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Role of Ultrasound and Duplex in Evaluation of Complicated Hernia; Correlated with the Surgical Findings and Post-Surgical Outcome

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Abstract

Background: Hernias are a prevalent medical condition where an organ or tissue pushes through an abnormal gap in the body. They can manifest in different areas such as the abdominal wall, groin, and diaphragm. Complex hernias, including those that are incarcerated, strangulated, or recurrent, present substantial challenges in medical practice because they can lead to serious complications like bowel obstruction, ischemia, and tissue necrosis. Prompt and precise diagnosis of these complications is essential for effective treatment and better patient outcomes.

Objective: This narrative review was performed to explore the role of ultrasound (US) and duplex imaging in evaluating complicated hernias, correlating imaging findings with surgical outcomes, and assessing their impact on the postoperative results.

Conclusion: US and duplex imaging offer non-invasive, real-time assessment of hernias, aiding in identifying complications and guiding surgical management. Correlating preoperative imaging with surgical findings enhances diagnostic accuracy and improves preoperative planning, thereby optimizing patient care.

Keywords: Hernia, Ultrasound, Duplex, Complications, Surgical outcomes.

1. Introduction

Hernias are a common clinical condition characterized by the protrusion of an organ or tissue through an abnormal opening in the body. They can occur in various locations, including the abdominal wall, groin, and diaphragm. Complicated hernias, which encompass incarcerated, strangulated, or recurrent hernias, pose significant challenges in clinical practice due to their potential for causing severe complications such as bowel obstruction, ischemia, and necrosis. Timely and accurate diagnosis of these complications is crucial for effective management and improved patient outcomes [1, 2].

Ultrasound (US) and duplex imaging have emerged as valuable tools in the evaluation of hernias, offering non-invasive, real-time assessment of hernia characteristics. These modalities provide detailed information about the hernia sac, its contents, and blood flow dynamics, which are essential for identifying complications [3]. Ultrasound is particularly advantageous due to its availability, cost-effectiveness, and ability to visualize hernias in various patient positions. Duplex imaging, combining traditional ultrasound with Doppler assessment, enhances the diagnostic capability by evaluating blood flow within the hernia sac and surrounding tissues, aiding in the detection of vascular compromise [4].

Surgical intervention remains the definitive treatment for complicated hernias, with the surgical findings providing a crucial correlation to preoperative imaging assessments. Accurate imaging not only guides the surgical approach but also helps predict potential intraoperative challenges and postoperative outcomes. By comparing ultrasound and duplex findings with surgical results, clinicians can refine diagnostic criteria and improve the preoperative planning process [5].

The aim of this narrative review is to explore the role of ultrasound and duplex imaging in the evaluation of complicated hernias, correlate these imaging findings with surgical outcomes, and assess their impact on postoperative results. By synthesizing current evidence, we aim to highlight the strengths and limitations of these imaging modalities and propose guidelines for their optimal use in clinical practice.

2. Hernias

Hernias, derived from the Latin term for "rupture," occur when an organ or tissue protrudes through a weakness or opening in the cavity wall that normally contains it. There are three primary types of hernias: external, diaphragmatic, and internal. External abdominal hernias protrude through the abdominal wall, internal hernias pass through mesenteric or peritoneal openings, and diaphragmatic hernias involve weaknesses in the diaphragm [2]. Ventral hernias, a subset of external hernias, are defined by protrusions through the anterior abdominal wall fascia. Incisional hernias, another type, occur when intra-abdominal contents herniate through a defect in the musculo-fascial layers of the abdominal wall, often at the site of a previous surgical incision [6].

The history of hernias dates back to ancient times, with the earliest recorded instance of an inguinal hernia in approximately 1552 BC in Egypt. The term "groin hernia" was introduced in the early 1950s by Henri Fruchaud (1894–1960), encompassing indirect inguinal, direct inguinal, femoral, obturator, and supravesical hernias [7]. Herniorrhaphy, a surgical technique for repairing hernias, has been performed since the 18th century. Edoardo Bassini (1844–1924) revolutionized this procedure, and it remains one of the most common surgeries today. In the United States alone, approximately 750,000 groin herniorrhaphies are performed annually, with direct costs exceeding 2.5 billion dollars [8].

❖ **Classification of Hernias**

The classification of hernias is a contentious issue among general surgeons and specialists, with no universally accepted method. To address this, the European Hernia Society (EHS) has developed a simple and systematic classification system to standardize terminology and improve communication among healthcare professionals [9]. This system facilitates the intraoperative description of hernia types, providing a structured approach to categorizing hernias.

