Evaluation of Laparoscopic Retrieval Endo Bag: Enhancing Precision Safety and Efficiency in Minimally Invasive Surgery for Ovarian Cancer Appendicitis, and Gallbladder Cancer Using in-Vitro Simulations

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Abstract

Laparoscopy is a minimally invasive surgical method that uses small incisions and specialized instruments, including a camera, to perform abdominal operations, resulting in less pain, faster recovery, and smaller scars compared to traditional open surgery. A laparoscopic retrieval bag is a specialized device used in minimally invasive surgery to safely collect and remove surgical specimens through small incisions. The pouch is designed to facilitate the retrieval process while minimizing trauma to surrounding tissues. The laparoscopic retrieval bag has been designed, to significantly improve minimally invasive surgery to address critical health issues. The objective of the study is to assess effectiveness and safety in enhancing surgery by summarizing several uses of the pouches in treating such conditions as ovarian cancer, appendicitis, and gallbladder cancer. The applied study also describes in-vitro simulations using with the Abdominal Endotrainer, which is a training device that replicates modeling the human abdomen for practicing laparoscopic skills. In this setting, the researchers were able to test the retrieval pouches regarding their deployment, functionality, and containment capabilities to remove specimens through small incisions that minimize surgical trauma and recovery times. Key conclusions highlighted are that the laparoscopic retrieval bag will improve surgical precision and safety significantly. Demonstrated, these pouches have provided for correct specimen retrieval along with no spillage and contamination risks, thereby minimizing overall procedure time. This approach is important in advanced surgeries, such as cholecystectomies for gallbladder cancer, appendectomies for appendicitis, and ovarian cancer management. This study confirms that retrieval pouches in laparoscopy are essential in ensuring better results regarding minimal invasion. The application of retrieval pouches is definitely advantageous for patient safety by preventing infection and enabling faster recovery, hence the need for continued development in terms of tools and techniques used in surgery.

Keywords: *Minimally Invasive Surgery, Laparoscopic Retrieval Bag, Bio-Compatible Pneumoperitoneum, in-Vitro Trials, Abdominal Endotrainer, Specimen Retrieval, Surgical Precision, Contamination Risks, Relative Risk Rates, Surgical Outcomes, Patient Recovery, Safety Features, Deployment Mechanisms, Surgical Innovation, Minimally Invasive Techniques.*

I. INTRODUCTION

Ovarian cancer has been estimated to be the eighth most common cancer in the world and the third highest among Indian women. Diagnosis and treatment have improved, but yet only 15% of cases are diagnosed at stage-1, leading to resulting in a high mortality case fatality ratio for the advanced stages. Appendicitis is more common with the intake of mixed diets ie, 63.8%. In one of the study, vegetarian diets are less common ie, 36.2%. Gallbladder cancer is more common in northern and northeastern India than in any other part of the country. This disease is more common in female than their male counterparts and more common in North Indian cities. The Rr Rates also vary significantly between North and South India; they are higher in the North, where the incidence of

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gallbladder cancer starts to rise from the age of 45 years and reaches a peak at the age 65 years.

The tremendous growth of minimally invasive surgery has significantly enhanced the effectiveness and safety of a wide range of surgical procedures.

A notable innovation in this area is the development of minimal invasive surgery of laparoscopic retrieval endo bags. These tools are designed with the primary aim of facilitating safe and efficient removal of specimen from the abdominal cavity such as gall bladder, appendix, other tissue and calculi, adnexal cysts, masses, uterine fibroids and ovaries during a laparoscopy surgery. In this respect, the continuous evolution of the endo bag is contributory to minimizing surgical incision and shorten cuts in reducing the recovery time of patients and consequently reduces post-operative risks. Mapping their journey from conceptualization through current applications with these pouches illustrates how central they are in ensuring the success of minimal invasive surgery today.

The laparoscopic retrieval bags are very instrumental in promoting precision during the handling of minimally invasive surgery. These devices enable surgeons to remove excised tissues or organs through small incisions, reducing surgical handling and minimizing damage to tissues. Such Endobags avail precision control required for very delicate procedures, including cholecystectomy and appendectomy. It also accelerate the entire process and enhances the surgeon's precision and confidence by cleanly enveloping the target specimen and removing it without spreading the contamination to other areas of the body.

