

Brief Overview about Ventral Hernias

Ahmed Hassan Atia Hassan, AbdelRahman Hassan Sadek, Islam Mohamed Ibrahim, Mohamed AbdAllah Zaitoun

Department of General Surgery, Faculty of Medicine, Zagazig University, Egypt

Corresponding author: Ahmed Hassan Atia Hassan

E-mail: a.attia22@medicine.zu.edu.eg, ahmedhassan3tia@gmail.com

Conflict of interest: None declared

Funding: No funding sources

Abstract

A hernia is a protrusion, bulge, or projection of an organ or part of an organ through the body wall that normally contains it. Abdominal wall hernias are typically classified by location or etiology. Hernias come in several types. Most commonly they involve the abdomen, specifically the groin. Most abdominal wall hernias should be evaluated by a surgeon when identified. The nature of the repair depends upon the size and location of the hernia. Abdominal wall hernia is often seen as a straightforward diagnosis with a relatively straightforward operative treatment. In a minority of cases, however, these patients have a significant undiagnosed underlying pathology which may be missed if not considered. A ventral hernia is defined by a protrusion through the anterior abdominal wall fascia. These defects can be categorized as spontaneous or acquired or by their location on the abdominal wall. Epigastric hernias occur from the xiphoid process to the umbilicus, Umbilical hernias occur at the umbilicus, and Hypogastric hernias are rare spontaneous hernias that occur below the umbilicus in the midline. Acquired hernias typically occur after surgical incisions and are termed Incisional hernias.

Keywords: Ventral Hernias

Tob Regul Sci. TM 2023;9(1): 1783-1797

DOI: doi.org/10.18001/TRS.9.1.123

Introduction:

A hernia is a protrusion, bulge, or projection of an organ or part of an organ through the body wall that normally contains it. Abdominal wall hernias are typically classified by location or etiology. Hernias come in several types. Most commonly they involve the abdomen, specifically the groin. Most abdominal wall hernias should be evaluated by a surgeon when identified. The nature of the repair depends upon the size and location of the hernia (1).

Abdominal wall hernia is often seen as a straightforward diagnosis with a relatively straight-forward operative treatment. In a minority of cases, however, these patients have a significant undiagnosed underlying pathology which may be missed if not considered (2).

Abdominal wall hernias are broadly classified according to the region of the abdominal wall in which they occur

- Ventral hernia – Ventral hernias occur anteriorly and include epigastric, umbilical, spigelian, parastomal, and most incisional hernias.
- Groin hernia – The groin is the region at the lower margin of the abdomen where the thigh meets the hip. Groin hernias include inguinal and femoral hernias.
- Pelvic hernia – Pelvic hernias can protrude through the pelvic foramina, as with sciatic and obturator hernias, or through the pelvic floor as perineal hernias.
- Flank hernia – Flank hernias protrude through weakened areas of back musculature and include the superior and inferior lumbar triangle hernias. (3)

Ventral Hernias

Introducion:

A ventral hernia is defined by a protrusion through the anterior abdominal wall fascia. These defects can be categorized as spontaneous or acquired or by their location on the abdominal wall.

Epigastric hernias occur from the xiphoid process to the umbilicus, Umbilical hernias occur at the umbilicus, and Hypogastric hernias are rare spontaneous hernias that occur below the umbilicus in the midline. Acquired hernias typically occur after surgical incisions and are termed Incisional hernias (4).



Figure 1: ventral hernias

Incidence:

Incisional hernias (IH) accounts for 15% to 20% of all abdominal wall hernias , Umbilical and Epigastric hernias(EH) constitute 10% of hernias. Incisional hernias are twice as common in women as in men. As a result of the almost 4 million laparotomies performed annually in the United States and the 2% to 30% incidence of incisional hernia, almost 150,000 ventral hernia repairs are performed each year. There is no conclusive evidence that demonstrates that the type of suture at the primary operation affects hernia formation. Patient-related factors linked to ventral hernia formation include obesity, older age, male gender, sleep apnea, emphysema, and prostatism. Wound infection has been linked to hernia formation. Whether the type of initial abdominal incision influences the incisional hernia rate remains controversial. The incidence of ventral herniation after midline laparotomy ranges from 3% to 20% and doubles if the operation is associated with a surgical site infection (5).