❖ **Groin Hernia Classification**

The EHS groin hernia classification is based on the Aachen classification, with modifications for laparoscopic surgery. The size of the hernia orifice is referenced by the diameter of a finger or laparoscopic instruments, typically around 1.5–2 cm [10]. Hernia sizes are categorized as 1 (1 finger), 2 (1–2 fingers), and 3 (3 fingers), with anatomical localization classified as lateral (L), medial (M), or femoral (F). Additionally, hernias are identified as primary (P) or recurrent (R) to provide a comprehensive description [11].

❖ **Primary and Incisional Abdominal Wall Hernias Classification**

In 2009, the EHS introduced a classification system for primary and incisional abdominal wall hernias based on localization and size. Primary hernias are classified as midline (epigastric and umbilical) or lateral (Spigelian and lumbar), with size described using one measurement. Incisional hernias are categorized based on their location in medial midline or lateral zones, with sub-zones (M1-M5 and L1-L4) defining precise regions. The classification also includes parastomal hernias, categorized by defect size and the presence of concomitant incisional hernias, with types I-IV based on these characteristics [12].

❖ **Etiology**

Hernias can arise from various factors that reduce the strength of the abdominal wall, broadly categorized as congenital or acquired. Congenital abnormalities may develop during the sixth week of gestation when the abdominal contents temporarily protrude through the umbilical cord due to rapid visceral growth. This process can lead to conditions such as omphalocele or gastroschisis. Another congenital issue, congenital rectus abdominis diastasis, involves the lateral insertion of rectus muscles, increasing hernia risk. Acquired conditions include obesity, increased intra-abdominal pressure, and previous abdominal surgeries, all contributing to weakened tissue and potential herniation [13].

❖ **Mechanism of Hernia Development**

Abdominal wall hernias share common pathophysiological mechanisms, primarily involving an imbalance between protease and antiprotease activities, leading to increased collagen breakdown. The integrity of the abdominal fascia, which relies on type 1 collagen for mechanical strength, is compromised when type 3 collagen, which provides less tensile strength, predominates. This imbalance can occur during the wound healing and remodeling stages of incisional hernia. Studies have shown overexpression of degrading enzymes like MMP2 and MMP9 in recurrent inguinal hernias, along with increased activity of MMP1 and MMP13, further weakening the abdominal wall and facilitating hernia development [14].

❖ **Diagnosis**

Diagnosing a clinically evident groin hernia typically relies on history and physical examination. Imaging may be necessary in cases of vague or intermittent groin swelling, poor localization of swelling, or other groin complaints without visible swelling. Physical examination can often reveal a hernia through an observable bulge or noticeable swelling when the patient strains [15].

Hernias can range from asymptomatic to presenting with non-specific symptoms, pain, or acute complications like incarceration and strangulation, which require prompt diagnosis and treatment. While most hernias with clear clinical features need no further investigation, uncertain cases might benefit from ultrasonography, MRI, CT, or herniography. Laparoscopy is generally not part of the diagnostic process for groin complaints and bulges [3].

❖ **Complications of Hernias**

Hernias can lead to several complications, including bowel obstruction, incarceration, and strangulation. Abdominal wall hernias (AWH) are a significant cause of small bowel obstruction, second only to adhesions, accounting for 10–15% of cases. While colonic obstruction is less common, inguinal hernias frequently present as surgical emergencies, with strangulation being a primary reason for urgent surgery. However, many acutely symptomatic hernias do not contain strangulated contents, allowing for elective repair if the hernia can be reduced and strangulation is excluded [16, 17].

Incarceration or strangulation of hernias, particularly in elderly and frail patients, is a major concern, with a 4.5% risk of inguinal hernia incarceration within two years, and up to 22% for femoral hernias within three months. Strangulation occurs in about 15% of cases, leading to compromised blood flow and potential ischemia, necessitating emergency surgery. In elderly patients, nearly 40% of hernia surgeries are due to incarceration, strangulation, or bowel obstruction, significantly increasing morbidity and mortality risks [18].

An incarcerated hernia, which cannot be manually reduced without signs of strangulation, poses a high risk for ischemia and strangulation, with postoperative mortality rates increasing from 0.01% to 5%. Strangulated hernias, where blood supply is restricted, often present with erythematous skin over the hernia. If left untreated, this can lead to necrosis and systemic complications like multiple organ dysfunction syndrome (MODS) due to severe water and electrolyte loss, toxin absorption, and massive inflammatory mediator release [19].

3. Ultrasonography (US)

❖ Ultrasonographic Anatomy

The inguinal canal is a narrow passage starting at the deep inguinal ring, lateral to the inferior epigastric artery, and ending at the superficial inguinal ring above the pubic tubercle. It houses the spermatic cord in males and the round ligament in females. The inferior epigastric artery is key in differentiating indirect from direct inguinal hernias. To visualize this artery, a linear transducer is placed horizontally near the lower abdomen's midline. The artery appears under the posterior rectus sheath, merging with the external iliac artery when the transducer is moved superior-medial to inferior-lateral [20, 21].

