American Journal of Surgery Case Reports

Research Article

Bactericidal Activity of Blood Serum During the Adaptation of the Operated Organism to Hyperoxia

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Abstract

Aim: To study the reactions of the bactericidal activity of blood serum to Gram (+) and Gram (-) microflora on a three-day course of HBO during Liver Resection (LR).

Materials and Methods: Experiments were conducted on 42 white rats (females) weighing 180 g - 220 g. LR was performed by removing part of the left lobe of the liver (15% - 20% of the body weight). HBO in 3 ata mode (303.9 kPa) - 50 min was carried out 4-8, 24 and 48 hours after LR. On the 3rd and 7th days of the postoperative (accordingly, 1st and 4th days of the posthyperoxic) period, the Bactericidal Activity of Serum (BAS) of Arterial Blood (AB, aorta), Portal Vein Blood (PVB) and Hepatic Vein Blood (HVB) to *Staphylococcus aureus* (strains 209 and 1726), *E. soli* (strain K-12), *S. enteriridis* and *S. choleraesuis*.

Results: Under the conditions of the use of HBO, the inhibitory effect of LR on the BAS of AB, PVB and HVB to *S. Aureus* 209 is limited, but the similar effect of surgery on the BAS of blood to *S. Aureus* 1726 remains. At the same time, the reduction of BAS AB to *E. Coli* caused by LR is selectively inhibited, but the inhibitory effect of LR on BAS AB to *S. enteriridis* and *S. choleraesuis* increases. At the same time, BAS AB, PVB and HVB to *S. choleraesuis* is completely suppressed. The cessation of hyperoxic exposure leads to an increase in the inhibitory effect of RP on BS to *S. Aureus* 209 on the 4th day of the posthyperoxic (7th day after the postoperative) period. This is manifested by its complete suppression in AB, PVB and HVB. At the same time, the BAS to *S. Aureus* 1726 remains reduced. On the 4th day of the posthyperoxic period, the BAS of AB and PVB to E. coli remained reduced and the BAS of blood to *S. enteriridis* and *S. choleraesuis*, suppressed during a three-day course of HBO, began to recover.

Conclusion: The bactericidal activity of sera of blood flowing in and out of the operated liver in relation to *S. Aureus*, *E. coli*, *S. enteriridis* and *S. choleraesuis* have different sensitivity to hyperoxic effects. This is reflected in the nature of its changes as when adapting to the course application of HBO, so it is in the dynamics of its changes after its completion.

Keywords: Adaptation; Bactericidal activity; Serum; Hyperoxia; Liver resection

Introduction

Despite the successes achieved in the treatment and prevention of infectious complications in critical conditions and surgical interventions [1,2], the problem of increasing antimicrobial protection of the body remains relevant [3,4]. This determined not only the need to study the role of the microbiota of the human body in the development of infectious complications [5], but also further study of the mechanisms of antimicrobial protection of the body during its adaptation to various pathological influences [6-8].

From the point of view of general pathology, any surgical intervention is an extreme irritant (stress factor) for the body [9], which, in addition to pathological reactions, causes activation of protective and adaptive mechanisms [4]. Their condition, including the innate immunity responsible for antimicrobial protection of the body, at the time of surgery determines the risk of postoperative complications. This is of particular importance during surgery on the liver, which takes an active part in the antimicrobial protection of the body, in particular, regulating the bactericidal properties of blood [7,10,11].

One of the methods of prevention of postoperative complications is Hyperbaric Oxygenation (HBO) [12]. In particular, its ability to eliminate violations of the phagocytosis-regulating function of the liver after partial hepatectomy has been shown [11], as well as to regulate the mechanisms of adaptation of the operated organism to surgical intervention on the liver [13]. Meanwhile, the effect of HBO on the bactericidal properties of blood serum flowing through the operated liver remains unexplored.

The purpose of this work is to study the reaction of the bactericidal activity of blood serum to Gram (+) and Gram (-) microflora on a three-day course of HBO during liver resection.

Material and Methods

Experiments were conducted on 42 white rats (females) weighing 180 g - 220 g. in the experimental laboratory of the Department of Normal Physiology (Head - Professor V.N. Yakovlev) Voronezh State Medical Academy named after N.N. Burdenko. The research was approved by the Ethics Committee of the Voronezh State Medical

Citation: Savilov PN, Dyachkova SYA, Kuznetsova NI, Turovsky AV. Bactericidal Activity of Blood Serum During the Adaptation of the Operated Organism to Hyperoxia. Am J Surg Case Rep. 2025;6(1):1156.