Diagnosis:

The evaluation of abdominal wall hernias requires diligent physical examination. The anterior abdominal wall is evaluated with the patient in standing and supine positions, and a Valsalva maneuver is also useful to demonstrate the site and size of a hernia. Imaging modalities may play a greater role in the diagnosis of more unusual hernias of the abdominal wall (6).

Classification:

- **Umbilical hernia**

The umbilicus represents a midline opening in the linea alba. Umbilical hernia occurs when the umbilical scar closes incompletely in the child or fails and stretches in later years in the adult patient. The hernia becomes readily apparent once the abdominal contents move through the umbilical opening given the relative lack of soft tissue in the anterior body wall at the site of the umbilicus . The etiology of umbilical hernia in the adult may be multifactorial, with increased intra-abdominal pressure working against a weak or incomplete umbilical scar. At birth, when the umbilical cord is manually ligated, the umbilical arteries and vein thrombose and the umbilical aperture closes. Any defect in the process of umbilical closure will result in an umbilical hernia through which omentum or bowel can herniate (7).

Clinical Manifestations

The diagnosis of umbilical hernia is not difficult to make. The condition presents with a soft bulge located anterior or adjacent to the umbilicus. In most cases, the bulge will be readily reducible so that the actual fascial defect can be easily defined by palpation. The patient may provide a history of vague abdominal pain associated with herniation and reduction. The list of differential diagnoses is short and includes abdominal wall varices associated with advanced cirrhosis, umbilical granulomas, and metastatic tumor implants in the umbilical soft tissue - Sister Joseph node. In

clinical practice, there is usually little doubt as to the diagnosis of umbilical hernia on physical exam. While the majority of umbilical hernias will close spontaneously in the infant, the clinical spectrum varies widely in the adult. The hernia in the adult is often symptomatic and does not show a tendency to close without intervention. As the hernia contents increase in size, the overlying umbilical skin may become thin and ultimately ulcerated by pressure necrosis (7).

The umbilical hernia with incarcerated omentum may present with significant tenderness on exam, despite the fact that bowel integrity is not at risk. Alternatively, an umbilical hernia may be found incidentally in the adult on physical exam. This hernia is usually small and any hernia contents are usually readily reducible. The small, asymptomatic, reducible hernia in the adult can be observed without the need for immediate intervention. Patients with umbilical hernia secondary to chronic, massive ascites require special consideration. The repair of such hernias is associated with significantly increased morbidity and mortality. Fluid shifts leading to hemodynamic instability, infection, electrolyte imbalance, and blood loss are all considerable risks for the patient in this clinical scenario. Umbilical hernia recurrence is also common in this setting given the persistently increased intra-abdominal pressure. Thus, hernia repair in this population should be reserved for those with progressively symptomatic or incarcerated umbilical hernias (8).

EPIGASTRIC HERNIA

An epigastric hernia is a defect in the abdominal wall in the midline junction of the aponeuroses of the abdominal wall musculature from the xiphoid process superiorly to the umbilicus inferiorly. The region of this midline raphe is termed the linea alba, and the rectus muscles are situated just lateral to the linea alba. In this area, there is no muscle layer to protect against herniation of intra-abdominal contents through defects in the midline fascia. A paraumbilical hernia is an epigastric hernia that borders on the umbilicus (8).

Etiology

The cause of epigastric hernia is largely unknown. Since the condition does not predominate in children, it is unlikely that the defect is entirely congenital in origin. Rather, the hernia is likely the result of multiple factors, such as a congenitally weakened linea alba from a lack of decussating midline fibers and subsequent increase in intra-abdominal pressure, surrounding muscle weakness, or chronic abdominal wall strain (7).

Clinical Manifestations

Epigastric hernia is often asymptomatic and represents a chance finding on physical exam. Patients with symptomatic hernias complain of vague abdominal pain above the umbilicus that is exacerbated with standing or coughing and relieved in the supine position. Severe pain may be secondary to incarceration or strangulation of preperitoneal fat or omentum. Bowel strangulation in epigastric hernias is a rare finding (8).

On examination, the hernia is diagnosed by palpating a small, soft, reducible mass in the midline superior to the umbilicus. The mass may protrude with a Valsalva maneuver or with standing. Palpation can be especially difficult in the obese patient. Rarely, imaging is needed to confirm the diagnosis, and computed tomography of the abdomen is the preferred technique (8).

