

ANATOMICAL FEATURES AND MEASURING OF THE APPROXIMATE MUSCLE TENSION IN THE COURSE OF SELECTION OF A METHOD OF INGUINAL HERNIAS REPAIR

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Hernia repair represents the most frequent surgical operation.

The objective of the research is determination of anatomical features of the inguinal canal and measuring of the approximate muscle tension as well as justification of the relaxing incision application in the process of the hernia repair in this region.

The research is based on the prospective study including 120 patients, who underwent the operation in the General Hospital in Berane. 60 of them went through measuring of the inguinal canal length, referential angle (α), overlapping of musculoaponeurotic arch with m.rectus abdominis (H), distance between the arch and inguinal ligament (L) as well as measuring of the surface of myopectineal orifice (P1) and deep opening of the inguinal canal (P2).

Approximate muscle tension was also measured before and after the relaxing incision.

Control group was treated using conventional methods without previous measurements. Percentage of relapse was 6,6% in that group.

The measured values were correlated. Inguinal canal length was in the range from 4,5 to 5,5 cm (64%). The average value of appendage (H) was 0,52 cm \pm 0,34. Referential angle was 116,26 \pm 1,68. The average value P1 was 9,75 cm² \pm 2,66. Surface of the deep opening P2 was 1,71 cm² \pm 1,07. The average values of approximate tension (N) before relaxing incision were I=19,9; II=22,4; III=21,7; IV=20,7; V=18,0, and after the relaxing incision the average values were I=15,7; II=17,6; III=16,7; IV=15,5; V=13,2.

Referential angle (α) and distance of the musculoaponeurotic arch (L) from the inguinal ligament were measuring parameters, which indicated presence of tissue tension in the course of suture material placement.

Approximate tension decreased after the relaxing incision and it reached maximum at the farthest distance L.

Relaxing incision was obligatory.

Local anesthesia was a matter of choice.

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Key words: hernia, approximate tension, relaxing incision, fascia transversalis, reparation

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Introduction

Hernia repair represents the most frequent surgery operation. 10-15% of operations belong to the spectrum of hernia surgery repairs. Frequent occurrence of hernia in the inguinal region, enigmatic quality of the etiologic background and selection of treatment method make the hernia surgery one of the significant parts of surgery.

In the last years special significance has been given to transversal fascia both in the etiology of hernia and in its usage in repair by anatomic "tension free" operations. Using the adequate approach, inguinal and preperitoneal, along with good surgical technique and usage of adequate nonresorptive monofilament suture material provides excellent results of the surgical treatment, which is assessed by the relapse percentage between 1 and 2%.

Although many facts have been revealed, development and causes of inguinal hernia occurrence have not been still clarified with certainty. Apart from anatomic imbalances of both congenital and traumatic origin, modern understanding gives significance to biological factors: atrophy, aponeurosis, and fascia, muscular hypotony, collagen disease, reduced values of

hydroxyprolin and reduction of fibroblast proliferation rate and poor presence of the polarized collagen. Important factor for the occurrence of hernia is also increased intra-abdominal pressure. For the purpose of preservation of inguinal canal integration and prevention of abdominal organs protrusion, there is a physiological protection of inguinal canal:

- a) function of the shelter or shutter (shutter action);
- b) valvular action of the internal ring "U-shaped" (sling);
- c) role of the contractile elements of cremaster as caps.

Incidence of inguinal hernias in the Great Britain amounts to 2%; for female 0.3%. Annual incidence of hernia occurrence in Germany is about 0.4% out of the total population. Inguinal hernia among children is linked to persistence of procesus vaginalis peritonei. Indirect hernia is the most common type of hernia and it is represented by ratio 4-8:1 in favor of males. Direct inguinal hernia is represented among men with 28% in comparison to 1.5% among women. That is why femoral hernias are by 11.1% more frequent among women than among men 2.8%. Incidence of relapse of the congenital indirect hernia among children and young people is insignificant (0.67%). As regards indirect inguinal hernia among adults, relapses after operation, which formerly amounted to 35%, fell to 3.6 up to 9.4% due to progress of the surgical technique and method selection. Today, the relapse percentage according to Glasow amounts to 1% and according to Rajan 1.7%. Relapses do not exceed 2% according to Shouldice's results.