The key advantages of using laparoscopic retrieval endo bag are the reduction of infection rates. The construction of such endo bag secures the pathological specimens and ensures no direct contact between the specimen and the surgical site. This acts as a form of crucial isolation for , minimizing the exposure of sterile areas to potential contamination thereby significantly reduce the chances of post-operative infections.

The use of the above-mentioned developed single-use, sterile endo bags ensures that every procedure starts uncontaminated equally vital to the overall sterility and safety in the surgical environment.

II. MATERIALS AND METHODS

➢ *Retrieval Endo Bag Construction:*

The following research article details the different components employed in constructing the laparoscopic retrieval endo bag. The primary component used to construct the pouch is typically made from durable, flexible materials such as Nylon, Polyethylene, Polyurethane, and Thermoplastic Polyurethane. It is designed with a multilayer construction to provide both strength and flexibility. These materials were selected for their biocompatibility and ability to function in the varied environments encountered during different surgical procedures. These Laproscopic Retrieval Pouch Assembly shown in the figure 01 often come with a drawstring mechanism or an analogous mechanism to close the top after retrieval. This inhibits the unintentional spilling of the specimen and keeps it well inside the pouch.

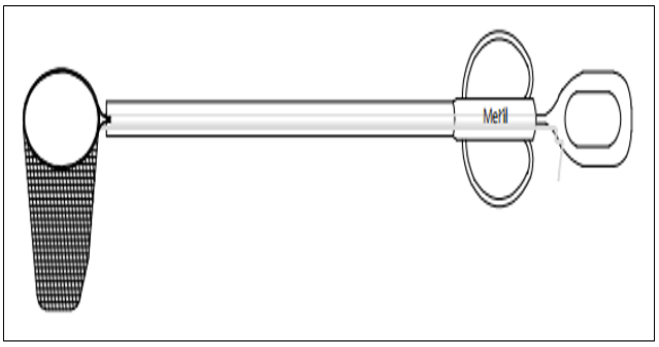


Fig 1 Laparoscopic Retrieval Endo Bag

- *Drawstring Mechanism:*

The laproscopic retrieval endo bag was constructed using drawstring mechanism or an analogous closure system mechanism to securely seal the top after retrieval. These features were incorporated to prevent the unintentional spilling of the specimen and maintain its containment within the pouch.

- *Size Matrix:*

The size matrix of the retrieval endo bag assembly along with the dimensions has been mentioned in the Table 01. The typical length was 330 millimeters. The outer diameter measures in the range from 10 to 12 millimeters, depending on the trocar used and the size of specimen to be retrieved. Therefore, the size of the retrieval bags was selected based on these two factors to ensure adequate volume for accommodating and removing the specimen. The previous dimensions were considered to determine the appropriate volume capacity for the specimen.

Table 1 Size Matrix of Retrieval Endo Bag

Sr.No	Volume of Retrieval Pouch	Outer Diameter of Outer Tube	Length of Outer Tube
1	200 ml	10 mm	330 mm
2	400 ml	10 mm	330 mm
3	700 ml	10 mm	330 mm
4	1200 ml	10 mm	330 mm
5	1600ml	12 mm	330 mm

- *Outer Tube and Handle:*

The deployment tube or the outer tube shown in the figure 02 covers and protects the retrieval pouch during insertion into the abdominal cavity. The deployment tube enters through a trocar a small incision used as an invasive guide to position the retrieval pouch at an exact position inside the abdominal cavity. It thus increases the port utilization by nullifying the need for an extra port, which is usually needed only for the retrieval pouch. This is especially helpful since, during laparoscopic surgery, the ports are generally at a premium.

It forms a tight seal, which will prevent the loss of pneumoperitoneum; in other words, the insufflated gas creating the operative space inside the abdominal cavity-during the deployment of the retrieval pouch. Maintaining pneumoperitoneum is crucial for sustaining visibility and promoting surgical invasive. The handle shown in the figure 02 provides a firm grip for surgeons to control the deployment tube and retrieval pouch for stability and precision during insertion.