Lumbar Hernias

Lumbar hernias are less common than groin or anterior abdominal wall hernias. These hernias occur posteriorly through the defects in lumbar muscle. Lumbar hernia generally occurs through the posterior fascia below the 12th rib, bounded by the erector spinae muscle medially and external oblique muscle laterally and iliac crest inferiorly. Lumbar hernia can be of two types, occurring through superior or inferior lumbar triangle. The hernia through superior lumbar triangle is called Grynflett-Lesshaft and is bounded by internal oblique muscle anteriorly, 12th rib superiorly and spinal muscles posteriorly. The inferior lumbar hernia called Petit is bounded by external oblique muscle anteriorly, iliac crest inferiorly, and latissimus dorsi posteriorly. Lumbar hernias are usually a sequel to surgery or previous trauma. They occur more commonly in males with age ranging from 50 to 70 years. Contents of lumbar hernia vary from bowel loops, retroperitoneal fat, and kidneys with strangulation being a common complication (9).

SPIGELIAN HERNIA

A spigelian hernia occurs along the semilunar line, which traverses a vertical space along the lateral rectus border from the costal margin to the pubic symphysis. Adriaan van der Spieghel, a professor of anatomy and surgery, was the first to accurately describe the semilunar line. He described the spigelian fascia as the aponeurotic structure between the transversus abdominis muscle laterally and the posterior rectus sheath medially. This fascia is what makes up the semilunar line, and it is through this fascial layer that a spigelian hernia forms (10).

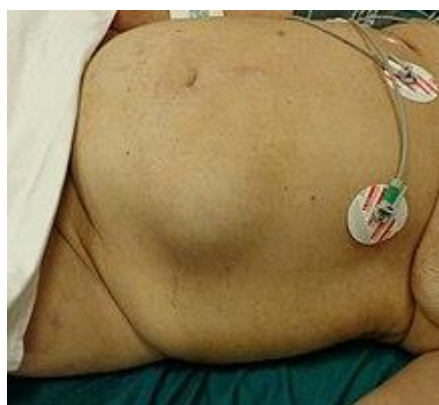


Figure 2: Spigelian hernia

INCISIONAL HERNIA

Of all hernias encountered, incisional hernias can be the most frustrating and difficult to treat. Incisional hernias occur as a result of excessive tension and inadequate healing of a previous

incision, which may be associated with surgical site infection. Obesity, advanced age, malnutrition, ascites, pregnancy, and conditions that increase intra-abdominal pressure are factors that predispose to the development of an incisional hernia. Obesity can cause an incisional hernia to occur because of increased tension on the abdominal wall from the excessive bulk of a thick pannus and large omental mass. Chronic pulmonary disease and diabetes mellitus have also been recognized as risk factors for the development of incisional hernia. Medications such as corticosteroids and chemotherapeutic agents and surgical site infection can contribute to poor wound healing and increase the risk for developing an incisional hernia. Large hernias can result in loss of abdominal domain, which occurs when the abdominal contents no longer reside in the abdominal cavity. These large abdominal wall defects also can result from the inability to close the abdomen primarily because of bowel edema, abdominal packing, peritonitis, and repeat laparotomy. With loss of domain, the natural rigidity of the abdominal wall becomes compromised and the abdominal musculature is often retracted. Respiratory dysfunction can occur because these large ventral defects cause paradoxical respiratory abdominal motion. Loss of abdominal domain can also result in bowel edema, stasis of the splanchnic venous system, urinary retention, and constipation. Return of displaced viscera to the abdominal cavity during repair may lead to increased abdominal pressure, abdominal compartment syndrome, and acute respiratory failure (11).

Classification Of Ventral/Incisional Hernia

Various classifications for ventral/incisional abdominal hernia are available in literature, but unfortunately none of them have been widely accepted. Various classification systems are proposed by Chevrel and Rath (12), Miserez et al. (13). They all have used variables like size and number of hernia defects, size of hernia sac and its ratio with anterior abdominal wall, primary or IH, recurrent hernia, location of hernia, and other symptoms and risk factors, in various combinations. One of the more accepted classification systems is the European Hernia Society (EHS) classification system. They separated the system into primary abdominal wall hernias and incisional abdominal wall hernias. (11).

Classification of primary abdominal wall hernias

For the primary abdominal wall hernias, there was agreement on the use of localization and size as the two variables to use.