Selection of operative technique, estimate of tissue quality as well as the surgeons' experience are of immeasurable importance. Methods used today are the following:

- A) Open anterior repairs
 - Bassini
 - Mc Vay
 - Shouldice
- B) Open posterior repairs
 - Nyhas
- C) Nontension techniques with usage of biomaterials
 - Lichenstein
 - Rutkow
 - Trabucco
- D) Laparoscopic hernioplastics

Selection of anesthesia is to be adapted to the patient's condition, interests of the surgical work and fast recovery with short hospitalization. Operation of hernia can be performed under general, regional, local infiltrative anesthesia. Today, all the attention is paid to the concept of minimum invasive surgery and one-day ambulance treatment. As regards anesthesia, differential epidural block and local infiltrative anesthesia are selected as options.

Objective of the Research

- Determination of anatomic features of the inguinal canal in relation to existence of hernia in this region.
- Measuring of the value of approximate muscle tension in the course of inguinal canal repair
- To point to significance of usage of anatomic operations of the type "tension free" in reducing the relapse percentage.
- Demonstration of purpose-serving of usage of the monofilament nonresorptive suture material.
- Justification of application of relaxing incision for the purpose of approximate muscle tension reduction.
- That anatomic characteristics of inguinal canal, individual peculiarities and profession play role in etiopathogenesis of occurrence of hernia in the inguinal region.

Material and Methods

Our research is based upon prospective study, which has been carried out with 120 patients who were surgically treated in the Surgical Department of the General Hospital in Berane. The examinees were selected by the method of random sample; accordingly, adult males were involved in the research. Their entrance ticket to the research was their arrival in order to undergo inguinal hernia operation. 60 of them were treated using conventional methods without measuring and determination of atomic structures and we compared them to the second group to which we did measuring and reconstruction of inguinal canal by means of anatomic methods along with usage of nonresorptive monofilament suture material. Methodology of work encompasses two kinds of researches:

- Clinical-physical examination of patients,
- Intraoperative measurements and observation of postoperative development.

Statistical processing of the results: results obtained for each of the patients were inserted into the database D Base IV and then statistically processed in the program Stutgraphics 4.0. In the course of the processing, standard statistical programs for processing of such data were used: Hi-square test and multivariate comparative analysis.

We measured and observed the following in relation to all the patients:

- Length of inguinal canal (D),
- Surface of myopectineal orifice of the posterior wall of inguinal canal (P1) in the way that the surface was approximated by ellipse with semi-axis of lengths $L/2$ and $S/2$ and that surface is presented in the following manner $P1 = \pi \cdot L/2 \cdot S/2 = \pi \cdot L \cdot S/4$
- Surface of the deep opening (P2), which was approximated by the ellipse with semi-axis $11/2$ and $12/2$ so that the surface of deep opening was presented as with $P2 = \pi \cdot 11 \cdot 12/4$

- Referential angle (α) was measured between the fibers of m. rectus abdominis and fascia of musculoaponeurotic arch $Z=4$ cm, expressed in degrees.

- One more characteristic of the upper wall of inguinal canal is that fibers of musculoaponeurotic arch overlap with the m. rectus abdominis at a different level of tuberculum pubicum. This anatomic variability was measured using the level of appendage H.

- Approximate muscle tension in the course of reparation of defects of the posterior wall of inguinal canal was measured before and after the relaxing incision. Measuring was done after placement of the ligatures of nonresorptive monofilament material in the way that a dynamometer was placed at the ends of ligatures and then the power needed was applied in order to bring musculoaponeurotic arch in contact with the inguinal ligament (A is brought into contact with B). The dynamometer power was read off with division using Newton (N).

- After causing the shutter mechanism we measured the surface of myopectineal orifice of the posterior wall P2. Noting the difference between P1 and P2 we determined P3 – surface which indicates the level of reduction of myopectineal orifice of the posterior wall after the shutter mechanism expressed in percentages $P3=P1 - P2 \text{ \%} = P3/P1 \cdot 100$

- We applied the relevant suture material (monofilament nonresorptive sutures), the observing the effect on tissues, avoiding the phenomenon of tissue cutting.