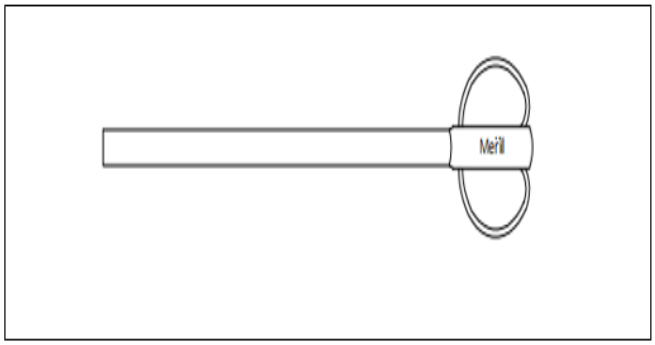


Fig 2 Outer Tube and Handle

- *Memory Wire Activation:*

The Endo bag with Memory Wire Pusher shown in the figure 03 represents an advanced automatic retrieval system tailored for laparoscopic procedures. This retrieval pouch is initially housed within a deployment tube in a coiled, compact form. Upon insertion of the deployment tube through a trocar a minor surgical incision the memory wire embedded within the pouch retains its pre-configured compact shape. However, as the deployment tube progresses into the abdominal cavity, the memory wire autonomously reverts to its predetermined expansive form, facilitating efficient deployment and retrieval of the pouch.

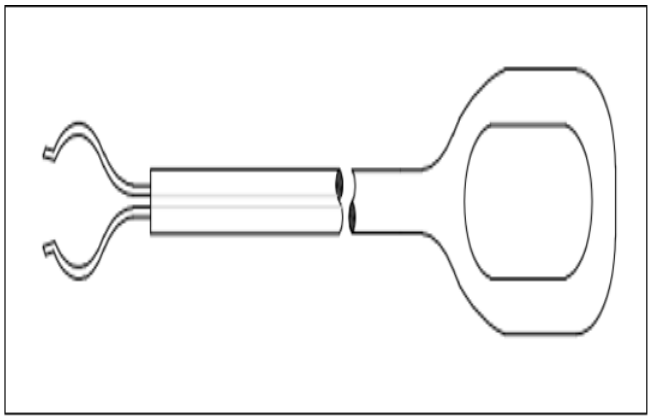


Fig 3 Memory Wire Pusher

- *Endo Bag and Closure String/Rope:*

After the successful capture of the specimen, the surgeon needed to secure the contents inside the Endo Pouch shown in the Figure 04. This was where the closure string (often made of strong nylon) as shown in the Figure 05 came into play. The surgeon pulled the closure string tight, fully closing the Endo bag. It was similar to tying a drawstring bag, ensuring that nothing spilled out.

