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## 8.1 Introduction

The clinical comparison of anesthetic effect on inguinal hernia repair dates back to the 1900s when Harvey Cushing extolled the advantages of local anesthesia over general anesthesia, “There is avoidance of the unpleasant or dangerous post-etherization sequelae. There is no vomiting or retching to put strain on recent sutures. Urinary disturbances are less apt to occur, and catheterization is rarely necessary. The diet continues as before the operation. [...] Above all is the advantage gained in being able to operate with comparative safety in patients who would incur immediate risk submitting to general anesthesia” [1].

Today, more than a century later, the risk of general anesthesia has significantly decreased from Cushing’s era, but both general and local anesthesia are still used for open and laparoscopic inguinal hernia repair. Yet, with over half a million inguinal hernias repaired each year in the USA and up to 20 million repairs globally [2], the optimal anesthetic approach remains an area of debate.

In this chapter, we will review the options for anesthesia for inguinal hernia repair based on operative approach, clinical setting, patient characteristics, cost, and long-term quality of life.

## 8.2 Options for Anesthesia in Inguinal Hernia Repair

### 8.2.1 Local Anesthesia

#### 8.2.1.1 Patient Selection

Most open inguinal hernia repairs are eligible for repair under local anesthesia. Though better studied in the elective setting, local anesthesia appears safe and effective in the emergent setting. In a study of 90 emergent open inguinal hernia in Shanghai, China, the patients who had local anesthesia had fewer cardiac and respiratory complications, shorter ICU and hospital stays, and lower costs compared to those who had general anesthesia; the authors concluded acutely incarcerated hernias be safely performed under local anesthesia, especially when surgeons predicted a low probability of bowel resection [3].

Cardiopulmonary and significant medical comorbidities are common indications to avoid general anesthesia in elective hernia repair. Infants, patients with high anxiety, morbid obesity, or strangulated hernias benefit from general anesthesia [4]. Furthermore, when a bowel resection is anticipated, the need for abdominal wall paralysis and adequate sedation becomes more important if the operation requires intra-abdominal exploration via either laparoscope or midline incision. Patients under local anesthesia can be asked to “bear down” to check the patency of a repair and also forces the surgeon to use delicacy when handling tissue, which may resort in less tissue trauma than under other anesthetic modalities.

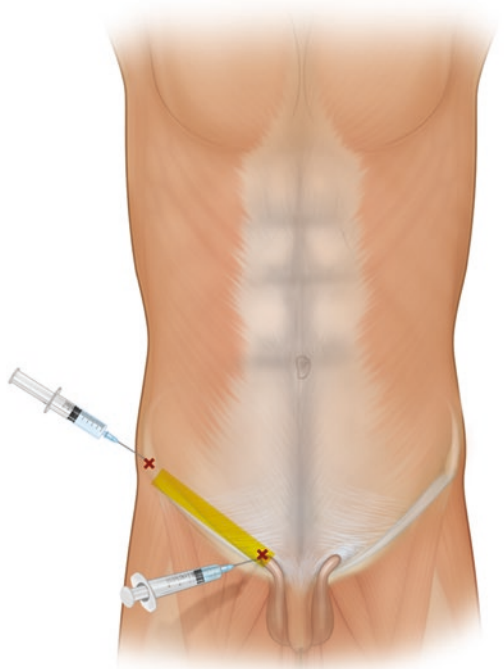
Anesthesia choice is affected by operative approach, as laparoscopic repairs are most often performed under general anesthesia. In some patients, a laparoscopic approach may be preferred, especially those patients who have high risk of wound infection such as poorly controlled diabetics, active tobacco users, and morbidly obese patients. In addition, patients who have had a failed open inguinal hernia repair are good candidates for a laparoscopic approach. A Cochrane review found a significantly lower risk of wound infection in

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laparoscopic versus open repairs (Odds ratio 0.45, 95 % confidence interval 0.32–0.65) [5]. A laparoscopic approach for primary hernias is also preferred by European Hernia Society (EHS) due to faster patient recovery, improved recurrence rates, and the ability to identify and fix bilateral hernias via same incisions, when the surgeon has appropriate laparoscopic expertise [4].

