, further fibrosis was noted: connective tissue replaced smooth muscle fibers in some places, forming dense fibrous areas. By day 60, fibrosis processes prevailed with the formation of hyaline connective tissue and persistent disruption of the myometrial architectonics. Morphologically, irregular arrangement of muscle fibers, pronounced venous engorgement were noted. In 60% of animals, the bundles retained a relatively typical orientation, but in 20% of animals, massive areas of connective tissue were found between them, and in another 20% of animals, signs of incomplete regeneration were detected with thinning and disorientation of muscle fibers.

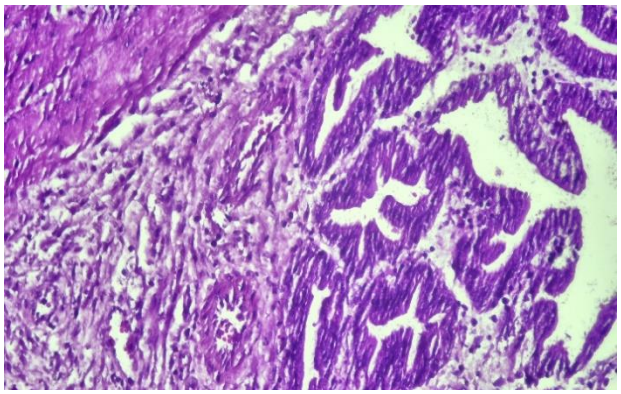


Figure 1. Myometrium in the area of the incision on the 7th postoperative day (control group). Strong inflammatory reaction, hyperemia and engorgement of blood vessels, interstitial edema, disruption of the architectonics of the muscle layer. Hematoxylin-eosin staining. Close-up. ×200.

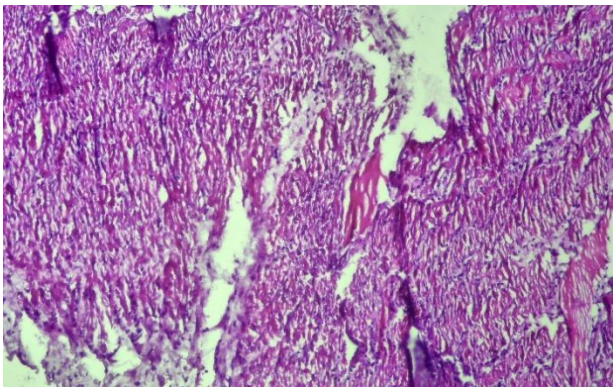
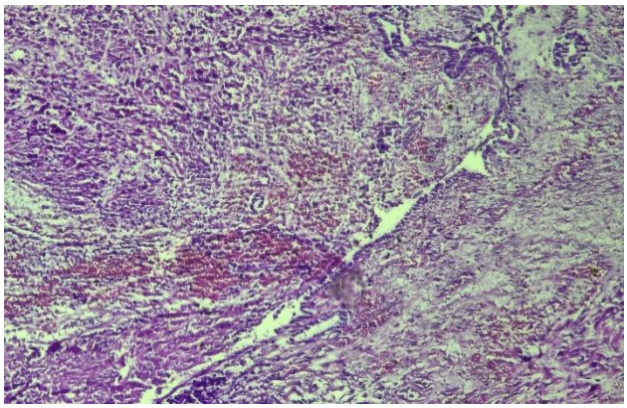


Figure 2. Myometrium in the area of the incision on the 14th day after surgery (control group). Massive growth of connective tissue with the formation of interstitial layers and separation of smooth muscle bundles, persistent inflammatory infiltration (macrophages, lymphocytes). Signs of activation of the fibroblastic component of repair and a tendency to a fibrous type of

endometrium. Hematoxylin-eosin stain. Ultraviolet. ×200.

In 60% of cases, a significant expansion of the interfibrous spaces was noted, in some animals interstitial edema and scattered smooth muscle cells were preserved. The sum of the signs corresponded to the formation of a morphologically and functionally insufficient scar. Quantitative assessment showed that the average total score in the control group was 4.40±1.88, which reflects moderate and in some places severe structural disorders. Hydropic dystrophy of myocytes and disorganization of muscle bundles made the greatest contribution to the overall score. The use of traditional local hemostatic gels led to a decrease in the severity of inflammatory-dystrophic changes and partial preservation of myometrial architectonics compared to controls, but fibrotic remodeling was not completely eliminated.

On day 7, weakly expressed hydropic dystrophy of myocytes was detected focally, mainly in the outer layers; the coarse disorganization of smooth muscle bundles, characteristic of controls, was usually not observed. By day 14, weakly expressed inflammatory phenomena (single macrophages and lymphocytes) were noted, interstitial edema was of a moderate nature and was not detected in all observations. Massive infiltration and pronounced disorganization were not noted during these periods. On day 30, local activity of inflammatory-reparative processes (macrophages, single neutrophils) remained without significant destruction of muscle elements; a moderate increase in connective tissue layers was noted between individual large bundles of myocytes (Fig. 3).



