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Assessment of the impact of mesh density on early and long-term results after laparoscopic transabdominal preperitoneal inguinal hernia repair

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Inguinal hernia is a common pathology. The main treatment method is surgical. Laparoscopic transabdominal preperitoneal hernia repair is a leading technique. Polypropylene mesh implants are classified by weight into heavy, medium, light, and ultralight. However, the optimal weight of the mesh to minimize complications remains debated.
The aim of the study: **to determine the optimal mesh density to minimize complications after laparoscopic transabdominal preperitoneal hernioplasty.**
Materials and methods**. Retrospective analysis of postoperative results obtained during treatment of 178 patients with inguinal hernia hernioplasty at the Department of Surgery and Vascular Surgery of Shupyk National Healthcare University of Ukraine, Kyiv in the period from 2018 to 2022.**
Results**. The average duration of surgical intervention was: Group I – 87.92±14.56 min, Group II – 85.21±14.74 min, Group III – 88.9±13.92 min. The level of pain according VAS scale was: Group I – 3.04±1.05 points; Group II – 3.07±1.23 points; Group III – 3.42±1.31 points. Readiness for discharge was: Group I – 8.41±0.82 points, Group II – 8.49±0.87 points, Group III – 7.56±1.01 points. The duration of taking NSAIDs in the early postoperative period was: Group I – 2.98±1.11 days; Group II – 3.3±1.06 days, Group III – 5.03±2.25 days. The development of chronic groin pain was noted: Group II – 2 patients; Group III – 5 patients. Recurrence of inguinal hernia was noted: Group I – 3 patients; Group II – 1 patient.**
Conclusions**. In the scope of our research, light polypropylene mesh demonstrates itself as a optimal mesh density when performing laparoscopic TAPP, which allows to achieve a low level of development of postoperative chronic groin pain and hernia recurrences.**
Keywords: *inguinal hernia, laparoscopic surgery, hernioplasty, mesh weight, general surgery.*

Оцінка впливу щільності сітки на ранні та віддалені результати після лапароскопічної трансабдомінальної преперитонеальної герніопластики пахової грижі

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Пахова грижа є поширеною патологією, основним методом лікування якої є хірургічний. Лапароскопічна трансабдомінальна преперитонеальна герніопластика – одна з провідних технік. Імплантати з поліпропіленової сітки класифікуються за вагою на важкі, середні, легкі та ультралегкі. Однак оптимальна щільність сітки для мінімізації ускладнень залишається предметом дебатів.
Мета дослідження: визначення оптимальної щільності сітки для мінімізації ускладнень після проведення лапароскопічної трансабдомінальної преперитонеальної герніопластики.
Матеріали та методи. Проведено ретроспективний аналіз післяопераційних результатів, отриманих під час лікування 178 пацієнтів з інгвінальною грижею в Департаменті хірургії та судинної хірургії Національного медичного університету України імені Шупика (Київ), у період з 2018 по 2022 рр.
Результати. Середня тривалість хірургічного втручання становила: група I – 87,92±14,56 хв, група II – 85,21±14,74 хв, група III – 88,9±13,92 хв. Рівень болю за візуальною аналоговою шкалою становив: група I – 3,04±1,05 бала, група II – 3,07±1,23 бала, група III – 3,42±1,31 бала. Готовність до виписки: група I – 8,41±0,82 бала, група II – 8,49±0,87 бала, група III – 7,56±1,01 бала. Тривалість прийому знеболюючих препаратів у ранній післяопераційний період становила: група I – 2,98±1,11 дні, група II – 3,3±1,06 дні, група III – 5,03±2,25 дні. Зафіксовано розвиток хронічного болю в паху: група II – 2 пацієнти, група III – 5 пацієнтів. Рецидив інгвінальної грижі спостерігався: група I – 3 пацієнти, група II – 1 пацієнт.
Висновки. У межах нашого дослідження легка поліпропіленова сітка демонструє себе як оптимальна щільність сітки під час проведення лапароскопічної трансабдомінальної преперитонеальної герніопластики, що дозволяє досягти низького рівня розвитку післяопераційного хронічного пахового болю та рецидивів грижі.
Ключові слова: *пахова грижа, лапароскопічна хірургія, герніопластика, щільність сітки, загальна хірургія.*

Inguinal hernia is one of the most common pathologies in surgeon practice [1, 2]. Inguinal hernias occur in 3–7% of the world's population, of which those over 18 years oaccount for 8–20%. About 1–5% of men and 0.2–2% of women suffer from the corresponding pathology [3]. And the specific share of inguinal hernias among the total number of hernias of different localization is about 70–75%, of which 37.5% are bilateral inguinal hernias [4].