- After measuring the approximative muscle tension, we performed a relaxing incision on vagina m. rectus abdominis in semi-arch direction of 5 cm length and then we measured approximate muscle tension.

- Patients went through a socioeconomic survey.

- Operative technique fitnesses were registered (cremaster resection, selection of method, opening, resection and hernia bag fixation).

- Occurrence of complications.

- Control of patients has been performed in 36 months.

- Degree of relapse was observed as a criterion of surgical work.

Work results

There are not statistical significances in relation to the age as regards the control and examined group. In the examined group the value for marking age amounts to 50.66 ± 15.67 . In the control group it amounts to 52.92 ± 16.96 . In addition, there are not statistically significant differences related to hernia frequency parameter according to the age ranges. In both groups, the highest frequency of occurrence of hernia is in the range from 51-60 years (21.67%) and in the range from 61-70 years 24% examinees.

In the examined group we calculated the ideal weight by De-Molle's formula. Inguinal

hernias are represented in the population where body weight varies from the ideal body weight (MITT) $\pm 10\text{-}20\%$ with frequency of 34% of the examined group.

72% of patients work and live in countryside and 28% of patients have a relative, who underwent a hernia operation. 18% of patients had a hernia on both sides, 72% indirect, 18% direct and 10% combined hernia.

Hernia representation on the right side is 44%, 38% of them had left hernia and 18% on both sides. In the control group 61% of patients had hernia on the right side and 37% patients on the left side, 2% patients had hernia on both sides. By making comparison there is a highly statistically significant difference for the parameter of hernia localization ($p < 0.001$).

In the course of selection of anesthesia we applied a local anesthesia in 24% of cases, peridural block in 16% cases and spinal anesthesia with 60% of patients. In the control group the spinal anesthesia was applied in 75% of patients, local in 5% of patients, general anesthesia in 15% patients and peridural in 5% of patients.

Out of operation methods in the examined group we chose the repair according to Bassini (70%), MC Vay (14%), Shouldice (10%) and Berliner (6%). In the control group, Ferarri dominates (54%), Hackenbruch (13%), Bassini (22%), Mc Vay (7%), Wolfer-Girard (2%) and Brener (2%).

While measuring the anatomic features, we obtained the following indicators: 64% of patients have the inguinal canal length of 4.5 – 5.5 cm, 24% of patients in the range from 5.5 – 6.5 cm, 24% of patients in the range from 5.5 – 6.5 cm, average value of the inguinal canal length amounts to 5.6 ± 0.73 .

Level of the transversal arch appendage i.e. overlapping with the tissues of m. rectus abdominis is at a different level from tuberculum pubicum (H).

The highest frequency of the transversal arch appendage (H) is in the range from 0-0.6cm from tuberculum pubicum (66%).

Average value of the appendage (H) is $0.52\text{cm} \pm 0.34$.

Referential angle of the cross-section α of the transversal arch and m. rectus abdominis was measured for the length of the arch $Z=4\text{cm}$ because of the possibility of approach of a protractor and its average value amounts to 116.26 ± 1.68 .

In addition, we measured the surface of myopectineal orifice of the posterior wall of inguinal canal (P1), the average value of P1 amounts to $9.75 \text{ cm}^2 \pm 1.07$.

We registered intraoperatively the presence of migration of the internal ring and change of the form. The presence of Shutter mechanism brings about reduction of defect of the posterior wall of inguinal canal. Thus, we calculated the surface (P3) for which the defect of the posterior wall was reduced after the shutter mechanism. Average value of the posterior wall surface reduction (P3) amounts to $21.45\% \pm 6.87\%$.

Then, we measured the applied power on ligatures, which is needed for bringing the muscleeponeurotic arch into the contact with the inguinal ligament. Average values of approximate tension (N) before the relaxing incision amount to I=19.9; II=22.4; III=21.7; IV=20.7; V=18.0. It is clearly visible that the approximate tension value is highest on II, III and IV suture expressed in Newton, which is also logical because that is the farthest point of the muscleeponeurotic arch from the inguinal canal. After the relaxing incision had been done, we obtained an evident decrease of average values of approximate tension from the first to the last ligature.

