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Innovative Endoscopic Pathways in Surgery: Exploring Efficacy, Safety, and Applicability through Cadaveric Studies

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Abstract

Introduction: Endoscopic surgery has revolutionized the medical field by enabling less invasive interventions, significantly reducing patient morbidity and improving postoperative recovery. This approach has become essential for treating a wide range of pathologies, offering precision that enhances treatment effectiveness and minimizes surgical trauma.

Objective: This study aims to evaluate multiple endoscopic pathways for accessing different body spaces using human cadaver research. We seek to analyze the efficacy, safety, and applicability of these techniques in modern surgery.

Methods: We explored four endoscopic approaches: scrotal, presacral, pelvic funnel, and ischiorectal fossa. Each technique was assessed for its procedural methodology, theoretical advantages, limitations, and potential clinical applications.

Results: Except the ischiorectal, all the endoscopic approaches could theoretically offer specific benefits, such as reduced tissue trauma and infection risks, and faster recovery times. However, the technical complexity and steep learning curves highlight the need for specialized training and careful patient selection.

Conclusion: This study underscores the promise of endoscopic surgery in managing various pathologies with minimal invasiveness. While except ischiorectal, each approach could offer specific benefits, successful implementation relies on the surgeon's expertise and careful candidate selection. Future research should focus on clinical trials to validate these techniques' efficacy and safety, along with advancements in endoscopic instruments and imaging technologies.

Keywords: Endoscopic pathways; Scrotal; Isquiorectal fossa; Presacral; Pelvic funnel

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Introduction

Endoscopic surgery is a modality that has revolutionized the medical field by enabling less invasive surgical interventions, significantly impacting patient morbidity and postoperative recovery [1]. This approach has become a cornerstone for treating a wide variety of pathologies, ranging from simple procedures to highly complex interventions in almost every system of the human body [2].

Endoscopy, by offering a direct and magnified view of internal structures, facilitates surgical interventions with a precision previously unattainable with conventional techniques [3]. This precision not only enhances treatment effectiveness but also significantly reduces surgical trauma, translating into decreased postoperative pain, a reduced need for analgesics, and a quicker return to daily activities for patients [4]. Moreover, the use of smaller incisions reduces the risk of infections and postoperative complications, which in turn shortens hospital stays and lowers associated healthcare costs [5].

In the present study, through research on human cadavers, we evaluated multiple endoscopic

pathways to access different body spaces, aiming to analyze their efficacy, safety, and applicability in various clinical contexts. Through this research, we seek to deepen the understanding of how endoscopic techniques can be optimized to improve clinical outcomes and expand therapeutic possibilities in modern surgery.

Approaches

Scrotal

The endoscopic pathway addressing pathologies at the scrotal level via the root of the scrotum is a novel and less invasive approach. This method (Figure 1) utilizes a single-port 1.5 cm incision at the root of the scrotum to create a cavity through which endoscopic instruments can be inserted.

*Technique Description:

The intervention begins with the patient in the jackknife position. A small incision is made at the root of the scrotum, followed by careful insertion of air to create a working space within the scrotum. This space must be sufficient to allow the manipulation of endoscopic instruments without causing damage to the scrotal tissue or adjacent structures. A single-port 1.5 cm is introduced through the incision, allowing direct visualization of the internal scrotal space. This approach enables a variety of procedures, including tumor biopsies, resection of benign tumors, and treatment of conditions such as varicoceles or hydroceles. Once the procedure is completed, the instruments are carefully withdrawn, and the incision is closed with generally absorbable sutures.

*Advantages of this approach:

- Less tissue trauma: The technique minimizes damage to healthy tissues, which is especially important in a sensitive area such as the scrotum.

- Faster recovery and less postoperative pain: The endoscopic approach reduces postoperative pain and accelerates the return to daily activities.

- Lower risk of infection: Smaller incisions and limited exposure of internal tissue reduce the risk of postoperative infections.

- Better cosmetic outcome: The small incision at the root of the scrotum generally results in a less visible scar.

*Limitations and considerations:

- Learning curve: The technique requires specific skills in endoscopy and handling instruments in a confined space.

- Patient selection: Not all patients are candidates for this type of intervention. Factors such as the size and location of the tumor may influence the choice of technique.

In summary, the endoscopic pathway through the root of the scrotum offers an alternative for managing various scrotal pathologies, combining efficacy with a favorable safety profile, although it requires specific training and careful considerations for its implementation.

Presacral

The pathway to the presacral space, using access behind the rectum through the lateral coccygeal area (Figure 2), is designed to address various benign pathologies located in the presacral space. This region, situated behind the rectum and in front of the sacrum, is a critical anatomical area due to its proximity to important nervous structures and pelvic organs.