Publisher Name: Medtext Publications LLC

Manuscript compiled: Mar 07th, 2025

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Academy. Liver resection was performed under ether anesthesia by removing part of the left lobe of the liver, which was 15-20% of the body weight. Hyperbaric Oxygenation (HBO) was performed with medical oxygen three times, one session per day in a therapeutic mode of 3 ata (303.9 kPa) - 50 minutes 4-8, 24 and 48 hours after liver resection. The animals were divided into 5 series of experiments. 1 series - healthy animals (norm), 2 and 3 series-animals examined, respectively, on the 3rd and 7th days after liver resection. These series served as a control to identify the "pure" effect of HBO. Series 4 and 5 were oxygenated animals with liver resection, studied, respectively, on the 3rd and 7th days of the postoperative (1st and 4th days of the posthyperoxic) period, respectively. The object of the study was Arterial Blood serum (AB), which was obtained from the aorta, Portal Vein Blood (PVB) and Hepatic Vein Blood (HVB). The latter was obtained from the interlobular venous sinus, after its isolation in situ from the posterior vena cava. The sequence of blood sampling: hepatic veins- portal vein-aorta. Blood sampling with subsequent removal of animals from the experiment by decapitation was carried out against the background of ethaminal anesthesia (40 mg of sodium ethaminal/kg of weight). Gram (+) microorganisms: Staphylococcus aureus (*S. Aureus*) strains 209 (pathogenic) and 1726 (conditionally pathogenic); Gram (-) microorganisms: *E. coli* (*E. coli*) strain K-12 and Salmonella (*S. Enteriridis* and *S. Choleraesuis*) were used to determine the bactericidal activity of blood serum by test microbes. The determination of the bactericidal activity of serum to these microorganisms was carried out by the cup method with the determination of the Bactericidal Index of Serum (BIS): BIS=Con/Ex, where Con (control) is the number of colonies grown on the control area, Exp (experience) is the number of colonies grown on the experimental area of lamellar agar [10].

Statistical processing of the obtained data was carried out using the program "Statistica 10.0" (Dell Inc., USA). The Shapiro-Wilk test revealed a difference in the distribution of most signs from the normal one. Therefore, the results of the studies are presented in the form of a median, as well as 25% and 75% quartiles (Me (Q25; Q75)). The statistical significance of the differences was assessed using the Wilcoxon criterion for dependent groups and the Mann-Whitney criterion for independent groups. The differences were considered statistically significant at $p<0.05$.

Results

Normal (1 series) The portal vein blood BIS (PVB) to *S. Aureus* 209 and 1726, *E. coli*, *S. enteritidis* and *S. choleraesuis* was significantly lower than similar Arterial Blood (AB) indices, respectively, by 12%, 14%, 17%, 14% and 13%. In turn, the BIS of Hepatic Vein Blood (HVB) was significantly reduced in relation to both strains of *S. Aureus*, *E. Coli* and *S. Choleraesuis* in AB, respectively, by 31%, 27%, 52% and 37%; in PVB, respectively, by 22%, 15%, 30% and 37% (Table 1).

Liver resection caused the disappearance by the 3rd day of the postoperative period of a significant difference in the BIS to the studied strains of Gram (+) and Gram (-) microflora between the blood flowing in and out of the liver. This was accompanied by a significant decrease in AB, PVB and HVB relative to the norm of BIS to *S. Aureus* 209, respectively, by 42%, 34% and 21%; BIS to *S. Aureus* 1726, respectively, by 45%, 30% and 23% (Table 1). The BIS to *E. Coli* and *S. Choleraesuis* in the HVB on the 3rd day after liver resection did not significantly differ from the norm, while the BIS to *S. Enteritidis* in it decreased by 26% (Table 1). Meanwhile, in AB, the decrease in BIS to *E. soli*, *S. Enteritidis* and *S. Choleraesuis* compared to the norm was, respectively, 59%, 48% and 52%; whereas in PVB, a significant decrease was noted only for BIS to *E. Coli* and *S. Enteritidis*, respectively, by 36% and 40% (Table 1). Comparison of the obtained results shows that the bactericidal activity of PVB and HVB sera in relation to *E. Coli* and *S. Choleraesuis* was the most resistant to the inhibitory effect of liver resection, and the bactericidal activity in relation to *S. Aureus* 209 was the least stable.