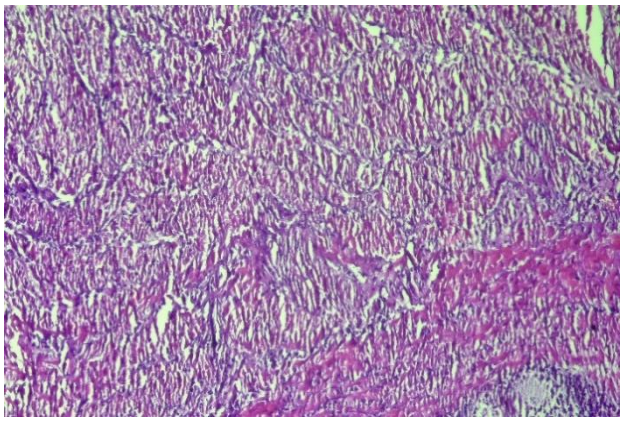


Figure 3. Myometrium in the area of the incision on the 30th day after surgery (group using conventional local hemostatic gels). Local activity of inflammatory-reparative processes (macrophages, single neutrophils), moderate enlargement of the intertwining connective tissue layers without significant destruction of smooth muscle fibers. Hematoxylin-eosin stain. Magnification. ×200 (objective ×20, eyepiece ×10).

Figure 4. Myometrial incision site 60 days after surgery (control group). Marked fibrosis, formation of hyaline connective tissue, and persistent disruption of muscle layer architecture. Hematoxylin-eosin stain. Magnification. ×200 (objective ×20, ocular ×10).

By day 60, collagen fibers were detected in the intertwining spaces, corresponding to the formation of the connective tissue component of the scar; at the same time, fibrosis was moderate, without massive replacement of smooth muscle fibers and hyaline, characteristic of the control group (Fig. 4). The total score on the Perepelova TA scale was 3.33±1.60, which confirms the less pronounced structural damage compared to the control group. Isolation of myocytes was noted very rarely and mainly singly; scattering and disorder often corresponded to a weak (+) or moderate (++) degree. The use of BloodStop was accompanied by the most favorable course of reparative processes: minimal inflammatory reaction, preservation of the spatial structure of the muscle layer and the formation of a thin, functionally complete scar.

By day 7, as a rule, no obvious pathological changes were observed: inflammation was minimal, interstitial edema was absent or weakly expressed; smooth muscle bundles retained their usual orientation, gross disorganization was not noted; myocyte dystrophy was occasionally detected. By day 14, single macrophages/lymphocytes were detected without chronic signs; connective tissue elements were formed in the form of thin fibers, mainly along the periphery, without massive expansion of the intertwining layers. By day 30, a thin connective tissue capsule was formed in the scar area without gross replacement of muscle fibers; rather, fibrosis, rather than remodeling, processes of regeneration prevailed. By day 60, restoration of architectonics was noted: orderly orientation of myocytes, minimal intertwining

connective tissue layers, no signs of massive fibrosis; dystrophic changes were of a limited nature and did not affect the general morpho-functional state of the tissues. The total score on the Perepelova TA scale was 2.58±0.99 - this is the lowest among all groups, which reflects the minimal expression of destructive-disorganizational changes and optimization of repair. The absence of local hemostatics (control) leads to significant inflammatory-dystrophic changes and the predominance of the fibrotic reparative direction with morphologically and functionally insufficient scar formation (4.40±1.88 points). Traditional hemostatic gels reduce the severity of damage (3.33±1.60 points), but do not exclude moderate fibrotic remodeling. The use of BloodStop provides the most optimal morphological recovery option with preserved myometrial architectonics and minimal expression of pathological signs (2.58±0.99 points), which confirms its organ-preserving potential.

Thus, in the control group, myometrial repair after cesarean section proceeded in an unfavorable direction, characterized by pronounced inflammatory-dystrophic changes and a predominance of fibrotic adhesion (4.40±1.88 points). Although traditional hemostatic gels partially reduced these changes, complete morphological restoration was not achieved (3.33±1.60 points). When BloodStop was used, a minimal inflammatory reaction, preservation of myometrial architectonics, and the formation of a functionally more complete, finely organized scar were observed (2.58±0.99 points).

Thus, the BloodStop hemostatic agent supports physiological regeneration in the myometrium, reduces fibrotic remodeling, and contributes to the formation of a functionally complete postoperative scar.

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