Localization of the hernia

Two midline (epigastric and umbilical) and two lateral hernias (Spigelian and lumbar) are identifiable entities with distinct localizations.

Size of the hernia

Primary abdominal wall hernias are usually more or less round or oval shaped. Therefore, the size can be described with one measurement. Width and length will be comparable most of the time. It was agreed to use the “diameter” of the primary abdominal wall hernia as the second variable. Cutoff values of 2 and 4 cm were chosen to describe three subgroups according to size: small, medium and large. (14).

Classification table

In Table 1 the grid format for classification of primary abdominal wall hernias is proposed.

E H S					
Primary Abdominal Wall Hernia		Diameter	Small	Medium	Large
Classification		cm	<2cm	≥2-4cm	≥4cm
Midline	Epigastric				
	Umbilical				
Lateral	Spigelian				
	Lumbar				

Classification of incisional abdominal wall hernias

Localization of the hernia

Here the abdomen was divided into a midline zone and a lateral zone. The borders of the midline area are defined as follows (11).:

A. Medial or midline hernias

The borders of the midline area are defined as:

1. Cranial: the xiphoid
2. Caudal: the pubic bone
3. Lateral: the lateral margin of the rectal sheath

Thus, all incisional hernias between the lateral margins of both rectus muscle sheaths are classified as midline hernia.

The Chevrel classification uses three midline zones (12). A simple and easily memorable classification from M1 to M5 going from the xiphoid to the pubic bone is summarized in. Therefore, this classification was defining 5 M zones as follows (11).

1. M1: subxiphoidal (from the xiphoid till 3 cm caudally)
2. M2: epigastric (from 3 cm below the xiphoid till 3 cm above the umbilicus)
3. M3: umbilical (from 3 cm above till 3 cm below the umbilicus)
4. M4: infraumbilical (from 3 cm below the umbilicus till 3 cm above the pubis)
5. M5: suprapubic (from the pubic bone till 3 cm cranially).

B. Lateral hernias:

The borders of the lateral area are defined as in (14).:

1. Cranial: the costal margin
2. Caudal: the inguinal region
3. Medially: the lateral margin of the rectal sheath
4. Laterally: the lumbar region

Thus, four L zones on each side are defined as follows:

1. L1: subcostal (between the costal margin and a horizontal line 3 cm above the umbilicus)
2. L2: flank (lateral to the rectal sheath in the area 3 cm above and below the umbilicus)
3. L3: iliac (between a horizontal line 3 cm below the umbilicus and the inguinal region)
4. L4: lumbar (laterodorsal of the anterior axillary line)

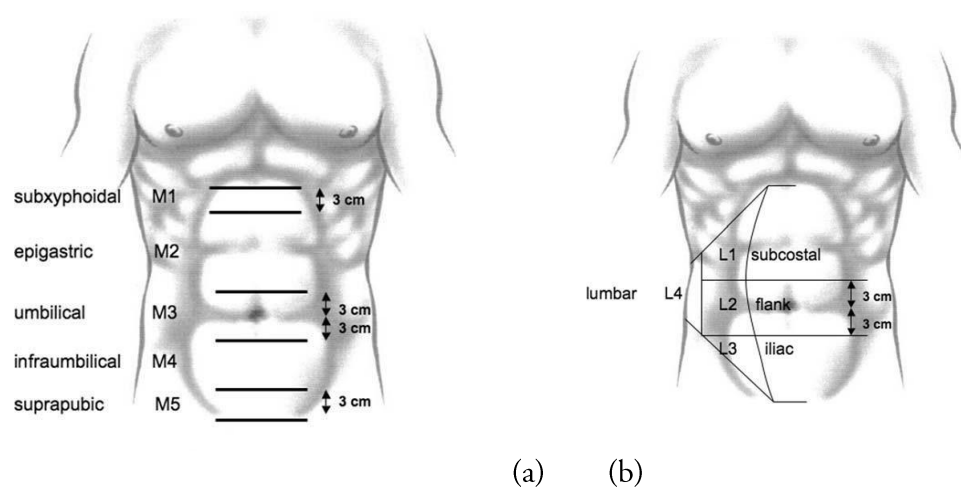


Figure 3: (a) 5M zone of incisional hernia. (b) four L zone of incisional hernia.

