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PREVENTION AND TREATMENT OF COMPARTMENT SYNDROME DURING CLOSED LOCKABLE INTRAMEDULLARY OSTEOSYNTHESIS OF TIBIA

[1]Tkach A. V., [2]Mykhaylichenko V. U., [3]Plotkin A. V., [4]Tihonenko Al. An., [5]Kobets Y. V., [6]Tihonenko An. Al. (un), [7]Baskakov P. N., [8]Babich T. Yu., [9]Bezrukov O. F.

[1]Doctor of Medicine, Professor, Department of traumatology and orthopedics - "V. I. Vernadsky Crimean Federal University" Medical Academy named after S. I. Georgievsky (structural subdivision) – AndreyT_71@mail.ru, [2]Doctor of Medicine, Professor, Department of General Surgery - "V. I. Vernadsky Crimean Federal University" Medical Academy named after S. I. Georgievsky (structural subdivision) – pancreas1978@mail.ru, [3] Doctor of Traumatology and Orthopedics Department, GBUZ RK "Emergency Hospital № 6» (Simferopol) - Irrit555@mail.ru, [4] Candidate of Medical Sciences, Associate Professor, Doctor traumatology and orthopedics GBUZ RK "Emergency Hospital №6» (Simferopol). tihonenckoand@yandex.ru, [5] Candidate of Medical Sciences, Associate Professor, Department of traumatology and orthopedics "V. I. Vernadsky Crimean Federal University" Medical Academy named after S. I. Georgievsky (structural subdivision) – ykobets@yandex.ru, [6] Student of - "V. I. Vernadsky Crimean Federal University" Medical Academy named after S. I. Georgievsky (structural subdivision) – tihonenckoand@yandex.ru, [7]Doctor of Medicine, Professor, Department of Obstetrics, Gynaecology and Perinatology - "V. I. Vernadsky Crimean Federal University" Medical Academy named after S. I. Georgievsky (structural subdivision) – petr.baskakov@gmail.ru, [8]Doctor of Medicine, Professor, Department of Obstetrics, Gynaecology and Perinatology - "V. I. Vernadsky Crimean Federal University" Medical Academy named after S. I. Georgievsky (structural subdivision) – 7047715@gmail.com, [9]Doctor of Medicine, Professor, Department of Surgery № 2 - "V. I. Vernadsky Crimean Federal University" Medical Academy named after S. I. Georgievsky (structural subdivision) – klinika_csmu@mail.ru.

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Abstract:

The aim of our study: to increase the effectiveness of prevention and treatment of compartment syndrome shin during locked reduction and osteosynthesis of the tibia shaft, based on preventive and semi-closed fasciotomy.

Methods of study: *The research is based on managing of 93 patients with tibia diaphysis fractures. Managing was made on BIOS in orthopedy and trauma department at GBUZ RK «Emergency Hospital № 6» (Simferopol) In most cases we have been using metal structures ChM (81 patients – 87,10%) 11,83% - Bliskunov's clamp, 1 case (1,07%) metal structures Stryker from 1992 to 2015. Medical surgery was made in orthopedic and trauma department of GBUZ RK «Emergence Hospital № 6» Simferopol.*

Conclusion: *based on the development and application of preventive fasciotomy from technological access for implantation of a blocking intramedullary rod, an effective method for the prevention of MGIS has been obtained. In 93, 7% of locked osteosynthesis of tibia MGIS (1-2 degree) appears. There was no MGIS in opened osteosynthesis. Increasing subfascial pressure in locked reposition with next using BIOS noticed in anterolateral and lateral shin cases. Preventive fasciotomy of shin from implantation locking rod dissections can prevent MGIS development.*

Keywords: *compartment syndrome, MGIS, intramedullary osteosynthesis.*

Corresponding author:
Tkach Andrey Viktorovich,
Professor of the department of traumatology and orthopedics, Medical Academy named after S.I. Georgievsky of Vernadsky CFU, Simferopol, Russia., E-mail: AndreyT_71@mail.ru

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INTRODUCTION:

Development of frequency MGIS (local hypertension ischemical syndrome or a compartment syndrome) in fractures 1 to 35%[2] confirms relevance of this problem. Probability is increasing in case of poly traumas and other shock conditions.