### 8.2.1.2 Technique for Local Anesthesia: Open Approach

In a Turkish study of 300 outpatient open inguinal hernia repairs, a typical dose of local anesthesia was 102 mg for lidocaine (median 100) and 48 mg for bupivacaine (median 50) [6]. The Lichtenstein method of local anesthesia administration, performed in over 10,000 patients and adopted by the EHS guidelines, recommends infiltration with 40–60 mg of a 50:50 mixture of 0.5 % bupivacaine and 1 % lidocaine, with a maximum recommended dosage of 300 mg 1 % lidocaine and 175 mg of 0.5 % bupivacaine (though this will vary by the patient's weight and if epinephrine is added) [4, 7]. The subcutaneous and intradermal space are infiltrated with approximately 3 and 10 mL, respectively, of local anesthetic [7] (Fig. 8.1). After the incision is made and carried down to the aponeurosis of the external oblique, local anesthesia is



**Fig. 8.1** Injection of local anesthesia in open inguinal hernia repair. *Yellow region* indicates location of subcutaneous and subdermal administration of local anesthesia. *Red “X”*s mark anterior iliac spine and superficial ring—administration of local anesthesia near these locations can anesthetize the three nerves to the inguinal region for an effective block

carefully injected into the subfascial space with at least 6–8 mL of local anesthetic into the inguinal canal to bathe in anesthetic and numb the three nerves to the inguinal region [7]. Slow injection, talking to the patient, and addition of sodium bicarbonate solution as a buffering agent can improve patient tolerance of the procedure [7]. Additional injections near the pubic tubercle and around the neck or interior of the hernia sac are sometimes required for reduction of hernias [7] (Fig. 8.2).

Local anesthesia can be combined with low dose propofol and/or benzodiazepine systemic administration; with selective use, this may improve patient tolerance of the procedure without compromising postoperative recovery time or creating need for a protected airway. Low dose propofol inhibits autonomic nervous system, has mild anticholinergic properties that prevent nausea, sweating, tachycardia, and much of the “hangover” effect of general anesthesia [8]; however, many Hernia Surgeons do not require this adjunct when utilizing local anesthesia in the standard patient [7].

### 8.2.1.3 Technique for Local Anesthesia: Laparoscopic Approach

A preliminary case series from Staten Island University Hospital of 10 patients with 14 hernias demonstrated that an extraperitoneal laparoscopic hernia repair could be safely performed under local anesthesia [9, 10]. Extraperitoneal may be better tolerated than intraperitoneal laparoscopic repair, as intraperitoneal insufflation is not required, but there is a published report of a patient tolerating bilateral intraperitoneal hernia repair under local anesthesia [11].

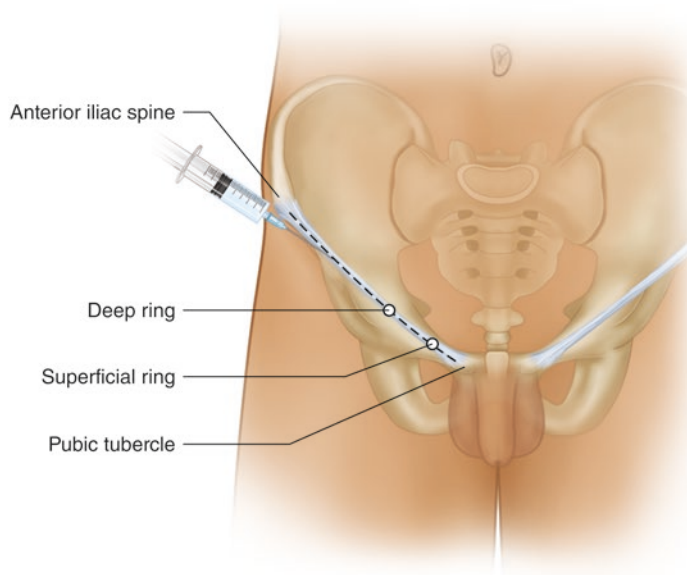
For laparoscopic repair under local anesthesia, the incision sites are anesthetized prior to incision [9]. The dissection of the peritoneal and development of the space of Retzius can be completed without pain and additional injections [9]. Discomfort can be associated with reduction of direct hernia contents, but can be mitigated by injecting lidocaine along the fold separating the transversalis fascia and peritoneal sac [9]. The cord structures should also be anesthetized at the internal ring. In a study comparing local ( $n=14$ ) to general ( $n=93$ ) anesthesia in extraperitoneal laparoscopic repair, there was no differences in postoperative complications or recurrence rates; the surgery was on average 29 minutes longer in the local anesthesia group, but patients tolerated the procedure well without any conversion to general anesthesia or open repair in the series [9].