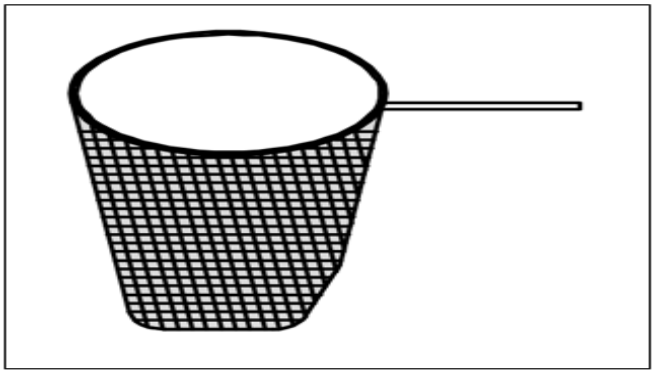


Fig 4 Endo Bag

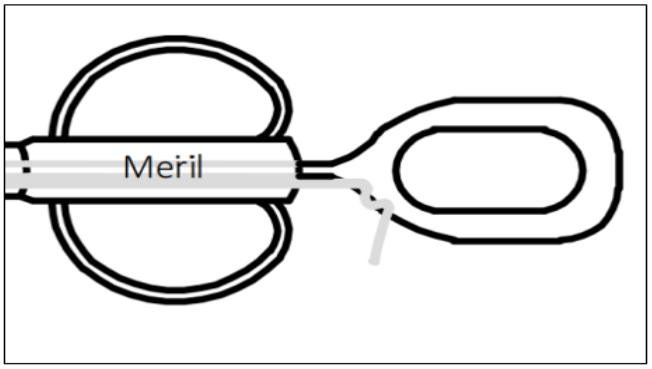


Fig 5 Closure String/Rop

- *Deployment Process:*

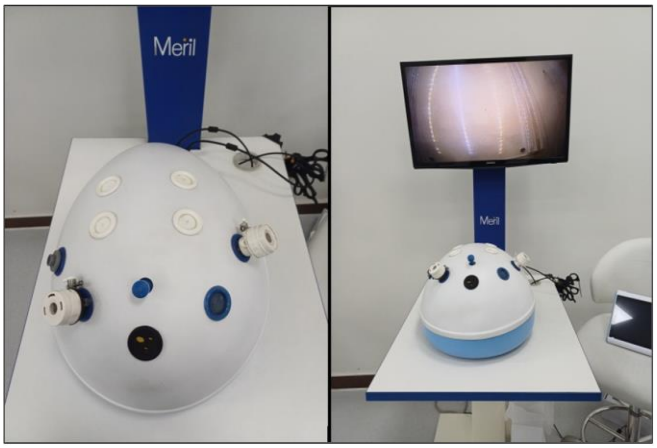
The laparoscopic retrieval bag was inserted in a sequential procedure in which the folded bag is first inserted into the abdominal cavity through a trocar or similar small incision. Inside the bag, it was carefully unfolded, usually with the help of special instruments. Surgical tools were used to maneuver the sample into the opened pouch. The drawstring or closure mechanism was then tightened so that the sample is securely encapsulated. The bag with the sample was carefully pulled out of the surgical site in such a way that the size of the incision allows passage without excessive strain and without risk to the patient.

- *Safety Features:*

The deployment process of laparoscopic retrieval bag is orderly, starting with the insertion of a folded endo bag into the abdominal cavity through a trocar or any similar small incision. Both the surgical tools and the endo bag with the drawstring or closure mechanism maneuver the specimen into the open endo bag and then tighten it to encapsulate the specimen securely. The endo bag, now containing the specimen, is gently tugged out of the surgical site, with the pull adjusted to the size of the incision to allow passage without strain or risk to the patient.

III. RESULTS AND DISCUSSION

➢ *In-vitro Trial on Abdominal Endotrainer*



(A) (B)

Fig 6 Abdominal Endotrainer with Integrated Live Feed Monitor Displaying Real-Time Surgical Simulation

The Abdominal Endotrainer, as shown in Figure 06 (A) & (B), has been specially developed for training in laparoscopic surgery. The Abdominal Endotrainer is a simulation device developed for training in laparoscopic surgery. It provides a highly realistic, controlled environment in which physicians can practice and refine their minimally invasive surgical skills. The device usually consists of a life-size model of the abdomen with simulated organs and tissue. It enables trainees to perform various surgical tasks such as suturing, dissecting and taking samples using laparoscopic instruments. The endotrainer is designed to simulate the complexity of the human abdominal cavity to provide realistic hands-on experience in a safe and repeatable environment. It helps refine surgical techniques, improve precision and shorten the learning curve for new surgeons.

Fig 7 Lamb Meat Specimen

The selection of lamb meat as the specimen for retrieval using the laparoscopic retrieval bag from Abdominal Endo training module was a deliberate choice. This decision was pivotal for evaluating and refining the efficacy of laparoscopic retrieval bag techniques under meticulously controlled conditions. These conditions were designed to closely mirror the complexities encountered during human abdominal surgeries.

Selection of ovine tissue for specimen retrieval with laparoscopic retrieval bag, as in Figure 07, was a calculated decisions in the Abdominal Endo training module. This was instrumental in evaluating and refining the efficacy of various laparoscopic retrieval bag methodologies under rigorously controlled conditions contrived artfully to simulate complexities inherent in human abdominal surgeries.