We did not have relapses in the treated group, and in the control group there were 4 (6.66%). Average hospitalization of operated patients amounted to 4.8 days.

We put all the measuring parameters into a certain relation with anatomic characteristics.

In the interrelation of the approximate tension and referential angle of the cross-section, both lines in the diagram 1 are parallel with a slight increase and we reached the conclusion that higher approximate tension (N) is also present with the increase of the referential angle α .

After measuring we put into interdependent relation the total approximate tension (N) and the maximum distance (L). We reached the conclusion that there is a growth trend, which can be seen in the diagram 2. Namely, the bigger distance L, the higher total approximate tension expressed in Newton.

In addition, after putting into interdependent relation the referential angle of the cross-section α and maximum distance L, we reached the conclusion that a rather linear dependence is present, diagram 3, i.e. the bigger referential angle of the cross-section, the higher also the maximum distance.

Table 1. Values of approximate muscle tension (N)

| I | II | III | IV | V | |
|------|------|-------|------|------|------------------------------|
| 19.9 | 22.4 | 21.17 | 20.7 | 18.0 | Before the relaxing incision |
| 15.7 | 17.6 | 16.7 | 15.5 | 13.2 | After the relaxing incision |

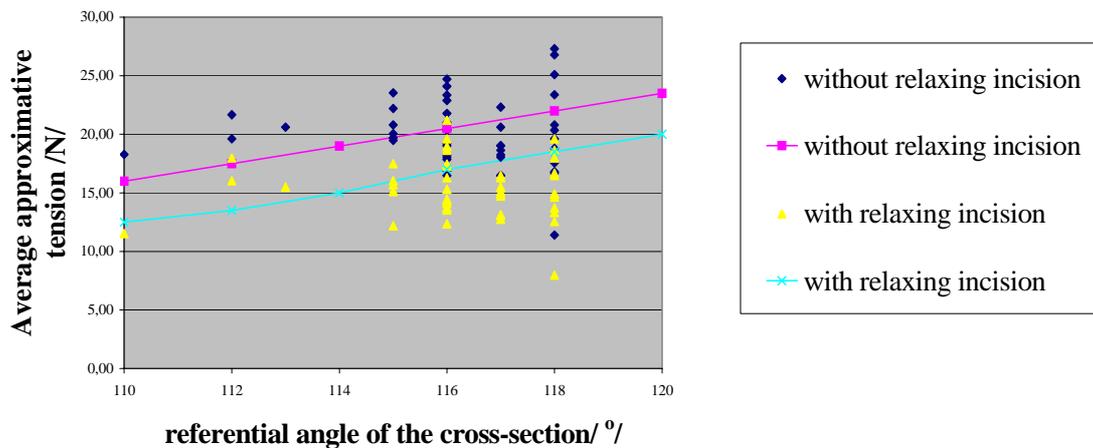


Diagram 1. Dependence of average approximate tension on the referential angle of the cross-section

