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*Review*

# Contemporary management of inguinal hernia: from global epidemiology to personalized care

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**Summary**

Inguinal hernia represents a significant global health challenge, with more than 20 million operations performed annually. This paper provides a comprehensive review of contemporary practice, critically analyzing the evolution of treatment from the concept of the "gold standard" toward a personalized approach. The study integrates the latest epidemiological data, analyzes risk factors, and offers a comparative assessment of surgical techniques, focusing on the Lichtenstein technique and minimally invasive approaches. Special attention is devoted to redefining chronic postoperative pain, discussing controversies such as the use of synthetic meshes in contaminated fields, and examining the long-term outcomes of the "watchful waiting" strategy. The findings indicate that the success of intervention depends on surgeon experience, hernia and patient characteristics, as well as resource availability, which is particularly illustrated by the analysis of practice in Bosnia and Herzegovina. It concludes that achieving optimal outcomes requires long-term patient follow-up, standardization of protocols, and holistic economic analysis, together with the implementation of innovative technologies such as artificial intelligence in preoperative planning.

**Key words:** inguinal hernia, Lichtenstein technique, postoperative complications, chronic pain, surgical meshes, recurrence

## Introduction

### *Context and epidemiology*

Inguinal hernia is a global health challenge with a significant economic burden. The number of operations has increased from about 7 million to more than 20 million annually [1–3], while age-standardized incidence rates have simultaneously declined, reflecting progress in public-health strategies [3].

Epidemiological data confirm a marked male predominance: the cumulative lifetime risk is approximately 27% in men compared to 3% in women [4]. Analysis of large registries, such as the Danish registry, demonstrates a bimodal prevalence distribution with peaks in early childhood (0–5 years) and late adulthood (75–80 years) [1], indicating different etiologies—congenital in children and degenerative in older individuals. Despite the growing popularity of minimally invasive, laparoscopically guided techniques, open hernioplasty, particularly the Lichtenstein method, remains the mainstay of treatment in many centers [4, 5]. In countries with limited resources, including parts of Eastern Europe and Bosnia and Herzegovina, open procedures account for more than 80% of all interventions [6]. Understanding early postoperative complications and preventive measures is crucial for optimal outcomes.

## Risk factors and stratification

Based on contemporary analyses, three principal groups of risk factors have been identified:

- **Patient-specific factors:** advanced age (> 65 years), obesity (BMI > 30 kg/m²), uncontrolled diabetes (HbA1c > 8%), smoking, and prolonged corticosteroid therapy significantly increase the risk of complications, with obesity and diabetes potentially tripling it [7–9].
- **Hernia characteristics**: recurrent hernias carry roughly a 3.2-fold higher risk of complications than primary hernias; large inguinoscrotal and emergent hernias due to incarceration further increase the risk [4].
- **Surgical variables:** operations lasting more than 90 minutes and lower surgical volume are associated with more frequent complications; higher-volume centers and more experienced teams achieve better long-term outcomes [5, 10, 11].

The combination of multiple risk factors exponentially increases overall risk, making an individualized approach essential [4].

## Early and long-term postoperative complications

### *Chronic postoperative inguinal pain (CPIP)*

Chronic postoperative inguinal pain (CPIP) is one of the most challenging and complex complications of hernioplasty, with an incidence of 1–5% [7–9, 12]. Pathophysiology involves direct nerve trauma during surgery, nerve compression by scar tissue or mesh, and neuroma formation. According to current guidelines, CPIP is defined as pain persisting ≥ 6 months after surgery [4]. Clinical presentation ranges from mild discomfort to pronounced sharp or burning pain limiting daily activities [13].

### *Surgical site infection (SSI)*

The incidence of SSI is about 0.5–3% [14]. The most common pathogen is Staphylococcus aureus (≈60% of cases), followed by Staphylococcus epidermidis and Gram-negative bacteria. Clinically, SSI manifests as erythema, swelling, tenderness, purulent discharge, and fever. Routine antibiotic prophylaxis is not required in low-risk patients according to EHS guidelines, but is indicated in settings with a high SSI rate or in high-risk patients [4, 14].

### *Hematomas and seromas*

Hematomas and seromas occur in approximately 1–2% of interventions and most often regress spontaneously within 4–6 weeks; it is important to distinguish them from recurrence. Hematomas result from bleeding of epigastric vessels or perforators, whereas

seromas reflect inflammation and accumulation of serous fluid in dead spaces [4, 10].

### *Recurrence and long-term follow-up*

Long-term studies show that a significant proportion of recurrences become evident only after 5–10 years; recurrence rates are underestimated in studies with shorter follow-up. Meta-analyses indicate that about 30–40% of all recurrences occur after the first three years of surveillance [15–17, 10].