## 8.2.2 General Anesthesia

### 8.2.2.1 Benefits and Risks

The discovery of general anesthesia revolutionized the field of surgery and allowed for the creation of modern surgical practice [12]. Today, general anesthesia routinely accompanies

**Fig. 8.2** Injection of local anesthesia. The skin and subdermal tissues are numbed along the inguinal ligament. Deeper subfascial injection anesthetic is utilized by the entry and exit to the inguinal canal, with careful aspiration to avoid intravascular administration



outpatient surgical procedures; 83 % of inguinal hernia repairs are performed as outpatient procedures in the USA [13]. Though local anesthesia has demonstrated benefits, general anesthesia has also been shown to be safe and effective in inguinal hernia repair. In a randomized controlled trial, patients who had general anesthesia had no detrimental short- or long-term effects on cognitive or motor function compared to regional anesthetic [14]. Even elderly patients can also be treated as outpatients; however one study found that age over 85 years, cardiovascular and cerebrovascular disease, and general anesthesia were independent predictors of hospitalization and death after outpatient surgery [15, 16].

General anesthesia facilitates laparoscopy by relaxing the abdominal muscles and allowing for insufflating for an intraperitoneal approach. Laparoscopic hernia repairs are commonly recommended for young women (due to the risk of femoral hernias), bilateral or recurrent hernias, and for patients who desire a quick return to work or activities [4, 6, 17, 18]. The European Hernia Society recommends laparoscopic approach, with preference for extraperitoneal approach, over open repairs for primary inguinal hernias, where the surgeon has laparoscopic expertise. As noted above, laparoscopy over open repair may also have benefits for patients at high risk for wound infection—such as patients with obesity, poorly controlled diabetes, tobacco use, and chronic steroid use. This is especially important in the setting of the increasing obesity epidemic of the Western world, with the majority of Americans now categorized as overweight and 34.9 % as medically obese. Laparoscopic surgery may also be safe and feasible in elderly cohorts [19], with improved short-term outcomes in one prospective series ( $n=345$ ) compared to an open approach, as measured by the Carolinas Comfort Scale, a validated hernia quality of life survey [20].

### 8.2.2.2 Optimizing Postoperative Recovery from General Anesthesia

The incidence of postoperative urinary retention ranges between 5.9 and 38 % after inguinal hernia repair and is one of the most common complications after general anesthesia for inguinal hernia repair [21]. Urinary retention appears to be more common after laparoscopic versus open approach (7.9 vs. 1.1 %,  $p<0.01$ ) [22]. However, the increase in urinary retention rates must be weighed against the risk of other postoperative outcomes such as hematoma, infection, and chronic pain, where an open approach has demonstrated significantly higher rates compared to a laparoscopic repair [23]. Drugs provided during general anesthesia can increase urinary retention. Common anticholinergics like atropine and glycopyrrolate block detrusor muscle contractions, and if more than 750 cm<sup>3</sup> of intravenous fluids are given, the risk of urinary retention increases by 2.3 times [21]. Preoperative discussion with the anesthesia team is necessary to reduce the risk of this common but bothersome postoperative complication by having the patient empty their bladder preoperatively, limit intraoperative fluids, and avoid reversal of the patient after surgery.