The use of a three-day course of HBO after liver resection did not reveal significant differences in BIS to both strains of staphylococcus compared with animals of the 2nd series on the 3rd day of the postoperative (1st day of the posthyperoxic) period (Table 1). In relation to the norm, the BIS to *S. Aureus* 209 was significantly reduced (by 31%) only in PVB, while the BIS to *S. Aureus* 1726 remained below it in AB, PVB and HVB, respectively, by 46%, 43% and 29% (Table 1). In oxygenated animals on the 3rd day after liver resection, the BIS to *E. coli* in AB selectively (by 34%) increased compared to the same indicator of animals of the 2nd series, but relative to the norm, it was reduced by 43% (Table 1). At the same time, on the 3rd day of the combination of liver resection and HBO, a significant (by 16%) decrease in BIS to *S. Enteritidis* in AB compared to animals of the 2nd series of experiments was revealed, while its decrease in AB, PVB and HVB relative to the norm was, respectively, 56%, 62% and 30% (Table 1). On the 3rd day of the use of HBO in operated animals, the BIS to *S. Choleraesuis* in AB, PVB and HVB was 1.0. This indicates a complete suppression of the antimicrobial properties of the serum to this microbe.

Consequently, in operated animals under the conditions of course use of HBO: a) the inhibitory effect of liver resection on the bactericidal activity of sera in AB, PVB and HVB to *S.aureus* 1726 remains; b) selectively eliminates the inhibitory effect of liver resection on the bactericidal activity of serum AB and PVB to *S. Aureus* 209; c) the inhibitory effect of liver resection on the bactericidal activity of serum in AB to *E. coli* is selectively weakened, but the inhibitory effect of the operation on the bactericidal activity of serum in AB and PVB to *S. enteritidis* is enhanced; d) the bactericidal activity of serum to *S. Choleraesuis* is completely suppressed in AB, PVB and HVB.

A study of the bactericidal activity of blood serum on the 7th day after liver resection (Series 3) did not find (Table 2) significant differences of BIS in relation to the studied strains of Gram (+) and Gram (-) microorganisms in comparison with 3 knocks of the postoperative period (2 series). Compared with the norm, the BIS to *S. Aureus* 209 in AB, PVB and HVB was reduced, respectively, by 42%, 34% and 17%, while the BIS to *S. Aureus* 1726, respectively, by 47%, 41% and 28% (Table 2). Compared with the norm, a significant decrease in BIS to *E. coli* on the 7th day after liver resection was detected in AB and PVB, respectively, by 41% and 31%, while BIS to *S. enteritidis* in AB, PVB and HVB did not significantly differ from it (Table 2). Consequently, on the 7th day of the postoperative period, the inhibitory effect of the operation on the bactericidal activity of the serum of AB and PVB and to both strains of *S. Aureus*, *E. Coli* and *S. Choleraesuis* remains, but is weakened in relation to *S. Enteritidis*.

In operated rats who received a three-day course of HBO, by the 4th day of the posthyperoxic (7th day of the postoperative) period (series 5), there was a significant decrease in BIS to *S. Aureus* 209 in AB, PVB and HVB, respectively, by 32%, 14% and 21% compared to the same indicator of animals 4th series of experiments (1st day of the posthyperoxic period). This was accompanied by a selective (by 42%) increase in BIS to *S. Choleraesuis* in PVB. Significant differences of

Table 1: Bactericidal index of rat serum to Gram (+) and Gram (-) microflora on the 3rd day of postoperative (1st day of posthyperoxic) period (Me (Q25; Q75)).