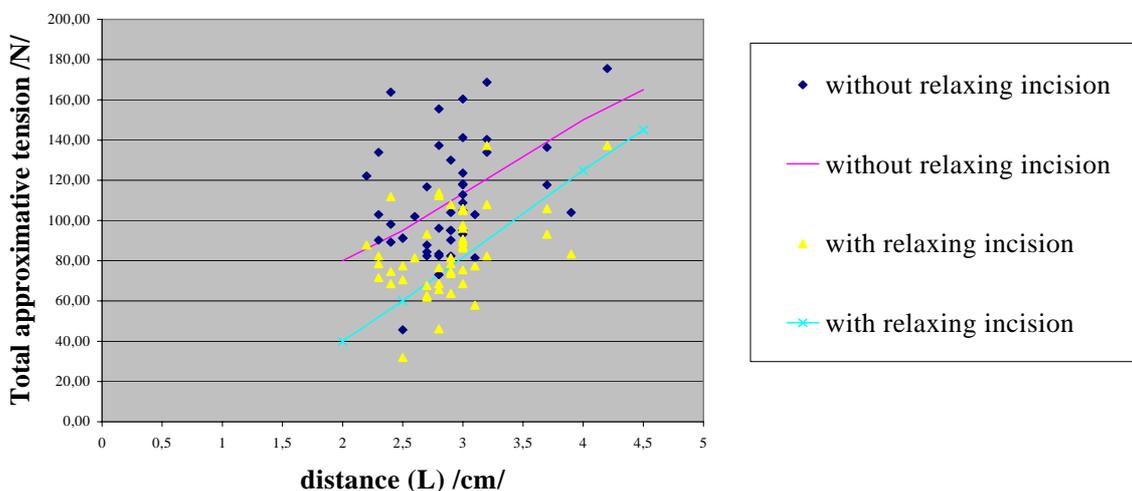


Diagram 2. Relation of total approximate tension and the maximum distance L

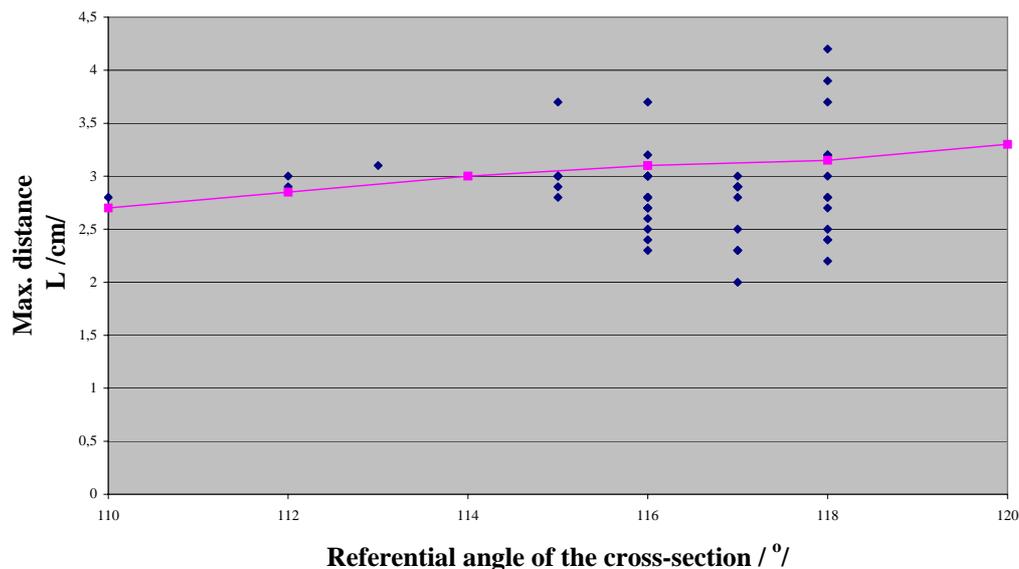


Diagram 3. Dependence of the referential angle of cross-section on the maximum distance – L

Discussion

120 patients, who were operated for inguinal hernia in the General Hospital in Berane, were involved in the research.

The treated group numbered 60 patients, who were surgically treated by anatomic methods.

The control group numbered 60 patients operated using conventional non-anatomic methods, observed retrospectively by insight into the history of disease and operative protocols.

Controls were performed on invitation in the following 36 months. Random sample method was used in the course of selection of examinees for involvement into the study. The only criterion of selection was that the patient has the inguinal hernia and that the male person is in question.

This selection served to make the group representative sample of patients of the age from 18 to 82. Males are more represented in comparison to females as regards indirect hernia 4-8:1 according to the statements from the literature (13, 21, 26).

Higher frequency of indirect hernia with the males is linked to the lowering of the testis into the scrotum. But, if we take into account the fact that 25% of the total male population possesses open processus vaginalis, then the hernia incidence is extremely low 1-2% (9,13).

In our research, the patients associate the hernia occurrence with physical toil, cough, illness, which corresponds to the data from the literature where physical work, sport, coughing of bronchitis sufferers as well as heavy burden lifting play a role in the hernia occurrence (11,19,31). Increased intra-abdominal pressure in the standing position represents a dominant factor in relation to hernia occurrence (11,23,26).

Every applied suture material represents aggression against the tissue and acts as a foreign body in the wound. Consequently, it must

have its tension power, elasticity, long duration, its own firmness; it must be inert, taken well by the organism. Therefore, the applied suture material in our research (polypropylene, PDS II, ethilon), which is monofilament and nonresorptive, satisfies basic standards. It does not cut the tissues, it provokes minimum reaction of the tissue and in that way the risk of wound and fistulas infection due to suture is slightest (4,12,34).