According to the literature, unsatisfactory results of managing limbs fractures depend on compartment syndrome [1]. Usually MGIS is developing in shin cases. These reasons are slow fusion, nonunion, forming false joint, forming fibrosis of soft tissues. All these conditions, including infection's complications, osteomyelities and neurological disorders are decreasing functionality of a limb. MGIS 3rd stage forming is an intention for an amputation.

According to the experimental data, main reasons of an compartment syndrome are local ischemia, reinforced by vessel spasm, which leads to vessel atonia, hypoxia. These processes destroy normal metabolism. Modeling MGIS dynamics of morphological changes throughout 4 hours shows fibrosis of soft tissues specific for compartment syndrome [9].

The aim of our study:

To increase the effectiveness of prevention and treatment of compartment syndrome shin during locked reduction and osteosynthesis of the tibia shaft, based on preventive and semi-closed fasciotomy.

Methods of study:

The research is based on managing of 93 patients with tibia diaphysis fractures. Managing was made on BIOS in orthopedy and trauma department at GBUZ RK «Emergency Hospital №6» (Simferopol) In most cases we have been using metal structures ChM (81 patients – 87,10%) 11,83% - Bliskunov's clamp, 1 case (1,07%) metal structures Stryker from 1992 to 2015. Medical surgery was made in orthopedic and trauma department of GBUZ RK «Emergence Hospital № 6» Simferopol. Distribution of patients with gender and age is described in table 1.

Table 1 - Distribution of patients with gender and age

Age (years)	Gender		total	
	man	women	all	%
21-40	18	1	19	20,43
41-60	44	14	58	62,37
61-70	11	4	15	16,13
71-80	0	1	1	1,07
total:	73	20	93	100

Distribution of implants according to sizes in described in table 2

Table 2. Calibers of intramedullary shafts using for BIOS of tibia

Caliber of shaft	Quantity of shafts	
	total	%
8	4	4,30
9	30	32,27
10	56	60,21
11	1	1,07
12	2	2,15

The lengths of shafts start from 250 to 390 mm.
Optimal range of intramedullary shafts for osteosynthesis tibia makes up 300 – 345mm.
Comparative diagram of the lengths of shafts is described in figure 1