### 8.2.3 Regional/Spinal Anesthetic

Extensive research has demonstrated that spinal anesthetic has no benefit over local anesthesia in open inguinal hernia repair and increases the risk of postoperative urinary retention [4]. However, this technique is still commonly utilized across the globe. It is sometimes selected in patients who have bilateral hernias but in whom general anesthesia is not preferred or recommended. Epidural and spinal anesthetics

have been explored for extraperitoneal laparoscopic repairs. In one analysis of 1289 laparoscopic total extraperitoneal (TEP) hernia repairs in India, patients who had spinal anesthesia compared to general anesthesia had similar rates of recurrence, conversion to open, and postoperative complication [24]. Additional research from the USA, India, and China reveals that TEP under spinal anesthesia appears to be safe and feasible [25–27]. Though post epidural headaches occurred in up to 5% of patients, in general, these studies found decreased rates of postoperative pain and improved quality of life when spinal anesthesia was compared to general anesthesia, as measured by use of oral analgesics, visual analogue scale, and Kernofsky's performance survey [24, 25, 27, 28]. Though more research is needed for definitive recommendations, spinal anesthetic may be a useful anesthetic choice in the patient who is otherwise an excellent candidate for TEP, but not fit for general anesthesia.

## 8.3 Epidemiology and Current Trends

### 8.3.1 Anesthesia and Operative Approach

When considering inguinal hernia repair, main choices for anesthesia are local, general, and regional/spinal (Table 8.1). Operative approach and anesthetic of choice varies greatly between regions of the world. Open inguinal hernia repair is the most common approach worldwide: 86% of hernias are repaired via an open approach in the USA, 96% in UK, and 99% in Japan [17].

General anesthesia appears to be the dominant anesthesia choice in most Western medical centers [29]. In Denmark, 64% of 57,505 elective open groin hernia repairs were performed under general anesthetic, 18% regional anesthetic, and 18% local anesthetic [30]. In a study of private and public sector patients in the UK, general anesthesia was utilized more often local anesthesia in both the private sector (52% of cases) and public sector (66%) [18]. However, local anesthesia is the preferred anesthetic approach for open repairs conducted at some specialist hernia centers, including those in the UK [31], Sweden [32], and the USA, such as the Lichtenstein Hernia Institute at ULCA [7]. However, the popularity of the laparoscopic approach has been increasing as surgeons gain expertise. In a Massachusetts General Hospital study of physicians who underwent inguinal hernia repair, the percentage of physicians choosing laparoscopic repair for their own inguinal hernias increased from 16% in 1994 to 75% by 1997, which increased faster than the non-physician group, where the proportion of laparoscopic repairs still increased from 22 to 42% in the same study period.

Laparoscopic repairs make up minority of inguinal hernia repairs, though the incidence of this operative approach is growing in North America [6]. While France and UK acceptance of laparoscopy for primary inguinal repair has been <5%, in a survey of Canadian surgeons, 15% of surgeons preferred a laparoscopic approach in a primary inguinal hernia, but this increased to 30% of surgeons for recurrent or bilateral hernias [6, 33]. Per European Hernia Society guidelines, laparoscopic inguinal hernia techniques result in a

**Table 8.1** Options for anesthesia in inguinal hernia repair

	Pros	Cons	Contraindications	Ideal use
General anesthesia	• Relaxed abdominal wall for laparoscopy	• Patient unable to participate • Higher rates of urinary retention	Severe cardiopulmonary disease	Laparoscopic inguinal hernia repair
	• Secure airway			
	• Allows for extension of procedure to include laparotomy and/or bowel resection	• Risk of intubation and cardio-pulmonary complications • Higher cost		
Local anesthesia	• Least expensive method	• Very challenging to perform laparoscopy	Severe obesity Anxiety	Open inguinal hernia repair without concern for major bowel resection
	• High rates of patient acceptance	• May need to convert to general anesthesia if procedure becomes more complex	Infants	
	• Long-term quality of life benefits compared to general anesthesia <sup>a</sup> • Patient may participate with Valsalva			
Spinal anesthesia	• Good cardiopulmonary risk profile compared to general anesthesia	• Higher urinary retention rates	Bleeding disorders	Resource limited settings with inability to perform general anesthesia safely
		• Post-spinal headache	Systemic anticoagulation	
		• Difficulty walking/moving postoperatively	Anatomical variation in spine	
		• Lower patient satisfaction		

<sup>a</sup>In open inguinal hernia repairs

lower incidence of wound infection, hematoma formation, and an earlier return to normal activities or work than the Lichtenstein technique however requires laparoscopic expertise. Like most laparoscopic procedures, the majority of laparoscopic inguinal hernia repairs are performed under general anesthesia. Several small recent studies have demonstrated that a laparoscopic repair is safe and feasible under local anesthesia [9, 10] and spinal anesthesia [24, 27, 28].