As for the anesthesia, local, spinal, peridural and general anesthesia are being applied today.

Local anesthesia experiences renaissance. In the specialized institutes for hernia surgery the operation is done in 90% of cases under local anesthesia (10, 16, 18, 20, 32).

General anesthesia is not desirable although it provides a surgeon with complete comfort, but the muscle structures paralysis occurs. Therefore, the estimate whether the sutures are under tension is very bad and an adequate relaxing tension (20, 26) can be overlooked.

Muscle-aponeurotic space contained in the thickness of the bottom edge of the inguinal region in the anatomic sense is called inguinal canal. The average length of it is 4.5-5cm, what corresponds also to the results of our measurements, where we had the inguinal canal length in the range from 4.5-5cm (2,3,30) in case of 64% patients.

Myopectineal orifice is the main anatomic structure of inguinal region and constitutionally determined position of the arch of transversal muscle also determines the myopectineal orifice size, and in that way also weakness of the posterior wall of inguinal canal (1,22,25,29).

Variations of the transversal arch level and its transfer to the musculus rectus abdominis are explained by the size of the inguinal angle opening, which amounts to 25-35 degrees

according to Stoppa, and it is measured between the Molgaigne and bispinal line (1,26). We objectified these variations also in the treated group, but in contrast to Stoppa's inguinal angle measuring we measured referential angle of the cross-section α of the transversal arch and m. rectus abdominis. Exactly the values of inguinal angle and referential angle of the cross-section α along with unfavorable disposition of appendage of transversal arch require intraoperative decision on application of relaxing incision.

In the course of the treatment method selection the decision is made intraoperatively, but the intention is to use anatomic operations along with using transversal fascia. In order to avoid or reduce tension on the sutures it is necessary to do relaxing incision (2,4,6,24,26).

In our study we applied different methods of reparation (Basini, MC Vay, Shouldice).

In the treated group the accent is put on fascia transversalis during reparation of the posterior wall of inguinal canal, which we consider the reason for not having relapse, what corresponds to the results from the literature (6, 22).

Our research of the shutter action corresponds to the data from the literature in the sense that it has a protective mechanism in preserving integrity of the inguinal canal in preventing the effect of increased and intra-abdominal pressure (1,23,26).

Lyttle was the first to learn about motility and change of the inner ring form when it turns from elliptic form into a narrow cut (4).

Parallel development of inguinal hernia and aneurysm of abdominal aorta is registered, first of all among the smokers (8), according to the new researches. It is considered that the cause lies in the proteolytic activity in blood. In the treated group, there were 26% patients, who were smokers.

Postoperative mortality is small after the operations of inguinal hernias. Complications may be intraoperative and postoperative and according to the time of occurrence they can be early and late complications.

Postoperative operations in the USA according to the data of Nyhus after the inguinal hernia operations amount to 5%. The haematoma and seroma occurrence is from 0.1-6.9%, and the percentage of infection of wounds is from 0.3-5.6%.

The results of our research for the purpose of marking complications correspond to the published data from the literature (13,17,26).

Being familiar with the anatomic characteristics of the posterior wall of inguinal canal, by measuring the surface of the myopectineal orifice as well as the surface of deep opening of the inguinal canal, we reached the conclusion that also the occurrence of both direct and indirect hernia depends on the size of these surfaces along with the quality of transversal fascia. Surface of the deep inguinal ring as origin of indirect hernia was between 1-2 cm² with 50% of treated patients, and surface of the myopectineal orifice was in the range between 7-10 cm² with

72% of patients. Factors which caused the continuation of relapse are inadequate surgical technique, increased intra-abdominal pressure and present tension on ligatures after hernias reparation (1,9,11,23).

Our research showed approximate tension values before and after the relaxing incision and pointed to the necessity of relaxing incision. Approximate tension is highest on ligatures II, III, IV, what is logical, taking into account also the presence of the most remote distance of musculoaponeurotic arch from the inguinal ligament (L).