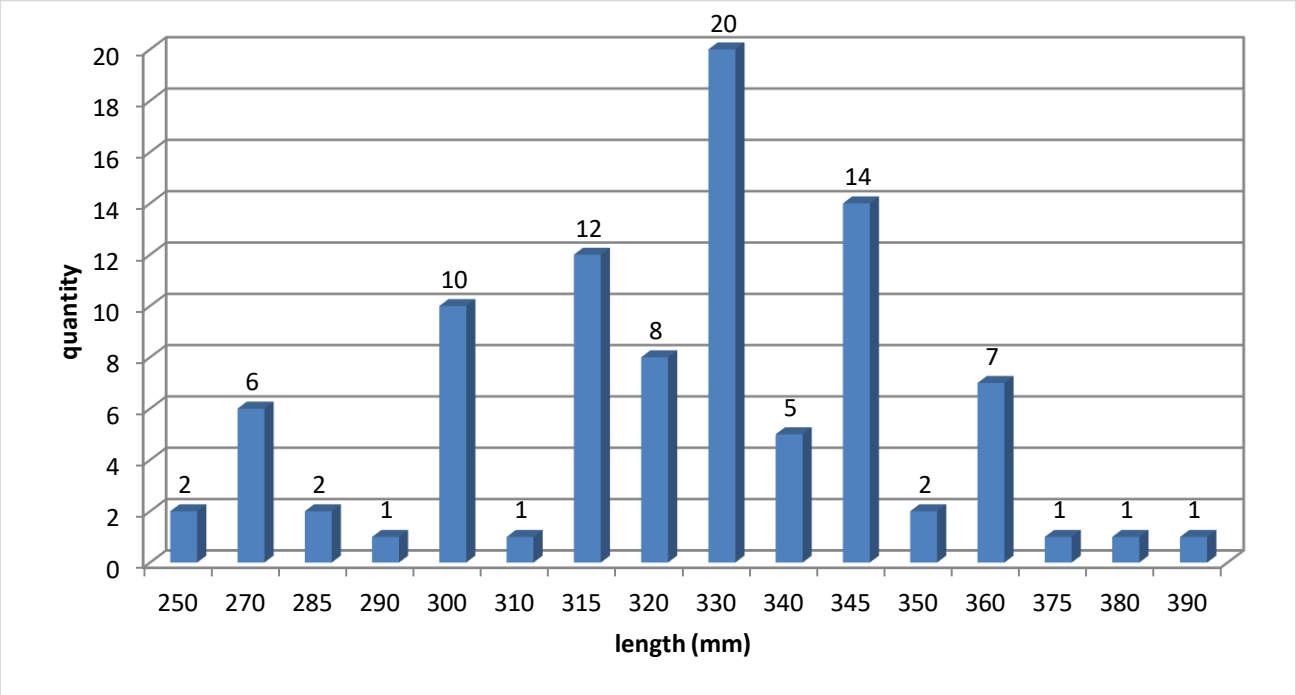


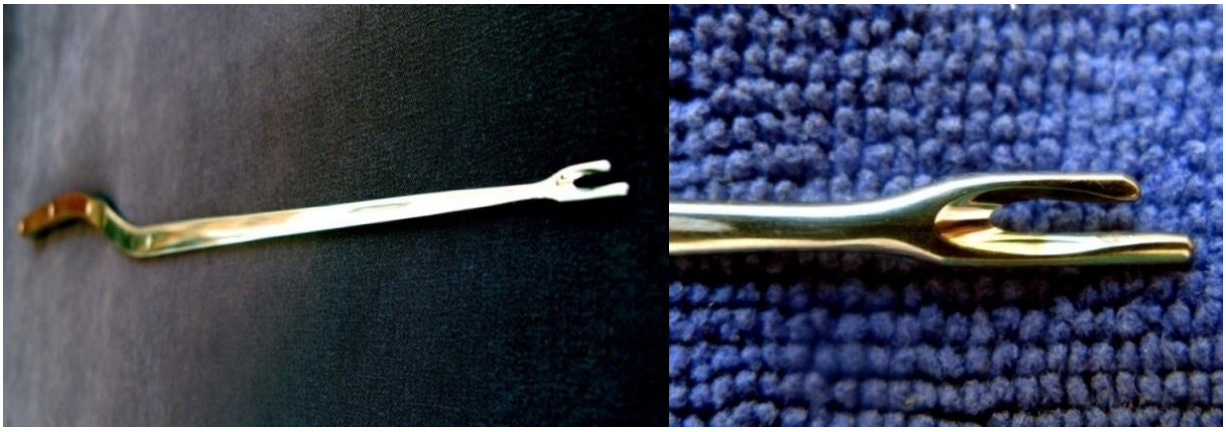
Figure 1. Comparative diagram of the lengths of shafts

Decompression fasciotomy of tibia during osteosynthesis was made in 27 cases (29%), in 66 cases (71%) osteosynthesis was made in classical technology.

Fasctiotomy can be made in 3 ways: opened, closed and semi-closed. We did not make an opened fasciotomy (dissection of the skin in proportion to the dissection of the fascia)

This method is not a preventive, but therapeutically. The intention for this surgery is local hypertension syndrome middle or a severe degree. According to our technology dissection was made in closed and semi-closed ways. Semi-closed fasctiotomy (dissection of the skin in the upper third of the leg, in the middle and lower third of the fascia is dissected using the fasciotome subcutaneously) was carried out in the anterior and anterolateral cases of the lower leg from the technological opening for implantation of an intramedullary fixator. The length of this access is 5-7 cm. The decompression of the posterior superficial and deep cases was carried out using closed technology (the skin is dissected only to ensure the introduction of the fasciotomy and the possibility of manipulation with it), from the technological section for the implantation of the proximal locking rod. The

length of this access starts form 1,0 – 1,5 cm. The look of fasciote is on the figure 1.



a) b)

Figure 1 – Fasciote: a – common view; b - working surface

Distribution of the patients with diaphysis fractures of tibia according the AO/ASIF classification described in table 3.

Table 3 - Distribution of the patients with diaphysis fractures of tibia according the AO/ASIF classification

Categories	A			B			C		
Severity	A1	A2	A3	B1	B2	B3	C1	C2	C3
Quantity	0	4	13	19	27	11	11	3	5
Summary	17			57			19		

Most cases are severe traumas (81, 72%) B category – 61, 29% and C category 20, 43% According to the literature these categories are causing local hypertension syndrome. There are no changes in closed intramedullar osteosynthesis of tibia during closed fasciotomy. Fasciotomy of 4 cases is made from usual accesses for implantation a rod (Fig. 2). [5, 8].