Size of the hernia

In contrast to primary abdominal wall hernias, incisional hernias come in many different sizes and shapes. So the size of an incisional hernia is not easily captured in only one variable or measurement. For classification in the two- dimensional grid format, it is essential to bring the variable "size of the hernia defect" in one quantitative or semi-quantitative measure. Chevrel solved this problem by choosing the width of the hernia defect as the one parameter to classify, stating that the width is the most important measurement of size to determine the difficulty of successfully repairing the hernia (12).

There was a consensus that the width of the hernia defect alone was insufficient to describe the hernia defect size adequately. **Muysoms et al.** (14) agreed that width and length should be used. This means that for a "grid format" both width and length have to be combined in one measurement.

The width of the hernia defect was defined as the greatest horizontal distance in cm between the lateral margins of the hernia defect on both sides. In case of multiple hernia defects, the width is measured between the most laterally located margins of the most lateral defect on that side (14).

Hernia defect surface can be measured by combining width and length in a formula for an oval, thus trying to make an estimation of the real surface in cm². This option was not withheld, because many incisional hernias are not oval shaped, and many hernias have multiple defects, making the correct estimation of hernia defect size difficult (14).

Because no consensus was reached on the variable "size of the hernia defect", it was not possible to make a "grid format" for an European Hernia Society (EHS) classification for incisional abdominal wall hernias. Instead, the grid could be made for the localization variable with space to note width and length correctly in cm. A semi-quantitative division, taking only the width as measurement for the size, was accepted to be included in the classification table. To avoid confusion with primary abdominal wall hernias (small, medium and large), a coded taxonomy was chosen (W1 <4 cm; W2 ≥ 4–10 cm; W3 ≥ 10 cm) instead of a nominative one (11).

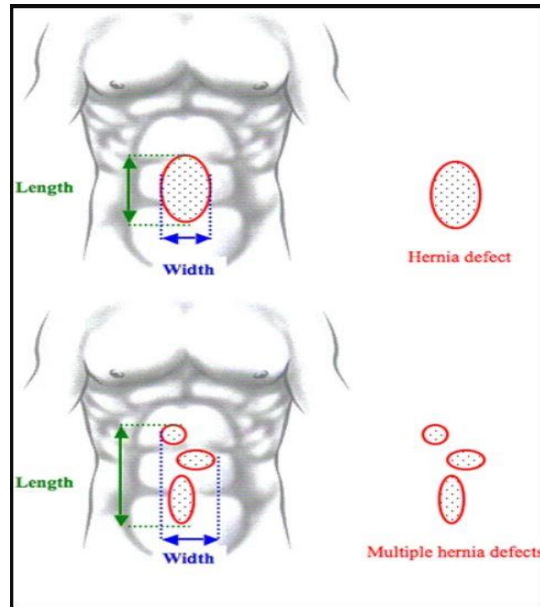


Figure 4: Definition of the width and the length of incisional hernias for single hernia defects and multiple hernia defects

E H S			
Incisional Hernia Classification			
Midline	subxiphoidal	M1	
	epigastric	M2	
	umbilical	M3	
	infraumbilical	M4	
	suprapubic	M5	
Lateral	subcostal	L1	
	flank	L2	
	iliac	L3	
	lumbar	L4	
Recurrent incisional hernia?		Yes <input type="radio"/>	No <input type="radio"/>
length:	cm	width:	cm
Width	W1	W2	W3
	<4cm	≥4-10cm	≥10cm
cm	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table 2

European Hernia Society classification for incisional abdominal wall hernias

Imaging of Abdominal Wall Hernias

Diagnosis of hernia is commonly made on physical examination. In cases where clinical assessment is difficult due to body habitus or painful condition, imaging studies have assumed importance for diagnosis and to delineate the extent of hernia. Conventional radiographs and Barium studies are no longer used, as multidetector computed tomography (MDCT) is widely available and remains the mainstay for diagnosis, sometimes aided with ultrasound (USG). Imaging studies other than USG and MDCT like magnetic resonance imaging (MRI) are rarely used but can be supportive for problem-solving (9).

Abdominal imaging is usually required for correct diagnosis, precise anatomical details, and diagnosis of complications and to differentiate hernia from other abdominal masses like tumors, hematomas, abscesses, or metastasis. Multiplanar reformations provides detailed images for better understanding by surgeons which helps them in surgical planning (15).



Figure 5: CT anatomy of the anterior abdominal wall (9).