*Technique Description:

The patient is positioned in the jackknife or lateral decubitus position, depending on the surgeon's preference and the case specifics.

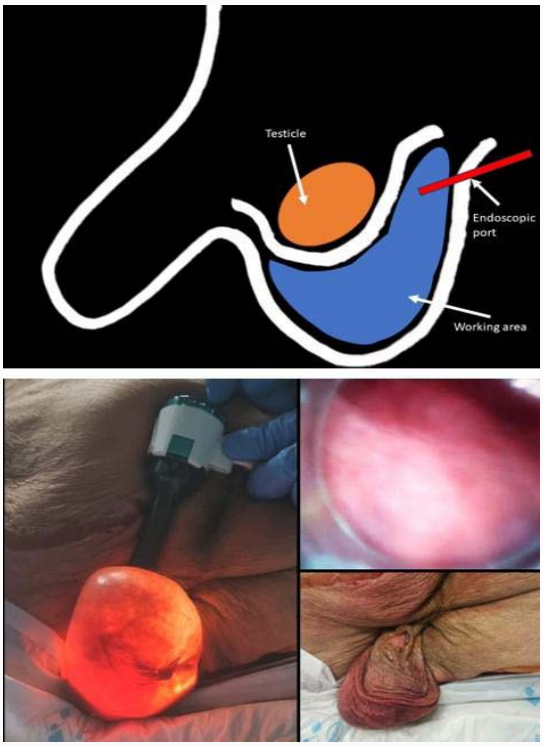

Figure 1: Scrotal approach.

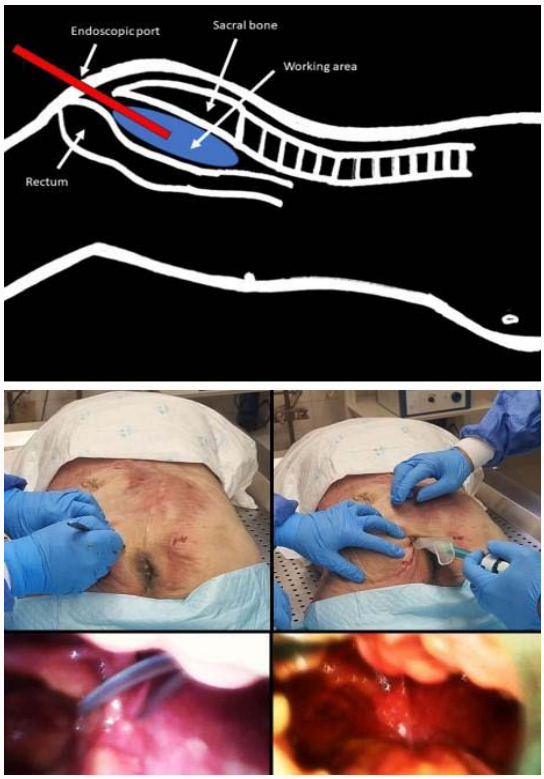

Figure 2: Presacral approach.

General anesthesia is administered, and the incision is made 1.5 cm to 2 cm from the midline between the anus and the coccyx, avoiding major muscular and ligamentous structures to minimize damage. The incision is usually small, about 1.5 cm, to place a single port. Following the initial incision, the surgeon digitally dissects the soft tissues and follows an avascular plane that leads directly to the presacral space, where a balloon dilator can be inserted. This phase of the procedure requires precision to avoid damaging the rectum and the pudendal nerve structures surrounding the entry pathway. Once the presacral space is reached, a single port is placed, air is inserted to occupy the space, and the procedure is performed. Specialized surgical tools, such as ultrasonic cutting devices, can be used to facilitate resection and minimize trauma to adjacent tissues.

*Advantages of this approach:

- Direct and safe access: The coccygeal route offers direct access to the presacral space without disturbing major pelvic structures.

- Lower risk of complications: By avoiding open or laparoscopic abdominal approaches and posterior (Kraske) approaches, the risks of infection and complications associated with these manipulations are reduced.

*Limitations and considerations:

- Demanding surgical technique: It requires great skill and experience due to the proximity of critical structures like nerves in a confined space.

- Potential nerve complications: There is a risk of damage to the pudendal nerve, although if the approach is made at the indicated site, the risk is minimal.

In conclusion, the pathway to the presacral space through the lateral coccygeal area is a valuable option for managing benign pathologies in this anatomically complex area. However, its success largely depends on the surgeon's skill, the available equipment, and meticulous preparation before the procedure.

Pelvic funnel

The approach through the coccygeal area to the pelvic funnel, traversing the pelvic floor musculature, is primarily used to access structures located in the deepest part of the pelvic cavity (Figure 3).