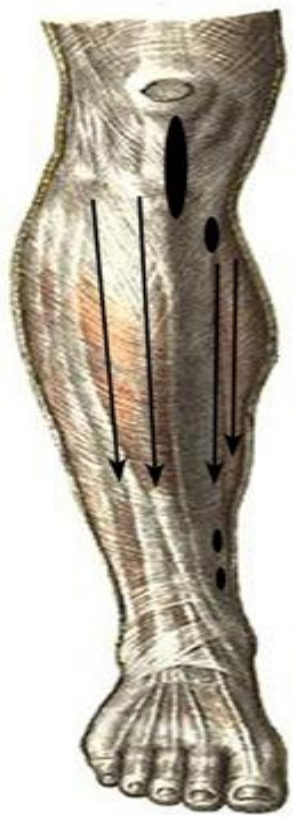


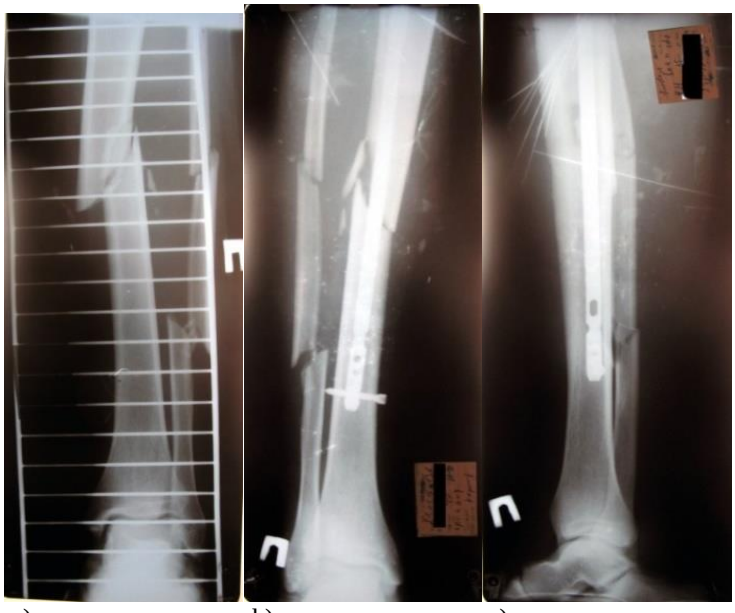
Figure 2. Place and direction of decompression tibia cases for BIOS implantation

RESULTS AND DISCUSSION:

Clinical example:

Patient № 1, women, 38 years old. Patient's card №731. Appeared in orthopedical and trauma department with next diagnosis: closed fracture of middle third tibia part, double fracture of fibia with displacement of fragments. Bruised head trauma. Alcohol intoxication.

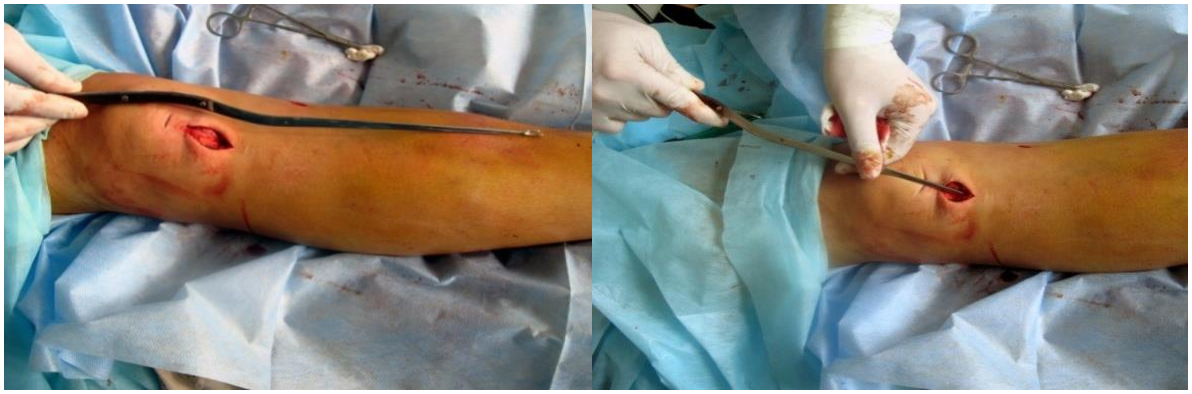
Localization and fracture pattern closed reposition and BIOS of tibia is recommended.