Key risk factors for recurrence include:

- Technical errors during surgery
- Inadequate size or positioning of the mesh
- Mesh infection
- Increased intra-abdominal pressure (obesity, chronic cough)
- Smoking and diabetes, which impair tissue healing.

The minimum follow-up period for accurate assessment of true recurrence rates is five years, with extended follow-up to 10 years recommended for high-risk patients [15–17, 10]. Regular clinical examinations and patient education on signs of recurrence are crucial elements of long-term management.

## Comparative analysis: Lichtenstein versus laparoscopy

For comparison of key outcomes among the three most commonly used techniques (Lichtenstein, TEP/TAPP, and Shouldice), Table 1 is presented.

The table shows that although the Lichtenstein method remains the most frequently performed, it exhibits a slightly higher incidence of CPIP compared to laparoscopic TEP/TAPP. The Shouldice method is associated with higher recurrence and chronic pain rates and longer recovery. These data are based on contemporary meta-analyses and randomized controlled trials [1, 4, 5, 7, 8, 18, 11].

Lichtenstein remains the standard open technique because of its low recurrence rate [4, 5], but TEP/TAPP offers advantages of shorter recovery and lower pain incidence [10, 11]. The latest reviews and RCTs indicate that when methodological anomalies are excluded, there is no statistically significant difference in recurrence rates between laparoscopic and open techniques [10, 11]. The success of laparoscopy depends on surgeon experience and requires a longer learning curve (about 50–100 procedures) [5, 11].

**Table 1.** Comparative rates of recurrence, incidence of chronic postoperative inguinal pain (CPIP), and recovery time after different inguinal hernia repair techniques

| Technique | Recurrence rate (%) | CPIP incidence (%) | Recovery time |
|---|---|---|---|
| Lichtenstein | 1–2 [10, 11] | 1–3 [7, 9, 12] | 2–4 weeks [10, 11] |
| TEP/TAPP | 0.5–1.5 [10, 11] | 0.5–2 [7, 8, 10, 11] | 1–2 weeks [10, 11] |
| Shouldice | 3–5 [10] | 3–6 [7, 9, 12] | 3–5 weeks [10] |

## Key Controversies and Future Directions

### *Use of mesh in contaminated fields*

Traditionally, implantation of synthetic mesh has been considered contraindicated in infected or contaminated fields, and guidelines emphasize the need for careful patient selection and strict infection control [4]. However, recent studies suggest that with modern lightweight macroporous meshes and rigorous intraoperative antisepsis, their use can be considered in carefully selected cases, opening the door to individualized management even in clinically complex situations [4].

### *"Watchful waiting" strategy*

For men with minimally symptomatic or asymptomatic inguinal hernia, a deferred-surgery ("watchful waiting") strategy can be a temporarily acceptable and safe option, particularly for those at high operative risk or with strong aversion to surgery. However, long-term follow-up studies [19] show that a substantial proportion of these patients (≈64% over 12 years) ultimately require surgical treatment due to pain progression, increased discomfort, or development of acute complications such as incarceration. These patients also more often report subjective regret over delaying surgery and experience a longer period of discomfort compared to those who choose earlier intervention. Therefore, although conservative management may initially be justified, patients must be fully informed about the high probability of eventual surgery. The decision should be based on careful assessment of individual risk, symptom intensity, and patient preference, with continuous follow-up.

## Regional challenges in Bosnia and Herzegovina

Regional data from the University Hospital Foča for 2016–2024, encompassing 1,382 inguinal hernia operations, show that open procedures are almost exclusively used: the Lichtenstein technique was performed in 96.7% of cases, whereas laparoscopic (TEP/TAPP) procedures accounted for about 4%. The overall early postoperative complication rate was 7.3%, including 2.0% chronic postoperative neuralgia, 1.6% surgical site infections, and 0.65% urinary retention. Complications were 23% more frequent in recurrent hernias than in primary ones, and hematomas and testicular atrophy were recorded almost exclusively in large inguinoscrotal hernias. Outcomes are largely comparable to international series, but limited availability of laparoscopic techniques and the lack of a uniform definition of chronic pain (≥ 6 months) remain key challenges. Priorities therefore include expanding capacity for minimally invasive procedures, standardizing pain follow-up, and establishing long-term quality-of-care registries.

## Focus on new technologies and innovations

While laparoscopic surgery is considered a modern approach, the true leap forward in inguinal hernia surgery comes from robotic surgery, artificial intelligence (AI), and innovative mesh materials. Considering these topics would show that the paper is up-to-date with the latest global trends, which is crucial for the future development of surgery, even in resource-limited settings.