*Technique Description:

Under general anesthesia, the patient is usually positioned prone in the jackknife position or in lithotomy position depending on the area of the funnel to be addressed. The intervention begins with a lateral incision 1.5 cm to 2 cm from the midline between the coccyx and the anus. This incision allows initial access to the more superficial layers and subsequently to the deeper layers of the pelvic floor muscles. Through the incision, the surgeon carefully dissects the tissues digitally (avoiding the surrounding pudendal nerve). Upon reaching the pelvic floor musculature, the surgeon digitally dissects the muscle fibers to enter the pelvic funnel, and a long trocar is placed to traverse the musculature of the funnel. Subsequently, two more trocars are placed, one symmetrical on the contralateral side and another more medially, always respecting the path of the pudendal nerve that surrounds the entry ports. These two trocars are introduced under direct vision into the pelvic funnel. Various interventions can be performed depending on the underlying pathology, including benign tumor resection, perineal hernia repair, or procedures on the pelvic floor.

*Benefits of this approach:

- Direct access: Provides direct and controlled access to the pelvic funnel region, which is difficult to reach with other approaches.

- Reduced complications associated with more invasive approaches: By avoiding the need to dissect the pelvis through the abdominal cavity, the associated risks can be reduced.

*Considerations and limitations:

- Technical complexity: Requires a high degree of skill and experience due to the complexity of the structures involved and the need to preserve critical functions.

- Risk of complications: Includes potential damage to pelvic nerves, which can result in functional alterations, as well as complications related to healing and the integrity of the pelvic floor.

In summary, the approach through the coccygeal area to the pelvic funnel can be a valuable surgical technique for specific pathologies in this complex area. Its success depends on meticulous surgical execution and adequate preoperative planning.

Ischiorectal fossa

The approach to the ischiorectal fossa through the mid-coccygeal area attempts to access an anatomically deep and complex region of the body (Figure 3). However, its applicability in clinical practice is limited due to the proximity of critical nervous structures, particularly branches of the pudendal nerve, which significantly increases the risk of neurological complications.

*Technique Description:

The patient is generally positioned prone in the jackknife position to facilitate access to the coccygeal region and under general anesthesia. The intervention begins with an incision between the anus and coccyx 1.5 cm to 2 cm from the midline. From this incision, the surgeon dissects downward, traversing soft tissues and subcutaneous fat, attempting to reach the ischiorectal fossa. The major complication of this approach lies in the need to carefully navigate around the branches of the pudendal nerve, which are vital for the sensory and muscular function of the perineum. Accidental damage to these structures can result in significant dysfunction, including incontinence and altered sexual sensitivity. Furthermore, the clinical applicability is very limited, and although we have explored it in cadavers, it seems to be a minimally useful approach.

*Limitations and Risks:

- Nerve damage: The proximity of the pudendal nerve and its branches is the main limiting factor. These structures are crucial for basic pelvic functions, and their damage can lead to devastating long-term consequences for the patient.

- Postoperative complications: Even with impeccable surgical technique, the risk of complications such as infections, bleeding, or fistula formation is considerable due to the nature of the targeted region.

In conclusion, while the technique for accessing the ischiorectal fossa through the mid-coccygeal area theoretically provides a direct pathway to this anatomical region, the associated risks, especially in terms of nerve damage and limited clinical applicability, make it impractical and of minimal utility. In clinical practice, other approaches are preferred that offer a safer balance between

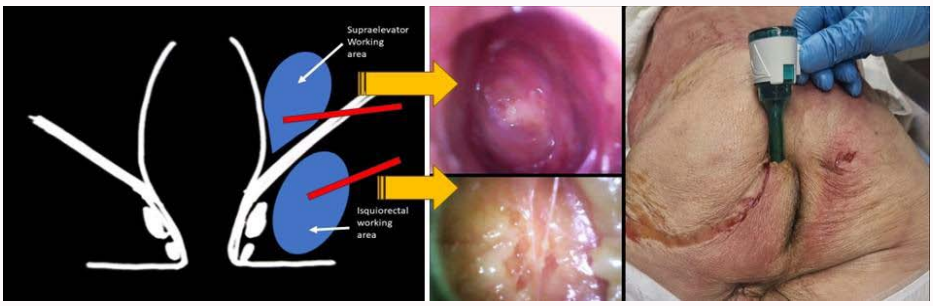

Figure 3: Pelvic funnel and isquiorectal fossa approach.

accessibility and minimization of risks.

Discussion

This study's findings significantly enhance our understanding of endoscopic pathways by providing detailed evaluations of various approaches through cadaveric research. When contextualizing these novel approaches within the landscape of currently employed techniques, several important comparisons and considerations emerge.