a) b) c)

Figure 3 - X-rays of patient № 1: a) at appearing b) - c) after blocked intramedullar osteosynthesis

Next stage after closed reposition and osteosynthesis was fasctiotomy. Fasciotomy of the anterolateral and lateral case is initially performed from the access for fixation implantation (Fig. 4).



a) b)

c) d)

Figure 4 – Stages of fasciotomy: a) planning the direction and length of fasciotomy of the anterolateral and lateral cases with the help of a fasciotomy; b) determining the location of the case (anterolateral) to begin fasciotomy; c) the beginning of fasciotomy of the anterolateral case; d) completion of fasciotomy of the anterolateral case

Given that fasciotomy is performed in a closed way with the help of special tools "fasciotom", it is necessary to clearly define the boundaries of the cases and the direction of fasciotomy (Fig. 5).

After decompression of the front cases, the rear superficial and profundus rear cases are decompressed according to the same principles.

a) b)

Figure 5 – Stages of fasciotomy: a) - beginning of fasciotomy of the posterior superficial and posterior profundus cases from the technological access for implantation of the proximal locking screw; b) completion of fasciotomy of the posterior surface case from technological access for implantation of a proximal locking rod

In some cases, with factors threatening the development of the compartment syndrome, it is shown that the rear cases are decompressed in the reverse direction (from the distal to the proximal).

These factors are fibrosis in soft tissues in the lower third of shin, burns, scabs, and fractures in the lower third of shin. In this case additionally fasciotomy was made considering massive scab and a fracture in the lower third of shin. Technique of fasciotomy was made from the same access for implantation of the locking rod and the same principles like surgical access for implantation for proximal locking rod.

In conclusion, it's possible to make decompression of shin cases from surgical access for an implantation of intramedullar shaft to prevent and manage MGIS.

a) b)

Figure 6 – Stages of fasciotomy: a) beginning of fasciotomy of the posterior surface case from the technological access for the implantation of the distal locking rod; b) completion of fasciotomy of the posterior surface case from technological access for implantation of a distal locking rod

DISCUSSION:

MGIS was diagnosed in 47 of our patients in postoperation period. Severity was set as mild. There was no middle or severe local hypertension syndrome. Verification of the diagnosis was proved by research of subfascial pressure with Stryker device.

Research was set in a few stages. The first one was before surgery. The next one took place after processing of the technological channel in the bone for implantation of an intramedullary fixative. At this stage, a bone marrow cavity boring was optional.

The third stage takes place after implantation of intramedullary rod. Forth stage takes place after suturing skin dissections. The last one was made in the next day after surgery.

Research was made by classical BIOS using. In this case, the preventive measure-fasciotomy of the cases was excluded. Next data is in table 4.

Table 4 - Data of subfascial pressure(mmHg) in BIOS implantation

Type of researching	Shin cases			
	anterior lateral	lateral	posterior surface	Posterior profundus
Before implantation of the rod	7±0,3	6±0,3	7±0,3	6±0,3
After processing of cavity for an implantation	9±0,7	9±0,8	7±0,3	7±0,2
After implantation	17±0,5	15±0,5	7±0,2	7±0,2
Finishing surgery	18±0,3	17±0,3	8±0,2	8±0,2
Next 24 hours after implantation	21±0,7	22±0,8	11±0,3	12±0,3

We have to admit that after standard technology of implantation we can see an increasing of subfascial pressure in shin cases.

In anterior and posterior deep cases this pressure makes up max 13 mm Hg. These data states as normal results.

Complex of changes in anterior lateral and lateral cases are different. After implantation data was close to normal. However, after 24 hours of implantation, data corresponds to mild form of MGIS.

These facts are explained by the smaller sizes of these cases, their form and that fact that boundaries of these cases over a large extent are the tibia and fibula.

As a percentage, the ratio of soft tissue / bone, these cases have the largest ratio of bone area in relation to soft tissue.