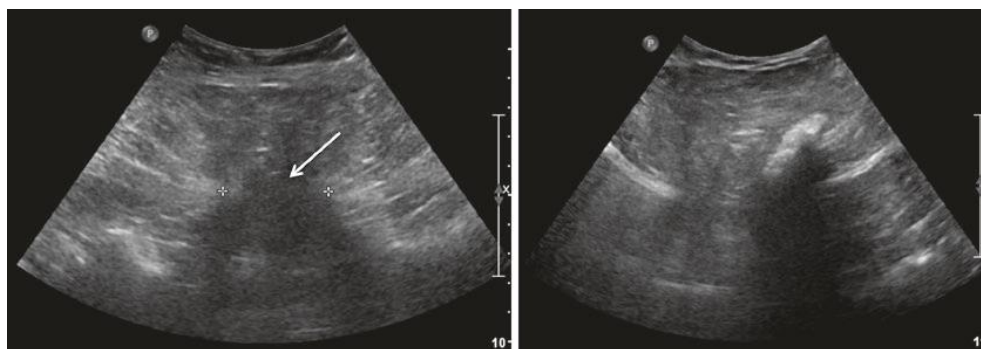


Figure 6: USG reveals anterior abdominal wall defect marked as (+). There is herniation of omentum and bowel in the hernial sac (arrow) (9).



Figure 7: Umbilical hernia; CT showing midline anterior abdominal wall defect with herniation of omentum through it (9).



Figure 8: Small umbilical hernia showing separation of rectus abdominis muscle and herniation of omental fat limited to subcutaneous fat (9).

MANAGEMENT OF VENTRAL/INCISIONAL ABDOMINAL HERNIA REPAIR

The management of ventral hernia includes non-operative and operative management. Non-operative management is indicated in patients who are not fit for surgery, those who require preoperative optimization or those who have highly complex hernia like loss of abdominal wall domain, patient with diagnosis of metastatic cancer, advanced cirrhosis, severe cardiopulmonary disease and super obesity ($\text{BMI} \geq 50 \text{ kg/m}^2$). Because the success of hernia repair is often measured by the absence of recurrence, the focus of preoperative optimization aims at eliminating factors that inhibit wound healing. Well-documented factors of adverse effects on wound healing include smoking, obesity, hyperglycemia, nutritional deficiencies, and infection (16).

Preoperative Management (17)

1. Weight reduction is very important before operating for incisional hernia. It is required to bring the BMI < 30–40 Kg/m².
2. Diabetes reduction: While glycemic control throughout all phases of patient management is important, preoperative reduction in baseline glycosylated hemoglobin (Hgb A1c) is essential for optimal outcomes
3. Nutrition and Metabolic Control: The nutritional status of the patient should be evaluated and optimized prior to major surgical procedures.
4. Control of COPD, definitive treatment of benign prostatic hyperplasia, stricture of the urethra and all other conditions who may increase the intra- abdominal pressure in postoperative period in view to avoid the recurrence.
5. Cessation of smoking is very helpful for good outcome.

Antibiotic Prophylaxis:

Antibiotic prophylaxis is recommended for abdominal wall hernia repairs. Antibiotics should be given 30–60 min before the incision is made and should be re-dosed if the procedure lasts longer than their half-life. Achieving adequate tissue levels in obese patients requires larger doses of the antibiotic in most cases (18)

Preoperative Skin Preparation and Decolonization Protocols:

Although shaving or removal of hair from the surgical site does not necessarily lower infection risk, it has been the standard of care for several years that clippers, rather than razors, be used to clear the surgical site hair that would interfere with the wound closure (19). Surgical site barriers, such as adhesive skin covers and skin sealants, have not been prospectively studied in ventral hernia repair. The information available on these applications is inconsistent, with reports varying from beneficial to potentially detrimental. Showering with antiseptic agents, such as chlorhexidine or Betadine, when compared to showering with standard soaps has not been proven to have a consistent benefit (20).