### 8.3.2 Current Guidelines and Recommendations

For open inguinal hernia repair, numerous randomized controlled trials have found benefit of local anesthesia over regional and general anesthesia [4]. In a Swedish multicenter trial, local anesthesia was associated with shorter hospital stay, less postoperative pain, and less urinary retention [34]. In prospective data collected on more than 29,000 hernia repairs in Denmark, regional anesthetic was associated with more postoperative complications including urinary retention and general medical complications compared to local anesthesia [35]. The current literature supports the use of local anesthesia over spinal anesthesia, as the results of ten randomized controlled trials demonstrate that repairs under local anesthesia have superior postoperative pain scores, reduced incidence of urinary retention, decreased rate of anesthetic failure, and increased patient satisfaction compared to spinal anesthesia [4, 32, 35–37].

Currently, the European Hernia Society (EHS) recommends that local anesthesia be considered for all adult patients with a primary, reducible, unilateral inguinal hernia undergoing an open repair. Additionally, the EHS warns that regional anesthesia has no demonstrated benefit over local anesthesia for patients and increases the risk of postoperative urinary retention. In 13 of 14 randomized controlled trials, local anesthesia has been shown to be superior to regional and/or general anesthesia for open repairs in metrics such as patient satisfaction, time to discharge, recovery time, and postoperative complications [4]. Furthermore, for patients with an American Society of Anesthesiology (ASA) classification III or IV, local anesthesia is also recommended as a preferred anesthetic method over general anesthesia.

### 8.3.3 Cost Considerations

When considering cost, many factors need to be assessed by patients, researchers, and care providers. Operative approach and type of anesthesia are the main determinants and can be quantified. Patient preference, costs associated with postoperative recovery, and return to work are important and also need to be considered.

A British multicenter randomized controlled trial noted lower overall costs for open inguinal hernia repair under local anesthesia in part due to earlier discharge and shorter operative times [34]. Regional and general anesthetic had higher total hospital and overall costs and were not significantly different compared to each other [34]. Other studies have demonstrated similar results comparing general anesthesia and local anesthesia, where cost benefit is again demonstrated by local anesthesia, secondary to increased anesthesia and recovery room fees [38].

Per Cochrane review, patients undergoing a laparoscopic inguinal hernia repair often return to work more quickly which may lead to an overall cost savings when compared to an open approach [5]. Furthermore, the use of more expensive general anesthesia is often cited when comparing the pros and cons laparoscopic versus open approach, as laparoscopy is rarely performed without general anesthesia [9]; however, the increased cost burden of general anesthesia is often balanced by the cost effectiveness for laparoscopy in addressing bilateral groin hernias, commonly discovered in up to 10% of cases and repaired in one operative setting [39]. Similar to other systematic reviews, European Hernia Society Guidelines note that hospital costs alone may be lower in open approach, but when including socioeconomic factors, including quicker return to work, laparoscopy has cost benefits over an open approach, even when performed under local anesthesia [4].

### 8.3.4 Anesthetic Choice in Resource Limited Settings

Inguinal hernia is a global problem with significant burden in the developing world, and repair of a groin hernia can be a cost-effective global health intervention, given its positive effect on patients' disability adjust life years [40–42]. However, because of shortage of medical supplies, trained personnel, monitoring and specialized equipment, anesthetic choice is often limited in developing countries. Globally, 19% of operating rooms lack even a pulse oximeter and many more have inconsistent supply of anesthetic drugs and supplies [43]. General anesthesia is less likely to be utilized in these settings, and local anesthesia and spinal anesthesia are the preferred techniques for local providers and international NGOs alike [40, 41, 44]. In a study of 452 patients who underwent inguinal hernia repair in northwest Tanzania, 69% had their hernia repaired under spinal anesthetic and only 1% had repair under local anesthesia [44]. The increased hernia size, chronicity, high rates of bowel resection, and often emergent presentation of hernias repaired in resource limited settings adds to the challenge of repair and associated anesthesia. Spinal anesthetic, where a modest amount of local anesthesia is injected into the subarachnoid space

without need for many supplies or monitoring, remains the preferred anesthetic choice for inguinal hernia repair in resource limited settings [43].