Using preventive locked fasciotomy in BIOS of tibia avoid clinical manifestations of MGIS. There were no complications such as infections, osteomyelities, unfusions, decreasing of functionality and decreasing muscle strength after fibrosis.

Therefore, using preventive decompression of anterior lateral and lateral cases is obligatory after BIOS in locked reposition. It's more comfortable to make fasciotomy from the access for implantation of the rod. Special device like fasciotom is not necessary for the decompression.

Surgical access for fasciotomy of posterior cases is an access for implantation the rod.

Size of this access is about 1, o cm. This size of access and surgeon skills is necessary for decompression of lateral cases. Also, it requires accurate verification of topographical cases location and special device like fasciotom to avoid complications.

Decompression of posterior superficial and posterior profundus cases is not necessary to prevent MGIS.

The data of tibia BIOS and fascitomy of shin cases are state in table 5

According to the data from decompression of shin cases in osteosynthesis of tibia there were no MGIS signs. The level of subfascial pressure didn't get the threshold indication of MGIS.

Table 5 - Data of subfascial pressure (mmHg) in BIOS implantation with decompressions

Type of research	Shin cases			
	anterior lateral	lateral	posterior surface	Posterior profundus
Before implantation	7±0,3	6±0,3	7±0,3	6±0,2
After proccessing of cavity for an implantation	9±0,5	9±0,6	7±0,2	7±0,2
After implantation	12±0,5	11±0,5	7±0,2	7±0,2
Finishing surgery	12±0,3	11±0,3	8±0,2	8±0,2
Next 24 hours after implantation	13±0,6	13±0,7	9±0,3	10±0,3

Before implantation tissue pressure was the same with control group. They were 6-7 mm Hg

After forming canal for intramedullar rod level of the subfascial pressure had no differences in two investigated groups. It was from 7 mmHg to 9 mmHg.

We have got the reliable data of differences of subfascial pressure in groups with fasciotomy and control group. In investigated group there were no differences in surface and posterior profunda shin cases. Anterior lateral cases subfascial pressure average was 12±0, 5 mmHg against 17±0, 5 in control. This can be considered the normal, so the specified data did not go beyond its border. In lateral shin case pressure was 11±0, 5 mmHg and comparing with the control group (15±0, 5 mmHg) and did not go beyond the normal border.

After 24 hours in all groups subfascial pressure increased at all 4 shin cases. We need to admit that MGIS appeared not a single time. The pain level was not expressed too. Increasing pressure was in the border of standard too: anterior posterior case 13±0,6 (21±0,7) mmHg, lateral case 13±0,7 (22±0,8) mmHg posterior surface case 9±0, (11±0,3) mmHg, posterior deep case 10±0,2(12±0,3) mmHg.

Considering all of the above we can make a conclusion of effectiveness of fasciotomy of shin cases in BIOS of tibia to prevent MGIS.

For visual comparison of data, we have built the graphs shown in Figure 7.