All of these parameters among the patients in the treated group were correlated and among them a linear dependence was determined. By increase of maximum distance L and referential angle α , both medium and total average values of the approximate tension increased.

The objective today is to resolve defects of inguinal region by mini-invasive one-day surgery under local anesthesia (10,18, 20).

Conclusion

1. Pathogenesis and etiology of inguinal hernia can be concisely subsumed under multifactorial event.

2. Anatomic variability of this region, individual characteristics, surgical biology of tissue as well as sex play role in the occurrence and type of inguinal hernia.

3. Transversal fascia plays a dominant role both in etiology of hernia and in usage of surgical repair of the inguinal hernia by anatomic "tension free" operations.

4. Level of musculoaponeurotic arch overlapping with m. rectus abdominis in relation to tuberculum pubicum (H), referential angle α and distance of musculoaponeurotic arch from inguinal ligament (L) are measuring parameters, which point to the possibility of presence of tissue tension during suture material placement.

5. Approximate tension of musculoaponeurotic structures after the relaxing incision declines almost symmetrically starting medially and laterally from the biggest distance (L) of musculoaponeurotic arch from the inguinal ligament.

6. Relaxing incision is obligatory.

7. M. cremaster, as emanation of m. obliquus internus abdominis should always be resected in order to better inspect into the edges of the inner inguinal ring.

8. Percentage of relapse is criterion of the surgical method value. Anatomic operations of type "tension free", monofilament nonresorptive suture material along with meticulous operative technique provide for excellent results, i. e. relapse percentage 1-2%. We did not have relapse in the treated group.

9. Usage of monofilament nonresorptive suture material is necessary.

10. Local anesthesia is a matter of choice.

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ANATOMSKE ODLIKE I MJERENJE APROKSIMACIONE TENZIJE MIŠIĆA PRI IZBORU METODE RJEŠAVANJA INGVINALNIH KILA

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Reparacija kila predstavlja najčešći hirurški zahvat.

Cilj istraživanja je utvrđivanje anatomskih odlika ingvinalnog kanala i mjerenje aproksimacione tenzije mišića te opravdanost primjene relaksacione incizije pri reparaciji kila ove regije.

Istraživanje se bazira na prospektivnoj studiji sprovedenoj kod 120 bolesnika operisanih u Opštoj bolnici u Beranama. Kod njih 60 vršena su mjerenja dužine ingvinalnog kanala, referentni ugao (α), susticanje muskuloaponeurotičnog luka sa m.rektus abdominis (H), rastojanje od luka do ingvinalnog ligamenta (L) kao i mjerenje površine miopektinalnog otvora (P_1) i dubokog otvora ingvinalnog kanala (P_2).

Mjerena je i aproksimaciona tenzija mišića prije i poslije relaksacione incizije. Kontrolna grupa tretirana je konvencionalnim metodama bez prethodnih mjerenja. U toj grupi procenat recidiva iznosio je 6,6%.

Mjerene vrijednosti stavljene su u međusobni odnos. Dužina ingvinalnog kanala je u intervalu od 4,5-5,5cm (64%). Srednja vrijednost pripoja (H) je $0,52\text{cm} \pm 0,34$. Referentni ugao iznosi $116,26 \pm 1,68$. Srednja vrijednost P_1 iznosi $9,75\text{cm}^2 \pm 2,66$. Površina dubokog otvora P_2 iznosi $1,71\text{cm}^2 \pm 1,07$. Srednje vrijednosti aproksimacione tenzije (N) prije relaksacione incizije iznose I=19,9; II=22,4; III=21,7; IV=20,7; V=18,0, a nakon relaksacione incizije iznose I=15,7; II=17,6; III=16,7; IV=15,5; V=13,2.

Referentni ugao (α) i udaljenost muskuloaponeurotičnog luka (L) od ingvinalnog ligamenta su mjerni parametri koji upućuju na prisustvo tenzije tkiva pri plasiranju šavnog materijala.

Aproksimaciona tenzija nakon relaksacione incizije opada, a najveća je na najvećoj udaljenosti L.

Relaksaciona incizija je obavezujuća.

Lokalna anestezija je anestezija izbora.

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Ključne riječi: *hernia, aproksimativna tenzija, relaksaciona incizija, fascia transversalis, reparacija)*