The list of etiological risk factors for the development of a primary inguinal hernia includes male sex [5, 6], advanced age [7], heavy physical work, changes in the type of collagen [8] and morphopathological changes in the tissue components of the inguinal canal [9].

The main method of treatment is surgical intervention. In the countries of the European Union, more than 1 million hernioplasty are performed annually, in the USA –

about 800 thousand [10], in South Korea – about 35 thousand [5]. At the same time, there is a tendency to further increase the number of these; in 2018, more than 20 million inguinal hernioplasty were performed in the world [11].

Among the list of surgical methods for the treatment of inguinal hernias, the leading place is occupied by hernioplasty with the use of a mesh implant, which demonstrates its effectiveness in comparison with autohernioplasty [12]. A prominent representative of relevant surgical techniques is laparoscopic transabdominal preperitoneal hernia repair (TAPP), as one of the most effective treatment methods in the structure of modern herniology [13, 14], which demonstrates a number of advantages compared to alternative open and endoscopic techniques [15–17].

Polypropylene is one of the most common mesh implant materials used during hernioplasty [18]. However, in addition to the mesh material, there is the issue of mesh implant weight when performing plasty. According to weight, mesh implants are classified as: heavy weight (HW), when their mass exceeds 140 g/m^2; medium weight (MW), from 70 to 140 g/m^2; light weight (LW), from 35 to 70 g/m^2; and ultralight, less than 35 g/m^2 [19].

However, the question of what weight of the mesh that should be used during TAPP in order to minimize the risks of early and late complications such as seroma, infection, chronic groin pain and recurrences remains debatable. Relevant questions formed the basis of this study.

MATERIALS AND METHODS

Retrospective analysis of postoperative results obtained during 3 years of treatment of 178 patients with inguinal hernia (unilateral or bilateral), including 19 female and 159 male, aged 18 to 70 years. All patients underwent TAPP at the Department of Surgery and Vascular Surgery of Shupyk National Healthcare University of Ukraine, Kyiv in the period from 2018 to 2022. The duration of patient observation was 1 year.

Characteristics of patient groups

In our research, we used meshs of the following weight: ultralight (< 35 g/m^2), light (35–70 g/m^2), standard (70–140 g/m^2). Depending on the above-mentioned weight of the applicable mesh implant, the patients were divided into 3 groups: I group included 71 patients, group II – 75 patients, group III – 32 patients. The sex ratio (women/men) in groups was: Group I – 7/64; Group II – 9/66; Group III – 3/29. The mean age of the patients was: Group I – 42.16±16.3 years, Group II – 45.04±15.03 years, Group III – 44.57±15.08 years. The average BMI of the patients was: Group I – 27.49±3.09 kg/m^2, Group II – 27.61±3.15 kg/m^2, and Group III – 28.01±3.64. The ratio of direct and indirect inguinal hernias among patient groups was: Group I – 16/55, Group II – 20/55, Group III – 7/25. Number of patients with bilateral inguinal hernia: Group I – 14 patients, Group II – 15 patients, Group III – 6 patients. The final diagnosis and classification of inguinal hernias was carried out according to the EHS classification.

Groups of patients participating in this study were representative and comparable according to the characteristics highlited in Table 1.

Perioperative manegment.

In the process of patient treatment, we used the basic principles of perioperative management of Enchanced recovery after surgery (ERAS) [20].

In the preoperative period, all patients, without exception, were given a preliminary consultation, information was provided about the available options for hernioplasty, methods of preparation for it, risks of developing short-term and long-term complications.

All patients were routinely examined by a complex of general clinical examinations in the context of preoperative preparation, diagnosis of concomitant diseases, and further assessment of perioperative risks.

Patients were hospitalized directly on the day of surgery [21].

There were no «absolute» contraindications for TAPP when assessing the patients' condition according to the ASA (American Society of Anesthesiologists) anesthetic risks in terms of comorbidities.

The risk of thrombotic complications was assessed according to the Caprini scale. Depending on the obtained results according to the Caprini Scale, a decision was made to administer low-molecular-weight heparin (LWH) 8–12 hours after the end of the surgical intervention [22]. A mandatory element of thromboprophylaxis was the use of compression stockings of the II compression class and early activation of patients in the postoperative period (3–5 hours after the completion of the surgical intervention).

Surgery was performed under general anesthesia.