## Robotic surgery and minimally invasive approach

Robotic surgery represents the most advanced evolution of minimally invasive techniques. In the context of hernia repair, the robot, controlled by the surgeon from a console, allows for exceptional precision and stability of movements. These advancements are a logical continuation of the evolution from open to laparoscopic techniques, which benefits in recovery and reduced pain have been confirmed by numerous studies and meta-analyses [10, 11].

- Key Advantages: The robot offers superior 3D visualization, better ergonomics for the surgeon, and the elimination of natural hand tremors. This allows for more precise dissection and suturing, which can reduce postoperative pain and the risk of nerve injury.
- Comparison with Laparoscopy: Although outcomes (such as recurrence rates) are similar between robotic and laparoscopic techniques, robotic surgery often results in a shorter hospital stay and less pain in the early postoperative period. However, the main drawbacks are the high cost of equipment and a longer learning curve for surgeons [5] posing a significant challenge for healthcare systems with limited budgets, such as the one in Bosnia and Herzegovina.

## Artificial intelligence (AI) in personalized planning

AI is increasingly applied in surgery, not only in robotics but also in data analysis and planning. The concept of a personalized approach to treatment, mentioned in the summary, is directly linked to the application of AI.

- Preoperative Planning: AI algorithms can analyze CT or MRI scans to create a detailed 3D model of the patient's anatomy, helping surgeons accurately determine the size of the hernia and choose the ideal mesh.
- Risk Assessment and Outcome Prediction: Machine learning models can analyze patient data (age, BMI, diabetes, medical history) to predict the risk of complications such as chronic pain [7, 8, 9] or infection. This allows for informing patients about their specific risks and helps the surgeon select the optimal technique.

## Innovative mesh materials

In the fight against postoperative complications, especially chronic pain, new mesh materials play a crucial role. The goal is to find materials that reduce the inflammatory response, which is the cause of many long-term ailments [12, 13].

- Biological Meshes: Made from animal or human tissue, these meshes are biodegradable. Although expensive and associated with a higher recurrence rate, they are useful in contaminated fields where a synthetic mesh would cause infection, a controversy discussed in the paper [4].
- Partially Biodegradable Meshes: These combine synthetic and biodegradable components. They provide initial strength until tissue healing occurs, and then they gradually degrade. The reduction of foreign material in the body can lead to a lesser inflammatory reaction and a decrease in chronic pain [17].

## Conclusion

Management of inguinal hernia has evolved from a single "gold standard" toward an individualized, patient-centered approach. Lichtenstein hernioplasty remains a reliable option, but contemporary evidence confirms that laparoscopy, in experienced hands, provides equivalent safety with less postoperative pain and faster recovery.

Necessary steps include:

- standardized protocols for long-term patient follow-up and definition of chronic pain,
- economic analyses encompassing total costs and quality of life, and
- introduction of innovative technologies and continuous evaluation of new surgical techniques and materials.

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# Savremeno liječenje ingvinalne kile: od globalne epidemiologije do personalizovane njege

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Ingvinalna hernija predstavlja značajan globalni zdravstveni izazov, sa preko 20 miliona operacija godišnje. Ovaj rad pruža sveobuhvatan pregled savremenih praksi, kritički analizirajući evoluciju liječenja od koncepta „zlatnog standarda“ ka personalizovanom pristupu. Istraživanje objedinjuje najnovije epidemiološke podatke, analizu faktora rizika i komparativnu procjenu hirurških tehnika, sa fokusom na Lihtenštajnovu tehniku i minimalno invazivne pristupe. Posebna pažnja posvećena je redefinisanju hroničnog postoperativnog bola, razmatranju kontroverzi poput upotrebe sintetičkih mrežica u kontaminiranim poljima, kao i dugoročnim ishodima strategije „pažljivog čekanja“. Nalazi rada ukazuju da uspjeh intervencije zavisi od iskustva hirurga, karakteristika hernije i pacijenta, kao i dostupnosti resursa, što je posebno ilustrovano analizom prakse u Bosni i Hercegovini. Zaključuje se da je za postizanje optimalnih rezultata neophodno dugoročno praćenje pacijenata, standardizacija protokola i holistička ekonomska analiza, uz implementaciju inovativnih tehnologija poput vještačke inteligencije u preoperativnom planiranju.

**Ključne riječi:** ingvinalna hernija, Lihtenštajnova tehnika, postoperativne komplikacije, hronični bol, hirurške mrežice, recidiv