The anatomical similarities with human tissue for handling characteristics offer realistic simulation conditions. This allows practitioners to practice complex maneuvers for skilled retrieval using laparoscopic methods and fine-tuning them. Hence, the use of lamb meat as a specimen for training in this module will allow the development of not only technical capabilities but also contribute significantly to the development of finer methods of laparoscopic surgery.

Trials were carried out with the abdominal endotrainer focused on the assessment of the deployment mechanisms of laparoscopic retrieval bag, usability, and safety during specimen extraction. The key findings from these trials include the following:

- *Deployment Precision*

Based on the discussion, most clinicians have faced significant challenges when deploying endobags without a memory wire pusher delivery assembly, particularly in confined spaces where maintaining precision and control is critical. These challenges often lead to reduced maneuverability and increased deployment times. The same issues are being addressed in this in vitro study, which evaluates advancements in endobag design. The improved design aims to enhance deployment accuracy and control, even within simulated abdominal cavities with limited space, ultimately improving maneuverability and reducing deployment time.

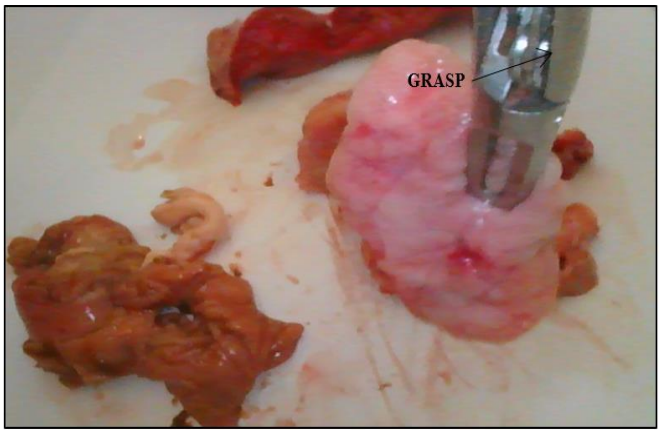


Fig 8 Grasping of Specimen

Laparoscopic graspers as shown in Figure 08 facilitate access to the surgical site by holding tissue clear of the operating field. They allow surgeons to gently grip and manipulate organs, tissues, or other structures during laparoscopic procedures. These specialized instruments are designed to manipulate delicate abdominal tissues while minimizing trauma.

Fig 9 Releasing of Endo Bag in to Abdominal Cavity

As shown in Figure 09, the laparoscopic retrieval bag was introduced into the abdominal endotrainer through a 10mm trocar. By utilizing the Endo bag, surgeons can avoid the need for an additional incision for specimen retrieval. The process began by placing the retrieved specimen in the endo bag using a laparoscopic grasper, as shown in Figure 10. Next, the Endo Bag is securely fastened using laparoscopic forcep, as illustrated in Figure 11. Once secured, no fluid leakage was observed, as demonstrated in Figure 12. After confirming the proper grip, the thread of the endo bag is carefully assured through the trocar, as shown in Figure 13. Finally, the Endo Bag, containing the specimen, was gently removed from the peritoneal cavity of the abdominal endo trainer, as depicted in Figure 14.