After the onset of anesthesia, in order to facilitate the dissection of the peritoneum, mobilization in the space of

Table 1

Characteristic of patients groups

Group	Group I	Group II	Group III	p
Number of patients	71	75	32	
Sex: female male	 7 (9.9%) 64 (91.1%)	 9 (12%) 66 (88%)	 3 (9.4%) 29 (90.6%)	$P_{(F)}$=0.949
Mean age (years)	42.2±16,3	45.0±15.0	44.6±15.1	$P_{(ANOVA)}$=0.496
BMI (kg/m2)	27.5±3.1	27.6±3.2	28.0±3.6	$P_{(ANOVA)}$=0.745
Hernia: Direct Indirect	 16 (22.5%) 55 (77.5%)	 20 (26.7%) 55 (77.3%)	 7 (21.9%) 25 (78.1%)	$P_{(x2)}$=0.848
Bilateral hernia	14 (19.7%)	15 (20.0%)	6 (18.8%)	$P_{(F)}$=0.989

Note: P(ANOVA) – comparison group according to variance analysis (ANOVA); P(F) – comparison group according to Fisher's exact test; * – statistically significant difference between groups (p<0.05).

Retzius, and to avoid injuries to the urinary bladder, a urinary catheter was installed [23].

All patients were operated on according to the standardized generally accepted surgical technique [24]. Absorbent tackers were used for fixition of the mesh.

Evaluation criteria

The evaluation criteria: duration of surgical intervention, Visual Analoug Scale (VAS) indicators, length of hospital stay, survey results according to the Readiness for Hospital Discharge Scale (RHDS) Questionnaire [25], duration of Non-steroid anti-inflammatory drugs (NSAID) use, number of cases of development of chronic groin pain (duration of pain syndrome from 3 to 6 months), the number of cases of inguinal hernia recurrence, infection or mesh rejection [26].

Statistics

Descriptive statistics included N (%) and mean (SD) where appropriate. For comparison between groups for and the occurrence of uncommon events and homogeneity of groups we used Fisher exact test and variance analysis (ANOVA). P values <0.05 were considered statistically significant.

RESULTS AND DISCUSSION

The average duration of surgical intervention was: Group I – 87.92±14.56 min, Group II – 85.21±14.74 min, Group III – 88.9±13.92 min.

According to the results of the survey in accordance with the VAS, the average indicator of the level of pain sensations in the early postoperative period in points at the time of discharge was 3.04±1.05 points in the Group I, 3.07±1.23 points in the Group II, Group III – 3.42±1.31 points.

According to the results of the patient questionnaire regarding their readiness for discharge, the following results were obtained: Group I – 8.41±0.82 points, Group II – 8.49±0.87 points, Group III – 7.56 1.01 points.

Patients in a satisfactory condition with improvement were discharged from the hospital.

In the early postoperative period and during the allotted follow-up period, infectious complications, mesh rejection, or seroma development were absent in all patients presented in this study.

The average duration of taking NSAIDs in the early postoperative period was 2.98±1.11 days for the Group I, 3.3±1.06 days for the Group II, and 5.03±2.25 days for the Group III.

In the distant postoperative period, the development of chronic groin pain was noted in 2 patients of the Group II and 5 patients of the Group III. In the process of observation, the symptoms of groin pain disappeared within 4–6 months after the operation and did not require further intervention to correct it.

Recurrence of inguinal hernia development was noted in 3 patients of Group I and 1 patient of Group II, which required repeated surgical treatment and correction. These patients underwent Lichtenstein hernioplasty. The results and statistical differences are shown in Table 2.

Researchers have conducted extensive studies on metals, composites, polymers, and resorbable biomaterials to identify the optimal surgical mesh and implantation technique. Key factors explored include inertness, resistance to infection, maintenance of long-term tensile strength to prevent early relapses, adequate flexibility to avoid fragmentation, and a non-carcinogenic response [27].

In 1955, Dr. Francis Usher directed his focus towards materials that could address prevalent issues. As research on Nylon, Orlon, Dacron, and Teflon revealed various drawbacks including foreign body reaction, sepsis, stiffness, fragmentation, loss of tensile strength, and encapsulation, the acceptance of polymer materials became unfeasible [28]. Upon encountering a new polyolefin material, Marlex, which exhibited exceptional properties in an article, Usher initiated the development of a mesh using this material [29]. Despite the array of benefits offered by woven and knitted polyethylene nets, Usher persisted in the pursuit of superior systems. He quickly found that knitted polypropylene offered numerous benefits: it could undergo autoclaving, possessed a strong strength index with two-way stretch, and could be rapidly integrated.

In 1958, Francis Usher introduced his surgical approach involving the use of polypropylene mesh. Three decades later, Lichtenstein's hernioplasty technique gained widespread popularity for addressing hernias [30].

In 2002, the European Union Hernia Trialists Collaboration conducted an analysis of 58 randomized controlled trials involving open mesh or laparoscopic treatment of inguinal hernias. Their conclusion was that the use of surgical mesh offers significant advantages compared to autoplastic techniques [31].