❖ Ultrasonography (US) Advantages

Clinical examination (CE) has traditionally been the gold standard for diagnosing inguinal hernias, with a sensitivity of 0.745 and a specificity of 0.963. However, groin ultrasonography (US) is increasingly recognized for its high sensitivity and ability to detect hernias, especially femoral and occult hernias undetectable by physical examination. US avoids the harmful effects of ionizing radiation and, when performed by skilled operators, offers greater sensitivity and specificity than MRI and CT. Despite its benefits, US is operator-dependent, relying heavily on the examiner's experience [22, 23].

❖ Postoperative Assessment and Complications

Previous hernia repairs can be identified via ultrasound, CT, or MRI by locating scarring, mesh, or plugs. Polypropylene mesh is visible on MRI but not radiopaque on CT. MRI is preferred for assessing hernia repair integrity, recurrence, and complications such as fluid collections, infections, and visceral complications. Testicular artery ligation and subsequent ischemia, though rare, can be detected by ultrasound. US remains the modality of choice for imaging-guided drainage of collections and for evaluating postoperative complications [24].

❖ Evaluating the Hernia Sac

During hernia evaluation, the transducer is moved from the deep inguinal ring to the scrotum in men or labia majora in women. A healthy inguinal canal maintains its integrity through the contraction of the external abdominal oblique muscle. In cases of incomplete closure of the processus vaginalis, increased intra-abdominal pressure can force various contents into the inguinal canal, causing an indirect hernia. The Valsalva maneuver is helpful in reproducing symptoms, especially when static conditions are asymptomatic. Changing positions from supine to erect may further aid detection [25, 26].

❖ Sonography of Complicated Hernias

Ultrasound can identify herniated organs, peritoneal fluid, Doppler signals, and peristalsis in herniated bowel loops. Incarcerated hernias, where the content cannot be manually reduced, and strangulated hernias, where blood flow is compromised, present distinct sonographic features. These include a narrow hernia sac neck, fluid within the sac, and parietal thickening. Identifying these features is crucial for indicating urgent surgical intervention. Advanced imaging like CT can provide additional diagnostic accuracy for complicated hernias [27, 28].

❖ Diagnosis of Incarcerated Hernia

An incarcerated hernia is identified by tenderness at the site, whole abdominal pain, bloating, nausea, vomiting, and obstruction signs. Physical examination often reveals an

irreducible, nonfluctuant bulge. Differentiation from other conditions, such as hydrocele, can be aided by ultrasonography. Abdominal radiographs can show bowel obstruction, while CT is the standard for detailed imaging, revealing transition zones and signs of strangulation, such as fluid in the sac, bowel-wall thickening, and luminal dilation [29].

❖ **Role of Doppler US**

Doppler ultrasound is valuable in early detection of strangulated hernias by evaluating blood flow in the strangulated intestinal wall. Recent advancements in Doppler sensitivity allow for the detection of minute blood flows, which is critical for assessing early blood flow disorders. This technique helps quantify blood flow velocity and can indicate early ischemia, making it a useful tool for determining the need for urgent surgical intervention [30, 31].

❖ **Other Imaging Modalities**

While imaging is often unnecessary for diagnosing a hernia, it can be useful in specific cases, such as suspected sports hernias or uncertain diagnoses. Ultrasonography has shown high sensitivity (over 90%) and specificity (82-86%) for detecting groin hernias. High-resolution CT and MRI can further aid in differentiating hernia types and assessing complications. MRI is particularly useful for diagnosing sports hernias and activity-related groin pain when physical examination does not reveal a hernia [32, 33].

4. Recommendations and future prospectives:

Integrating ultrasound and duplex imaging into routine clinical practice for evaluating complicated hernias is recommended to enhance diagnostic accuracy and surgical planning. Standardizing imaging protocols and training healthcare providers in the interpretation of hernia-related findings can further improve outcomes. Future research should focus on advanced imaging techniques, such as three-dimensional ultrasound and contrast-enhanced ultrasound, to refine diagnostic capabilities. Additionally, exploring the role of artificial intelligence in image analysis may streamline interpretation and decision-making. Longitudinal studies assessing the long-term impact of preoperative imaging on post-surgical outcomes are warranted to validate its clinical utility and optimize patient care pathways.

5. Conclusions:

Ultrasound and duplex imaging play crucial roles in the evaluation of complicated hernias by providing real-time, non-invasive assessment of hernia characteristics and complications. These modalities enhance diagnostic accuracy, guide surgical planning, and correlate well with intraoperative findings, thereby improving patient management and outcomes. Standardization of imaging protocols and further advancements in technology hold promise for optimizing diagnostic capabilities and refining treatment strategies in the management of complicated hernias.

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