Indications of surgery in incisional hernia

- To get the relief from symptoms
- Prevention of complication like pain, incarceration, bowel obstruction and strangulation
- To improve the quality of life

References:

1. Fitzgibbons, R. J., Jr, & Forse, R. A. (2015). Clinical practice. Groin hernias in adults. *The New England journal of medicine*, 372(8), 756–763.
2. Upchurch, E., & Al-Akash, M. (2016). Abdominal wall herniae and their underlying pathology. *International journal of surgery case reports*, 20, 130–132.
3. Ansari, P. (2021). Hernias of the abdominal wall - gastrointestinal disorders. Retrieved April 26, 2023, from <https://www.merckmanuals.com/professional/gastrointestinal-disorders/acute-abdomen-and-surgical-gastroenterology/hernias-of-the-abdominal-wall>.
4. Flynn W, Vickerton P. **Anatomy, Abdomen and Pelvis, Abdominal Wall**. [Updated 2022 Jul 25]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022.
5. Holihan JL, Alawadi ZM, Harris JW, Harvin J, Shah SK, Goodenough CJ, Kao LS, Liang MK, Roth JS, Walker PA, Ko TC. Ventral hernia: Patient selection, treatment, and management. *Curr Probl Surg*. 2016 Jul;53(7):307-54.
6. Shamim, M., 2021, 'Clinical Evaluation of Abdominal Wall Hernias', in M. Shamim (ed.), *The Art and Science of Abdominal Hernia*, IntechOpen, London. 10.5772.
7. Troullioud Lucas AG, Jaafar S, Mendez MD. Pediatric Umbilical Hernia. [Updated 2022 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan.
8. Konaté, I., Ndong, A., Tendeng, J. N., 2020, 'Umbilical Hernias in Adults: Epidemiology, Diagnosis and Treatment', in M. Shamim (ed.), *The Art and Science of Abdominal Hernia*, IntechOpen, London.
9. Mathur, R.K., Goyal, N. (2020). Imaging of Abdominal Wall Hernias. In: Chowbey, P., Lomanto, D. (eds) *Techniques of Abdominal Wall Hernia Repair*. Springer, New Delhi
10. D. Rohan Jeyarajah, William V. Harford, Jr., Chapter 24 - Abdominal Hernias and Gastric Volvulus, Editor(s): Mark Feldman, Lawrence S. Friedman, Lawrence J. Brandt, Sleisenger and Fordtran's *Gastrointestinal and Liver Disease (Ninth Edition)*, W.B. Saunders, 2010, Pages 379-395.e4.
11. Kumar A, Paswan S (2019): Chapter "Incisional Hernia". In: *Techniques and Innovation in Hernia Surgery*. Intech Open, 19: 1-20.
12. Chevrel JP, Rath AM (2000) Classification of incisional hernias of the abdominal wall. *Hernia* 4:7–11.
13. Miserez M et al (2007) The European hernia society groin hernia classification: simple and easy to remember. *Hernia* 11(2):113–116.
14. Muysoms FE, Miserez M, Berrevoet F, Campanelli G, Champault GG, Chelala E, Dietz UA, Eker HH, El Nakadi I, Hauters P, Hidalgo Pascual M, Hoferlin A, Klinge U, Montgomery A, Simmermacher RK, Simons MP, Smietański M, Sommeling C, Tollens T, Vierendeels T, Kingsnorth A. Classification of primary and incisional abdominal wall hernias. *Hernia*. 2009 Aug;13(4):407-14.

15. Lassandro, F, Iasiello, F, Pizza, N, Valente, T, Stefano, M, Grassi, R, Muto, R, (2020). Abdominal hernias: Radiological features. World journal of gastrointestinal endoscopy. 3. 110-7.
16. Martindale RG, Deveney CW. Preoperative risk reduction: strategies to optimize outcomes. Surg Clin North Am. 2013;93(5):1041–55.
17. Petro CC, Haskins IN, Perez AJ, Tastaldi L, Strong AT, Ilie RN, Tu C, Krpata DM, Prabhu AS, Eghtesad B, Rosen MJ. Hernia repair in patients with chronic liver disease - A 15-year single-center experience. Am J Surg. 2019 Jan;217(1):59-65.
18. Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Surg Infect. 2013;14(1):73–156.
19. Jakobsson J, Perlkvist A, Wann-Hansson C. Searching for evidence regarding using preoperative disinfection showers to prevent surgical site infections: a systematic review. Worldviews Evid Based Nurs. 2011;8(3):143–52.
20. Dumville JC, McFarlane E, Edwards P, Lipp A, Holmes A. Preoperative skin antiseptics for preventing surgical wound infections after clean surgery. Cochrane Database Syst Rev. 2013;3:CD003949.