№	series of experiments	number of animals	arterial blood	portal vein blood	hepatic veins blood
S. Aureus 209					
1	norm	10	1,92 [1,81;2,30]	1,69▼ [1,59;1,77]	1,32▼▲ [1,25;11,36]
2	LR	8	1,10* [1,04;1,14]	1,11* [1,06;1,11]	1,04* [1,03;1,12]
4	LR+HBO	8	1,50 [1,14; 1,95]	1,16* (1,09;1,29]	1,27 (1,06; 1,50)
S. Aureus 1726					
1	norm	10	2,10 [1,88;2.36]	1,81▼ [1,60;2,01]	1,54▼▲ [1.44;1,58]
2	LR	8	1,15* [1,11;1.38]	1,18*[1,15;1,31]	1,18* [1,11;1,25]
4	LR+HBO	8	1,13* (1,05;1,21)	1,04*(1,00; 1,13)	1,10* (1,00; 1,15)
E. Coli					
1	norm	10	3,39 [2,70;3,95]	2,82▼ [2,23;3,10]	1,63▼▲ [1,44;1,85]
2	LR	8	1,43* (1,27; 2,06)	1,83* (1,27; 2,08)	1,89 (1,73; 2,50)
4	LR+HBO	8	1,92*• (1,24;2,38)	1,71 (1,23; 2,29)	1,43 (1,19; 2,06)
S. Enteritidis					
1	norm	10	2,26 [1,76;3,10]	2,00▼ [1,67;2,53]	1,58 [1,31;2,45]
2	LR	8	1,18* (1,15;1,60)	1,20* (1,15;1,54)	1,12* (1,11; 1,61)
4	LR+HBO	8	1,02*• (1,00;1,13)	1,06* (1,00;1,20)	1,10* (1,00; 1,11)
S. *Choleraesuis*					
1	norm	10	3,28 [2,15;5,01]	2,87▼ [1,83;4,65]	1,92▼▲ [1,45;3,00]
2	LR	8	1,55* (1,24; 1,91)	1,89 (1,54; 2,00)	1,45 (1,15; 1,91)
4	LR+HBO	8	1,00*• (1,00;1,02)	1,00*• (1,00;1,00)	1,04*• (1,00; 1,10)

LR: Liver Resection; HBO: Hyperbaric Oxygenation; ▼▲: ($p<0.05$)- the reliability of differences compared to arterial and portal blood of this series of experiments, respectively, *($p<0.05$): The reliability of differences compared to the norm (1 series); ●($p<0.05$): The reliability of differences compared to with a similar indicator of the 2nd series of experiments.

Table 2: Bactericidal index of rat serum to Gram (+) and Gram (-) microflora on the 7th day after the surgical (4th day of posthyperoxic) period (Me (Q25; Q75)).

№	series of experiments	number of animals	arterial blood	portal vein blood	hepatic veins blood
S. Aureus 209					
1	norm	10	1,92 [1,81;2,30]	1,69▼ [1,59;1,77]	1,32▼▲ [1,25;11,36]
3	LR	8	1,13*[1,11; 1,19]	1,09* [1,02; 1,23]	1,10* [1,06; 1,12]
5	LR+HBO	8	1,04*• [1,00;1,21]	1,00*• [1,00; 1,06]	1,00*• [1,00; 1,11]
S. Aureus 1726					
1	norm	10	2,10 [1,88;2.36]	1,81▼ [1,60;2,01]	1,54▼▲ [1.44;1,58]
3	LR	8	1,11* [1,06; 1,25]	1,06* [1,00; 1,17]	1,11* [1,02; 1,22]
5	LR+HBO	8	1,06* [1,00; 1,13]	1,19* [1,06; 1,25]	1,20* [1,06; 1,34]
E. coli					
1	norm	10	3,39 [2,70;3,95]	2,82▼ [2,23;3,10]	1,63▼▲ [1,44;1,85]
3	LR	8	1,73* [1,22; 2,54]	2,00* [1,15; 2,06]	2,05 [1,78; 2,35]
5	LR+HBO	8	2,16* [1,72; 3,09]	1,83* [1,38; 2,25]	2,02 [1,67; 2,80]
S. Enteritidis					
1	norm	10	2,26 [1,76;3,10]	2,00▼ [1,67;2,53]	1,58 [1,31;2,45]
3	LR	8	1,38 [1,11; 2,46]	1,44 [1,12; 1,99]	1,27 [1,17; 1,84]
5	LR+HBO	8	1,04*• [1,00;1,11]	1,04*• [1,00;1,14]	1,07*• [1,00; 1,14]
S. *Choleraesuis*					
1	norm	10	3,28 [2,15;5,01]	2,87▼ [1,83;4,65]	1,92▼▲ [1,45;3,00]
3	LR	8	1,68* [1,34; 2,38]	1,45* [1,23; 1,85]	1,46 [1,15; 1,88]
5	LR+HBO	8	1,04*• [1,00;1,14]	1,06*• [1,00; 1,18]	1,10*• [1,02; 1,11]

LR: Liver Resection; HBO: Hyperbaric Oxygenation; ▼▲($p<0.05$): The reliability of differences compared to arterial and portal blood of this series of experiments, respectively; *($p<0.05$): The reliability of differences compared to the norm (1 series); ● ($p<0.05$): The reliability of differences compared to with a similar indicator of the 3rd series of experiments.