One of the parameters paid attention to in the treatment of inguinal hernias, in addition to the material from which the mesh is made, is its density. At the present time, the issue of the weight of the material of the mesh implant

Table 3

Obtained results

Group	Group I	Group II	Group III	p
Number of patients	71	75	32	
Duration of surgery (minutes)	87.9±14.6	85.2±14.7	88.9 ±13.9	$P_{(ANOVA)}$=0.375
VAS (points)	3.04±1.05	3.07±1.23	3.42±1.31	$P_{(ANOVA)}$=0.282
Readiness for hospital discharge scale (points)	8.41±0.82	8.49±0.87	7.56±1.01	$P_{(ANOVA)}$=0.0005*
Duration of taking NSAID (days)	2.98±1.11	3.3±1.06	5.03±2.25	$P_{(ANOVA)}$=0.0001*
Chronic groin pain	0 (0%)	2 (2.7%)	5 (15.6%)	$P_{(F)}$=0.001 *
Recurrence of inguinal hernia	3 (4.2%)	1 (1.3%)	0 (0%)	$P_{(F)}$=0.326

Note: P(ANOVA) – comparison group according to variance analysis (ANOVA); P(F) – comparison group according to Fisher's exact test; * – statistically significant difference between groups (p<0.05).

is relevant and debatable in terms of modern herniology, and it is not clear-cut even to this day.

One of the problems of this issue is the lack of a unified classification of mesh implants and the discrepancy in the results of research by different authors that revealed this problem.

A certain category of studies note the importance of a universal definition of the weight of mesh implants, since even international recommendations for the treatment of inguinal hernias indicate the problem of the lack of universality in the classification of mesh implants [11].

Deveci et al. in their analysis emphasized that most studies hardly use the definition of a medium-weightmesh implant and come to a consensus of using only light and heavy mesh implants. Accordingly, Deveci et al. offers a simplified definition, where all nets with a specific weight ≤ 60 g/m^2 can be light, and all mesh implants with a specific weight > 70 g/m^2 can be heavy [32].

S. Elangoand co-authors in their study analyzing the materials of mesh implants note that the use of light polypropylene meshes reduces the number of complications, such as chronic groin pain, discomfort, etc., compared to heavy ones. This is explained by the properties of polypropylene, which consists in the excessive weight of the material, which leads to an increased reaction to a foreign body in the body, and the intense inflammatory reaction that occurs as a result of this leads to side effects and complications regardless of the presence of a coating, mono- or polyfilament threads in grid structure. Accordingly, the advantage of a light mesh over a heavy one is explained by the smaller amount of polypropylene in their composition [33].

S. D. Leeet al in their study also emphasize the advantages of absorbable mesh implants, showing better tissue integration, new collagen deposition, and sustained neovascularization compared to polypropylene meshes. Light mesh implants, characterized by a reduced volume of polypropylene in the composition and a large pore size, led to a higher concentration of mature collagen and a lower amount of fibrosis [34].

However, there are a number of studies with opposite and contradictory findings.

Thus, Burgmans et al. in their long-term double-blind study comparing mesh implants of different densities in laparoscopic hernioplasty did not determine the advantage of light mesh implants over heavy ones in the 2-year period after surgery [35].

In their randomized clinical trial, Carro et al found statistically significant differences in the reduction of postoperative pain on day 1 and day 7 and subjective foreign body sensation with the use of lightweight mesh implants. During the first year, there was no difference in pain, as measured by a visual analog pain scale, between the groups of patients with light and heavy mesh implants. One year after surgery, no patient required pain medication, and groin discomfort was minor and did not interfere with patients' daily activities, nor did it cause a decrease in work capacity.

A foreign body sensation was reported by 10.3% of patients after one year when using a heavy weight mesh (HWM), and only 5.2% of patients with light weight (LWM) [36].

Summarizing, it can be concluded that the discussion about the material weight of mesh implants in herniology and the advantages of their use in clinical practice are relevant for modern herniology and require further research and statistical analysis in search of an answer.

CONCLUSIONS

According to the obtained results, a corelation was found between mesh weight and development of postoperative chronic groin pain and hernia recurrences. In our study the advantage of light meshes in comparison with ultralight and heavy meshes was noted. In the scope of our study, light polypropylene mesh demonstrates itself as a optimal mesh weight when performing laparoscopic TAPP, which allows to achieve a low level of development of postoperative chronic groin pain and hernia recurrences. However, the corresponding problem requires further study and expansion of the patient database in order to deepen knowledge in the search for the ideal type of implant for hernioplasty.

Conflicts of interest. The authors declare that they have no conflict of interest in relation to this study, whether financial, personal, authorship or otherwise, that could affect the study and its results presented in this article.

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