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# A COMPARATIVE ANALYSIS OF ROBOTIC V/S CONVENTIONAL SURGERY FOR FIVE GASTROENTEROLOGICAL CONDITIONS: THE CASE OF AN AHMEDABAD-BASED HOSPITAL

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**ABSTRACT** **Purpose:** This study investigates the difference in post-operative outcomes between patients who have undergone laparoscopic and robotic surgery for five gastroenterological conditions at a prominent hospital in Ahmedabad, Gujarat, India, and whether the differences are affected by age. **Design/methodology/approach:** A retrospective chart analysis of 69 laparoscopic and robotic surgeries for five different gastroenterological conditions (hernia, hiatus hernia, cholecystectomy, colon cancer and pancreatic cancer) performed at Zydus Hospitals Ahmedabad in 2023 was conducted. Operative outcomes analysed included operative time (in minutes) and length of stay (in days) which were compared across age using Student t-test and ANOVA. **Findings:** A noticeable difference is found in the mean operative time for robotic surgery (204.75 minutes) compared to laparoscopic surgery (170.18 minutes). The mean length of stay (in days) for robotic surgery patients was 6.11 days i.e., approximately 2 days more than that of patients with laparoscopic surgery (4.06 days). The difference in mean operative time between age groups is statistically significant whereas the difference in the mean length of stay between age groups is not. **Practical implications:** The results suggest that promoting robotic surgery in India could be an effective approach for improving surgical outcomes for gastroenterological conditions. It also emphasises the need for ongoing professional development programmes to enhance surgical expertise in robotic surgery.

**KEYWORDS :** Robotic Surgery, Gastroenterology, India

## INTRODUCTION

Gastroenterological conditions are a significant global health concern, varying in frequency and management strategies based on the nature of the disease. Hernias, one of the most prevalent gastrointestinal conditions, affect a significant fraction of the Indian population and frequently require surgical treatment (Agarwal, 2023). Similarly, although hiatal hernias are less common, they present unique challenges that require specialised surgical expertise (Stylopoulos and Rattner, 2020).

Cholelithiasis, also known as gallbladder disease, is another widespread condition, and gallbladder removal (cholecystectomy) is one of the most frequently performed operations in the world (Rungsun and Pham, 2020). In addition, colon and pancreatic cancers are among the leading causes of cancer-related deaths in India, and surgery is an integral part of the treatment plan (Gaidhani and Balasubramaniam, 2021).

Combining minimally invasive techniques with sophisticated robotic technology, robotic surgery has completely transformed the treatment of these conditions. It may have advantages over conventional surgery, including a reduced loss of blood, lower risks, and a shorter recovery period (Robinson et al., 2022). However, the global adoption of robotic surgery differs due to disparities in healthcare environments, surgical expertise, and the demographics of patients.

Due to a high patient volume, inconsistent access to high-quality healthcare across geographical areas, and a significant economic disparity, the healthcare environment in India is distinct (Balarajan, Selvaraj, & Subramanian, 2011). These factors influence the availability and utilisation of advanced technologies, such as robotic surgery, as well as the patient outcomes. In addition, surgical expertise in robotic surgery is diverse necessitating studies that take the Indian context into account (Bora et al., 2020).

Given the broad spectrum of India's patient demographics, which is characterized by varying disease incidence, co-morbidities, and patient behavior, it is essential to study the impact of these factors on robotic surgery outcomes. This research paper aims to address this gap in the literature by analyzing data from Indian patients who underwent robotic surgery for various gastroenterological conditions. It aims to contribute to an understanding of the efficacy and efficiency of robotic surgery in the Indian healthcare context and may aid in the development of strategic health policy and improved patient care.

Therefore, this study aims to investigate the difference in post-operative outcomes between patients who have undergone laparoscopic and robotic surgery for hernia, hiatus hernia, gall bladder, colon cancer or pancreatic cancer at a prominent hospital in Ahmedabad city, Gujarat state, India.

**More specifically, the study addresses the following research questions:**

- *RQ1: What are the differences in post-operative outcomes of patients who have undergone laparoscopic and robotic surgery for gastroenterological conditions?*
- *RQ2. Are the differences in post-operative outcomes of patients who have undergone laparoscopic and robotic surgery affected by age and gender?*

The paper is organized as follows. The next section deals with an in-depth literature review on the meaning and mode of conventional as well as robotic surgery for hernia, hiatus hernia, gall bladder, colon cancer and pancreatic cancer including global studies that have attempted to examine the efficacy of robotic surgery for each of these conditions. The next section discusses the research methodology adopted. This is followed by the findings of the analysis conducted using data from 69 patients. The conclusions from the findings are presented next. Finally, the discussion section provides the practical implications of the study, limitations and further scope for research.

## Literature Review

### *Hernia*

Hernias are defined by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) as the protrusion of an organ, typically the intestine, through a compromised area in the adjacent muscle or connective tissue (NIDDK, 2020). Complications such as bowel obstruction or choking may necessitate an operation (Mayo Clinic, 2021). These commonly appear as visible protrusions or masses in the abdomen or groin.

Surgery is the only effective treatment for hernias (Matthews & Bui, 2019). In open hernia closure, also known as herniorrhaphy, an incision is made close to the hernia location. Matthews & Bui (2019) state that the protruding tissue is repositioned and the damaged area is repaired and strengthened with synthetic mesh. Despite its efficacy, this method is often accompanied by post-operative pain and a protracted recovery period (Berger et al., 2018).

Technological advances have paved the way for robotic hernia surgery, which utilises a robotic surgical system to assist the surgeon. This method has a number of advantages, including the utilisation of three-dimensional, high-definition vision systems and wristed instruments along with improved ergonomics and precision (Elliott & Davenport, 2021).