Currently, scrotal surgeries typically employ open techniques. The novel single-port scrotal endoscopic approach presents several advantages over these conventional methods. Traditional open surgeries often result in significant tissue trauma and larger scars, which can lead to extended recovery periods and higher risks of infection. In contrast, the single-port technique described in this study utilizes a 1.5 cm incision at the root of the scrotum, which minimizes tissue damage, reduces postoperative pain, and results in better cosmetic outcomes [6,7]. This approach aligns with the growing trend in minimally invasive surgeries aimed at enhancing patient recovery and satisfaction [8].

However, the learning curve associated with this endoscopic approach is steeper compared to traditional methods. Surgeons must acquire specific skills in endoscopic manipulation within a confined space, emphasizing the need for advanced training programs [9].

The presacral space is traditionally accessed through open or laparoscopic approaches, often involving significant manipulation of pelvic structures. These methods can result in high morbidity rates and prolonged recovery times [10]. The lateral coccygeal endoscopic approach described in this study offers a minimally invasive alternative that reduces the disturbance of major pelvic structures and lowers the risk of postoperative complications. This method's precision is paramount, as the presacral space is surrounded by critical nerves and the rectum, necessitating meticulous dissection to avoid complications [11].

Compared to the traditional Kraske approach, which requires a more extensive dissection, the endoscopic lateral coccygeal method presents a safer and less invasive option. However, this technique requires significant surgical expertise and experience, particularly in navigating the presacral space without damaging adjacent structures [12].

On the other hand, accessing the deepest parts of the pelvic cavity traditionally involves extensive open surgeries or laparoscopic methods, which can be invasive and carry risks of complications. The coccygeal approach to the pelvic funnel described in this study provides direct access while avoiding the need for pelvic dissection, thus reducing the associated risks [13]. This method's direct and controlled pathway is a significant advantage, particularly for complex procedures such as benign tumor resections or pelvic floor repairs.

However, the technical complexity and the need for preserving critical pelvic functions mean that only highly skilled surgeons can effectively employ this technique. The requirement for advanced training and precise surgical execution cannot be understated [14].

Accessing the ischiorectal fossa traditionally involves open surgeries that pose significant risks due to the proximity of critical nerve structures, particularly the pudendal nerve. The mid-coccygeal endoscopic approach described in this study theoretically offers a direct pathway but is limited by its high risk of neurological complications. The potential for long-term dysfunctions, such as incontinence and altered sexual sensitivity, reduces its clinical applicability [15,16].

When considering the integration of these novel endoscopic pathways into current surgical practices, their advantages in reducing tissue trauma, infection risks, and recovery times are evident. However, the technical demands and steep learning curves associated with these methods highlight the necessity for specialized training and careful patient selection. As minimally invasive surgery continues to evolve, these approaches represent significant advancements but must be adopted with caution and thorough preparation [10,11].

Future research should focus on clinical trials to validate these endoscopic techniques' efficacy and safety in live patients. Additionally, developing advanced endoscopic instruments and imaging technologies will further refine these methods, making them more accessible and effective. Enhanced surgical training programs are also crucial to equip surgeons with the necessary skills for these complex procedures [13,14].

This study underscores the promise of endoscopic surgery in managing various pathologies with minimal invasiveness. While each approach offers specific benefits, their successful implementation relies on the surgeon's expertise and the careful selection of suitable candidates. The ongoing evolution of endoscopic techniques holds the potential to expand the boundaries of minimally invasive surgery, ultimately improving patient outcomes and advancing modern medicine.

Disclosure Section

Drs. Francisco Javier Pérez Lara, Francisco Javier Moya Donoso, Cristina Muñoz Romero, Pablo Salinas Sanchez, Tatiana Prieto Puga Arjona, Patricia Maldonado Validivieso and Carmen Rueda Cruces

have no conflicts of interest or financial ties to disclose.

Authors Contribution

FJ Pérez Lara: made a substantial contribution to the concept and design, drafted the article or revised it critically for important intellectual content, approved the version to be published.

F.J. Moya Donoso: made a substantial contribution to the design, drafted the article or revised it critically for important intellectual content, approved the version to be published.

C. Muñoz: made a substantial contribution to the design, drafted the article or revised it critically for important intellectual content, approved the version to be published.

P. Salinas: made a substantial contribution to the design, drafted the article or revised it critically for important intellectual content, approved the version to be published.

T. Prieto-Puga Arjona: approved the version to be published.

P. Maldonado Valdivieso: approved the version to be published.

C. Rueda Cruces: approved the version to be published.

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