BIS AB, PVB and HVB to *S. Aureus* 1726, *E. Coli* and *S. Enteritidis* in animals of the 4th and 5th series of experiments were not detected.

Comparison with animals of the 3rd series of experiments revealed a significant decrease in the operated oxygenated rats by the 4th females of the posthyperoxic period in the bactericidal activity of serum to *S. Aureus* 209 in AB, PVB and HVB, as a result of BIS=1.0 (Table 2). This indicates a complete suppression of the bactericidal activity of serum flowing through the operated liver of blood to *S. Aureus* 209, which was not observed in relation to the bactericidal activity of serum to *S. Aureus* 1726. Without showing significant differences compared to the animals of the 3rd series of experiments, the BIS to *S. Aureus* 1726 in AB, PVB and HVB remained below normal, respectively, by 50%, 35% and 33% (Table 2). Compared with the animals of the 3rd series of experiments on the 4th day of the posthyperoxic period, a significant decrease in BIS to *S. enteritidis* was found in the animals of the 5th series in AB, PVB and HVB respectively, by 25%, 28% and 16%; whereas the BIS to *S. Choleraesuis* was reduced, respectively, by 38%, 27% and 25% (Table 2). Compared with the BIS norm, *S. enteritidis* and *S. Choleraesuis* also remained significantly reduced in AB, PVB and HVB, but at the same time, unlike animals of the 4th series, exceeded one (Table 2). BIS to *E. Coli* remained significantly reduced only in AB and PVB, respectively, by 36% and 35% (Table 2). Consequently, the cessation of hyperoxic effects in operated animals has an ambiguous effect on the bactericidal activity of serum to the studied strains of Gram (+) and Gram (-) microflora.

Discussion

It is well known that the bactericidal activity of serum is the ability of fresh blood to cause the death of bacteria that have penetrated or introduced into it. This is achieved due to the presence in it of both non-specific (lysozyme, β-lysines, proteins of the compliment system,

properdin, etc.) and specific (antibodies) humoral immunity factors [14]. Analysis of the results obtained by us will allow us to say that under normal conditions in mammals (rats), part of the humoral factors determining the bactericidal activity of blood serum in relation to *S. Aureus*, *E. Coli*, *S. Enteritidis* and *S. Choleraesuis* is secreted into the lumen of the gastrointestinal tract, possibly taking part in the regulation of its microbiota. Some of these substances are retained in the liver, which explains the significant difference in the values of the BIS of blood flowing in and out of the liver. At the same time, it should not be about the destruction of these antimicrobial factors, but about their deposition. This is indicated by the discrepancy found by us (Tables 1 and 2), after liver resection, in the degree of reduction of BIS in the blood flowing in and out of the operated organ. Another reaction aimed at reducing the bactericidal activity of blood serum in the operated organism may be the cessation of partial secretion into the gastrointestinal tract of humoral factors determining the bactericidal activity of serum in relation to *S. Aureus*, *E. Coli*, *S. Enteritidis* and *S. Choleraesuis*. This is supported by the discrepancy between the degree of decrease in the BIS of arterial blood and portal vein blood after liver resection (Tables 1 and 2). The selectivity of reducing the bactericidal activity of the serum of the operated organism indicates a different sensitivity to liver resection of physiological processes that regulate the content of humoral factors in the blood that determine the antistaphylococcal, anticolibacterial and antisalmanellosis activity of its serum.

The use of a three-day course of HBO in the 3 ata-50 min mode after liver resection showed that hyperbaric oxygen has an ambiguous effect on the bactericidal activity of blood serum in relation to the studied microbes. At the same time, we found a weakening in the conditions of the course use of HBO of the inhibitory effect of liver resection on the bactericidal activity of serum AB to *S. Aureus* 209 (Table1), it can be considered as a result of a decrease in the catabolism of antistaphylococcal humoral factors in hyperoxia and (or) the cessation of their partial deposition in the part of the liver remaining after resection. It is no coincidence that the value of BIS HVB to *S. Aureus* 209 in oxygenated animals of the 4th series of experiments was within the normal range, unlike in non-oxygenated animals of the 2nd series of experiments (Table 1). This effect stopped after the completion of hyperoxic exposure, which led to the complete elimination of these substances from the blood by the 4th day of posthyperoxic period.