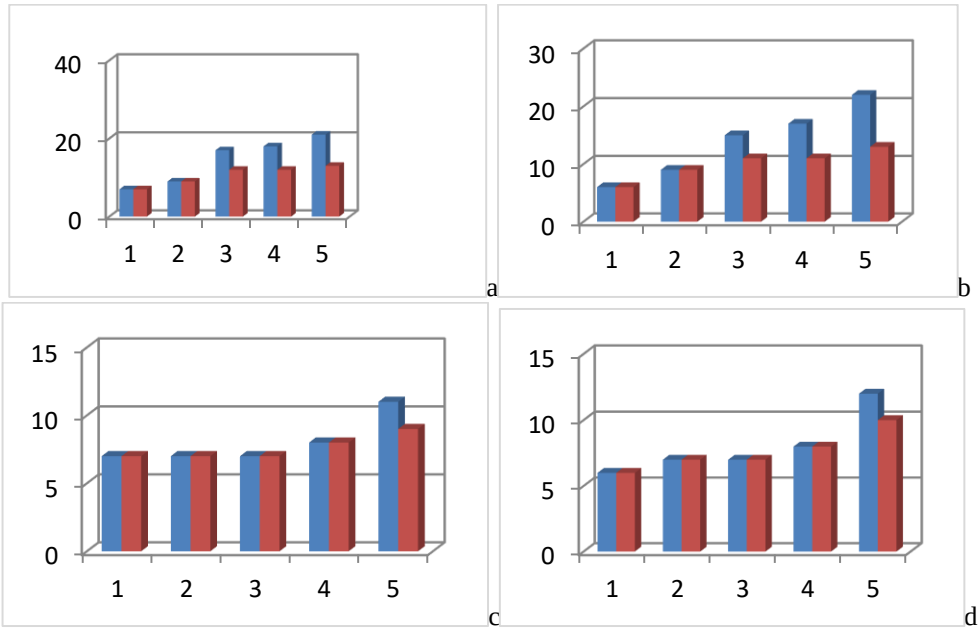


Figure 7 - The dynamics of changes in subfascional pressure in the study and control groups: a) anterior posterior shin case; b) lateral shin case; c) posterior surface shin case; d) posterior deep shin case.

At the figure 7 we can see dynamics of pressure of anterior lateral shin case in study and control group. The X axis shows 5 steps for measuring SFP - before implantation, after processing the channel for implantation of an intramedullary rod, after implantation of the rod, after completion of the operation, and 24 hours after implantation. The y-axis indicates the level of SFP, expressed in mm Hg. It is clearly seen that the level of SFP in the control group grows with increasing stages of the study. Row 1 - control group, without decompression of the case; Row 2 - the study group where the case was decompressed. In the study group, the pressure level increases only after processing the technological channel for implantation of intramedullary osteosynthesis, and subsequently at all other stages of the study it remains unchanged. This fact confirms the effectiveness and validity of decompression of the case for preventive purposes, without waiting for the development of MGIS.

By analogy, we constructed histograms for the remaining three cases of the shin (Fig. 7 b-d)

Analyzing the foregoing, we can conclude in this section on the effectiveness of decompression of the shin cases from surgical access for the implantation of locking intramedullary osteosynthesis for the prevention and treatment of MGIS.

DISCUSSION:

We have developed an algorithm for the tactics of managing a patient during intramedullary osteosynthesis of the tibia. It's based on prognostic development index of MGIS (Strafun SS, Tkach AV, 2014) This method of mathematical forecasting is made with different other methods: methodology of probable mathematical analysis according to Gubler EV, based on determining the probability of possible pathological processes, based on the use of Bayesian algorithms, according to the method of an inhomogeneous sequential procedure based on Wald's sequential analysis.

The essence of this prognostic method is next: for each calculated factor, a risk factor for the development of MGIS was determined, expressed from - 120 (min) to +100 (max).

On the base of this data we can make three groups:

1. Decreased risk: -120,0 to -50
2. Middle risk: -49,9 to +30
3. Increased risk: +30,1 to +100

Based on the prognostic risk data, we have carried out the following options for the prevention of ischemic disorders.

In the reduced-risk groups in (66 (71%) patients), fasciotomy was not performed.

In the medium-risk group (27 (29%) patients), preventive fasciotomy was performed in cases, where according to our studies, with the development of the shin MGIS, an increase in subfascial pressure was always noted in the anterior lateral and lateral cases. Preventive fasciotomy of the posterior superficial and posterior deep cases is shown only in high risk group. There was no high risk at MGIS group.

In the dynamic monitoring of patients in the postoperative period, we have not observed the development of MGIS.

Prediction of the risk of developing local hypertensive ischemic syndrome was carried out according to a score proposed by Strafun SS and Tkach AV, which showed ease of use and effectiveness. In the reduced risk group, fasciotomy is not advisable. In the medium-risk group, it is advisable to conduct a locked preventive fasciotomy of the anterolateral and lateral cases. If there is an increased risk, prophylactic fasciotomy is mandatory for all 4 cases of the shin during intramedullary osteosynthesis.

CONCLUSION:

Based on the development and application of preventive fasciotomy from technological access for implantation of a blocking intramedullary rod, an effective method for the prevention of MGIS has been obtained.

1. In 93, 7% of locked osteosynthesis of tibia MGIS (1-2 degree) appears. There was no MGIS in opened osteosynthesis. Increasing subfascial pressure in locked reposition with next using BIOS noticed in anterolateral and lateral shin cases.
2. Preventive fasciotomy of shin from implantation locking rod dissections can prevent MGIS development.

List of symbols and Abbreviations:

MGIS – local hypertension ischemical syndrome or a compartment syndrome
BIOS – locked intramedullar osteosynthesis
X-ray – X-ray examination

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