Fig 10 Securing the Specimen


Fig 11 Assuring Endo bag

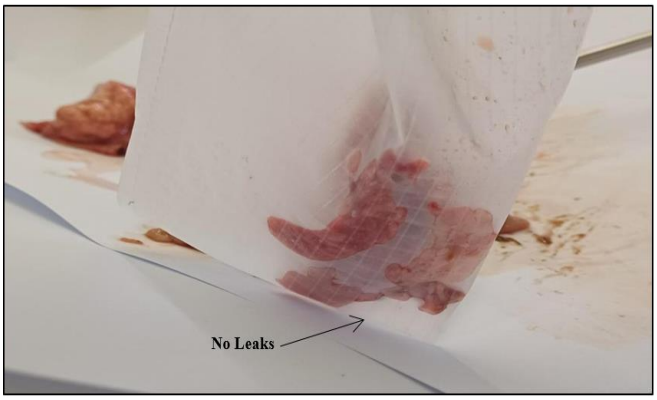


Fig 12 Assuring no fluid leak

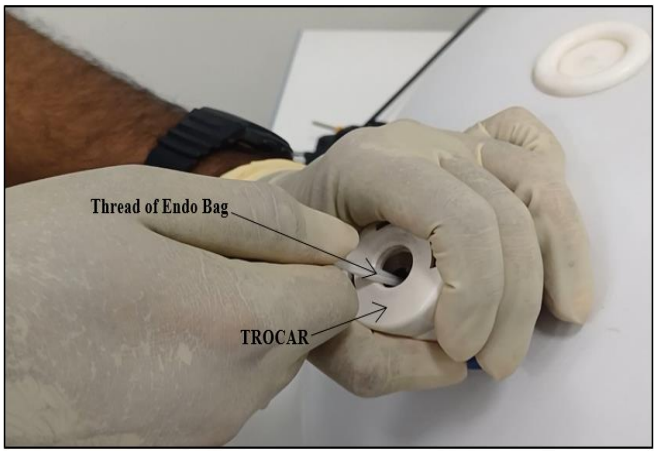


Fig 13 Gripping the Thread

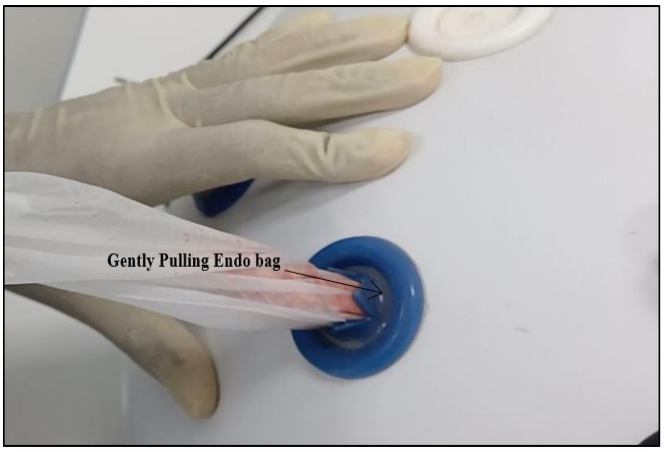


Fig 14 Pulling the Endo Bag

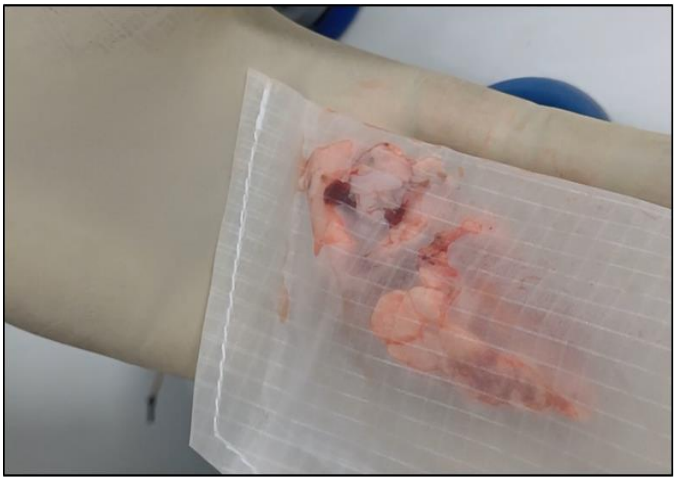


Fig 15 Retrieved Endo Bag

Figure 15 shows that retrieved the bag possessed excellent properties in terms of maintaining the specimen safely inside and reducing the chances of spillage or contamination. This is critical in surgeries that may handle tissues with the potential for cancer and must be careful to leave no cells behind the abdominal cavity.

Overall, the in-vitro trial results underscore the significant advancements in the design and functionality of laparoscopic retrieval bag. These improvements can lead the safety and efficiency of minimally invasive surgeries but also enhance the training of surgeons, providing them with reliable tools that mimic real-life scenarios.