A completely different picture was found in the reaction to HBO of the antistaphylococcal activity of the blood serum of the operated organism to *S. Aureus*1726 (Table 1). It indicates the refractory to hyperbaric effects of mechanisms that cause a decrease in the content of humoral factors in the blood that determine the bactericidal activity of its serum against *S. Aureus* 1726 in the first three days of the postoperative period.

On the other hand, it should be noted the selective effect of hyperbaric oxygen on the bactericidal activity of serum in the arterial and venous blood of operated animals. For example, by stimulating the bactericidal activity of its serum to E. *Coli* in AB, it enhanced the inhibitory effect of liver resection on its bactericidal activity against *S. Enteritidis* and *S. Choleraesuis*. In the latter case, this was accompanied by suppression of serum bactericidal activity in the PVB (Table 1). In other words, there was a selective elimination of humoral factors determining the bactericidal activity of her serum to *S. Choleraesuis* from the blood flowing to the operated liver.

Heterogeneous sensitivity of antistaphylococcal, anti-colibacterium and antisalmatinella bactericidal serum to hyperoxia determined the dynamics of resistance to the studied microorganisms and in the posthyperoxic period. For example, selective suppression of the bactericidal activity of serum to *S. Aureus* 209 on the 4th day after the course of HBO was caused by the cessation of the inhibitory effect of hyperbaric oxygen on the similar ability of RP in relation to this link of antimicrobial protection of the body. Meanwhile, the bactericidal activity of serum to *S. Aureus* 1726, reduced in response to liver resection and refractory to hyperoxic effects, remained the same on the 4th day of the posthyperoxic period.

Without having a significant effect on the anti-bacterial activity of the blood serum of the operated organism, the cessation of hyperoxic exposure created conditions for the beginning of restoration of the antisalmanellosis activity of the blood serum in relation to *S. Enteritidis* and *S. Choleraesuis*, suppressed during the course of HBO use. It can be assumed that this was achieved by reducing the secretion of the corresponding antisalmanella humoral factors into the lumen of the gastrointestinal tract and their formation by cells of the reticuloendothelial system. If we consider that Gram (+) and Gram (-) microorganisms are at different stages of evolutionary development [15,16], then we can also talk about the phylogenetic aspect of the heterogeneous reaction to hyperoxia of humoral factors that determine the specific bactericidal activity of serum to the studied representatives of Gram (+) and Gram (-) microflora.

Conclusion

Studies have shown that liver resection, in the amount of 15% - 20% of the body weight, reduced the bactericidal activity of serum in the blood flowing to the liver to all the representatives of Gram (+) and Gram (-) microflora studied by us, whereas in the blood of hepatic veins, this was observed only for both strains of *S. Aureus* (209 and 1726) and *S. Enteritidis*. The bactericidal activity of portal and hepatic blood sera in relation to *E. Coli* and *S. Choleraesuis* was the most resistant to the inhibitory effect of liver resection, the least resistant was the bactericidal activity of blood serum to *S. Aureus* 209. The inhibitory effect of liver resection on antistaphylococcal, anti-bacterial and antisalmanellosis activity of blood serum persisted by the 7th day of the postoperative period.

A three-day course of HBO in the mode of 3 ata, 50 min, 1 session per day, used in the first three days after liver resection, caused ambiguous changes in serum bactericidal activity in AK, KVV and KPV in relation to the studied representatives of Gram (+) and Gram (-) microflora, both in the process of direct hyperoxic exposure, and after its completion. This depended not only on the source of serum production (arterial blood, portal vein blood, hepatic vein blood), but also sensitivity to the hyperoxic effects of humoral factors that evolutionarily determine the specificity of serum bactericidal activity in relation to a specific microbe. The most sensitive to the inhibitory effect of hyperbaric oxygen during liver resection was the bactericidal activity of serum to *S. Aureus* 209, the least to *E. coli*. The cessation of hyperoxic effects on the body stimulated the beginning of the restoration of antisalmanellosis activity of serum from the 4th day of the posthyperoxic period. This was accompanied by a selective increase in the delayed inhibitory effect of HBO on the anti-bacterial activity of the portal vein blood serum. At the same time, the bactericidal activity of serum flowing through the liver of blood to *S. Aureus* 209 was suppressed, as a result of the increased inhibitory effect of liver resection, while the bactericidal activity of serum flowing through the

operated liver of blood to *S. Aureus* 1726 was not restored by the 4th day of the posthyperoxic period.

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