## 8.4 Patient Satisfaction and Long-Term Quality of Life

An international, prospectively collected study of over 1100 open inguinal hernia repairs found significantly improved quality of life (QOL) outcomes in patients undergoing repair under local versus general anesthesia [45]. Patients undergoing repair under general anesthesia reported more than three times higher odds of pain, movement limitation, and mesh sensation in the first postoperative month compared with those who underwent local anesthesia; these differences persisted for up to 6 months for all QOL indicators [45]. The local anesthesia infused prior to incision and surgery may hypothetically stop the buildup of nociceptive molecules and prevent their inappropriate upgrade [7]. A recent multicenter trial demonstrated that local anesthesia compared with regional or general anesthesia was associated with short length of stay, reduced immediate postoperative pain, and, similar to Cushing's observations, the trial demonstrated that patients repaired under local anesthesia had less nausea, vomiting, and anorexia after surgery [46].

With rates of infection and recurrence after inguinal hernia repair decreasing and becoming reproducible in both laparoscopic and open approaches [47], postoperative quality of life has become a benchmark for an effective hernia repair. Despite the fact that as few as 14% of patients are warned of the risk chronic pain during the preoperative consent process [48], chronic pain remains the most common complication after inguinal hernia repair with reported rates of 8–40% in the literature [49–60]. From a survey of 2456 patients from the Swedish Hernia registry, bothersome pain was conveyed by 31% patients following an inguinal hernia repair with long-term follow-up; furthermore, 6% of patients described symptoms interfering with work or leisure activities, and 2% frequent severe pain [52]. Numerous studies have examined the effects of operative approach with a slight advantage towards laparoscopic over open [47, 50, 61–63], nerve identification [54, 64–67], mesh type and weight [68–71], anesthesia type [45, 72], and mesh fixation methods [73–77] to understand and reduce the risk of chronic pain after inguinal hernia pain. After introducing a hernia-specific index to quantify quality of life (QOL) in patients undergoing hernia repair, Heniford et al. at the Carolinas Medical Center's Hernia Center developed an algorithm to predict postoperative pain following an inguinal hernia repair based on preoperative risk factors. This has been adapted into a free mobile app for daily clinical use [20, 78] (Carolinas Equation for Quality of Life, CeQOL™, Charlotte, NC, available online) and has been downloaded in over 135 countries.

Despite ongoing research, chronic pain continues to complicate postoperative outcomes, which may prompt a more thorough informed consent that includes detailed discussion of operative approach and intended anesthesia.

Despite some surgeons' perceptions, patient acceptance of local anesthesia is high. In one large case series of consecutive open inguinal hernias repaired under local anesthesia, 99 of 100 patients stated they would choose local anesthesia again over other anesthetic choices if they had to undergo repeat repair [79]. Even when performed by surgical residents, patients who chose local anesthesia had acceptable outcomes with 93–95% of patients in another study stating they were "very satisfied" with the operation, with no statistical difference between attending and supervised resident surgeons with results from a 10-year audit [80].

## 8.5 Conclusions

Inguinal hernia repair under local anesthesia is associated with less postoperative nausea and pain, better postoperative quality of life scores, lower overall cost, and is well tolerated by patients. When performing an elective open inguinal hernia repair in an adult, local anesthesia should be considered as it is associated with better postoperative outcomes including long-term pain and quality of life and reduced costs compared to repair via general and regional anesthesia. Laparoscopic inguinal hernia repair is recommended for primary hernias, hernias in women, and bilateral hernias, as well as patients with a desire to return to work or activity more quickly or those at risk of wound infections. In those patients who undergo laparoscopic repair, general anesthesia is still the standard. However, laparoscopic hernia repair under local anesthesia, especially via extraperitoneal approach, may be a promising alternative in the future. As the trend is toward increase in laparoscopic inguinal hernia repairs, further larger studies should be performed to investigate this approach and compare quality of life outcomes as well as cost.

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