IV. CONCLUSION

The present study addressed the improved status of laparoscopic retrieval bag for better safety and effectiveness in minimally invasive surgery. In-vitro trials conducted using abdominal endotrainer showed that the retrieval pouch improves surgical precision, specimen containment, and procedural efficiency. These endobag have been successfully used in a simulated environment to show their effectiveness by reducing deployment times and maneuvers, while advanced design features such as memory wire technology and drawstring mechanisms will minimize risk related to spilling or contamination. These results highlight the importance of retrieval endobag in minimizing trauma, contamination risks, and hastening patient's recovery. These benefits can be achieved by resecting cancerous tissues, appendicitis, and gallbladder diseases, where specimen containment is considered essential in preventing further complications. As surgical practice continues to evolve in the direction of more precise and patient-centered approaches, retrieval bags play an increasingly important role in enhancing the outcomes of minimal invasive surgery. Future pre-clinical and clinical testing will, no doubt, be incredibly useful in endo bag design refinement and emergent technologies in a constant quest for precision and ease. Innovation in the design of laparoscopic retrieval bag plays a critical role in meeting the increasingly sophisticated needs of the modern surgical practice, with implications for patient safety, quicker recovery, and long-term outcomes. These studies represent not only the current trend in minimally invasive surgery but also a need for further development of surgical instrumentation to meet future challenges in healthcare.

REFERENCES

[1]. Smith, J.T., & Brown, H. (2021). Innovations in Minimally Invasive Surgical Devices. Journal of Medical Devices.

[2]. Harper, W.L. (2020). Advancements in Laparoscopic Surgery: A Focus on Retrieval Pouches. Surgical Innovations.

[3]. Chen, M.K. (2019). laparoscopic retrieval bags: Mechanism and Material Advancements. International Journal of Surgical Devices.

[4]. Lee, G., and Kumar, S. (2022). Economic Impact of Minimally Invasive Surgery Tools. Healthcare Finance Review.

[5]. Patel, R.N., Davis, G.J. (2023). Deployment Techniques of Laparoscopic Pouches in Surgery. Clinical Surgery Journal.

[6]. Thompson, C. A., & Jenkins, M. L. (2018). Bio-Compatible Materials in Laparoscopic Instruments. Biomedical Journal.

[7]. Singhal, D., & Lopez, R. (2021). A Ten-Year Review of Laparoscopic Surgery Tools and Techniques. Surgical Practice Today.

[8]. Miller, T.O. (2020). Patient Outcomes Following the Use of Retrieval Pouches in Laparoscopic Procedures. Journal of Clinical Outcomes Management.

[9]. Bennett, C., & Khanna, A. (2022). Technological Trends in Minimally Invasive Surgical Instruments. Tech in Surgery.

[10]. Graham, J., & Foster, T. (2019). The Future of Surgery: Emerging Tools and Technologies. Future of Medicine Journal.

[11]. Dr. Hemant B. Tongaonkar Head, Department of Surgical Oncology, Consultant Urologic & Gynaecologic Oncologist,(2019) Consensus Document For Management Of Epithelial Ovarian Cancer. Indian council of medical research.

[12]. G. Mohandhas1 & Vijayan M. Associate professor, Department of Surgery, Dhanalakshmi Srinivasan Medical College, Perambalur, Tamil Nadu, India (2018) Epidemiological Analysis of Appendicitis in a Rural Tertiary Care Hospital, Tamilnadu. International Journal of Current Medical And Applied Sciences

[13]. Dr. Hari S. Shukla.(2014) Consensus Document For Management Of Gallbladder Cancer.Indian council of medical research.

[14]. Pandey M. (2001). Risk factors for gallbladder cancer: A reappraisal. European Journal of Cancer Prevention, 10(1), 81-89.

[15]. Dhir V., Mohandas K. (1999). Epidemiology of digestive tract cancers in India. Indian Journal of Gastroenterology, 18(1), 24-28

[16]. Mohandas K., Desai D. (1999). Epidemiology and clinical presentation of gallbladder cancer: A review. Journal of Surgical Oncology, 72(1), 26-33.