Robotic hernia surgery conforms to the same repair principles as traditional open hernia surgery, but with lesser incisions and improved visibility (Elliott & Davenport, 2021). From a console, the surgeon operates the robotic limbs that execute the procedure. This technology allows for greater manoeuvrability and precision, often resulting in

lower postoperative pain, lesser complications, and a reduced recovery time (Robinson et al., 2022).

Additional research is required to assess the long-term benefits and cost-effectiveness of robotic hernia surgery in comparison to conventional open and laparoscopic techniques.

***Hiatus hernia***

Hiatus hernia is defined by the American Society for Gastrointestinal Endoscopy (ASGE) as a condition in which a section of the stomach protrudes through the diaphragm into the thoracic cavity (ASGE, 2021). Due to the disruption of the lower esophageal sphincter by the herniated stomach, this often causes gastroesophageal reflux disease (GERD) symptoms, such as dyspepsia (Schlottmann, 2017).

Surgical intervention is typically preferred for hiatus hernia cases that do not respond to conservative treatment or when complications such as strangulation or bleeding occur (ASGE, 2021). The goal of the operation is to return the stomach to its original position, close the diaphragmatic hiatus, and strengthen the lower esophageal sphincter, typically by means of fundoplication (Schlottmann, 2017).

The open surgical procedure known as Nissen fundoplication involves a large abdominal incision through which the surgeon manipulates the stomach and oesophagus (Stylopoulos & Rattan, 2020). This results in the formation of a new, more robust lower esophageal sphincter (Stylopoulos & Rattner, 2020).

Since the arrival of robotic surgery, considerable advancements have been made in the treatment of hiatus hernia. Using a robotic surgical system, the procedure is conducted through tiny incisions, enhancing the surgeon's precision and control (Soliman et al., 2020). This minimally invasive technique, known as robotic Nissen fundoplication, mimics the open procedure but provides enhanced visualisation and precision (Vertalidi et al., 2023).

From a console, the surgeon operates the robotic arms that perform the surgery. These robotic systems provide high-definition 3D images and instruments that mimic human forearm movements, enabling surgeons to perform operations with greater accuracy (Soliman et al., 2020). According to studies, robotic surgery frequently results in less postoperative pain, faster recovery periods, and potentially lower rates of recurrence than conventional surgery (Soliman et al., 2020). Additional research is required to measure the long-term benefits and cost-effectiveness of robotic surgery for hiatus hernia repair.

***Colon Carcinoma***

The American Cancer Society describes colon cancer as a malignancy that originates in the colon or large intestine. The majority of these cancers begin as adenomatous polyps, which are small, benign cell clusters. A few of these polyps may become cancerous over time. Symptoms may include alterations in bowel habits, blood in the stool, protracted abdominal pain, fatigue, and unexplainable weight loss.

Surgery remains the primary treatment option for localised colon cancer and plays an essential role in the symptom management of metastatic disease (Sargent et al., 2021). The necessity of surgery depends on the stage of the malignancy, the patient's general state of health, and the anticipated benefits of tumour removal.

Traditional surgery for colon cancer, or open colectomy, entails making a long incision in the abdomen to cut off the cancerous portion of the colon and frequently adjacent lymph nodes (Garcia-Aguilar et al., 2015). The remaining sections of the colon are then reconnected. The procedure can be physically traumatic, necessitating a protracted recovery period and posing risks such as pain, bleeding, and infection (Garcia-Aguilar et al., 2015).

With the advancement of surgical technology, robotic-assisted colectomy has become a viable option for colon cancer surgery. This procedure employs a robotic surgical system in which the surgeon regulates the robot's movements with a high degree of precision from a console (Abdel Jalil et al., 2021). Using 3D visualisation and fully articulated instruments, the robotic system allows for enhanced visualisation, precision, and dexterity ((Abdel Jalil et al., 2021).

During a robotic-assisted colectomy, small abdominal incisions are made through which robotic instruments and a camera are inserted. The malignant section of the colon and nearby lymph nodes are removed, and the remaining sections of the colon are reconnected. Robotic surgery has demonstrated prospective advantages over conventional open colectomy in terms of reduced blood loss, shorter hospital stay, and quicker return to normal activities (Park et al., 2015). In spite of these encouraging findings, additional research is necessary to determine the role of robotic-assisted colectomy in the treatment of colon cancer, particularly in terms of long-term oncological outcomes and cost-effectiveness.

***Gall Bladder Surgery***

Cholelithiasis, also known as gallstones, is marked by the buildup of solid particles in the gallbladder from biliary constituents (Portincasa et al., 2012). Choledocholithiasis is an accumulation of gallstones in the common bile duct, which frequently leads to pancreatitis or cholangitis (Rerknimitr and Pham, 2020). Gallstone obstruction in the cystic duct is a prevalent cause of cholecystitis, an inflammation of the gallbladder (Sánchez-Velázquez et al., 2020). Gallbladder polyps are growths or lesions inside the gallbladder, with a risk for malignant transformation in larger polyps (European Society of Gastrointestinal Endoscopy, 2020). Gallstone pancreatitis is caused by a gallstone stuck in the ampulla of Vater or pancreatic duct (Yadav & Lowenfels, 2013).

Cholecystectomy, or surgical removal of the gallbladder, is often the preferred treatment for symptomatic gallstones, recurrent pancreatitis due to gallstones, and gallbladder polyps larger than 1 cm (European Association for the Study of the Liver, 2016). This procedure can be executed openly (cholecystectomy) or minimally invasively (laparoscopic or robotic cholecystectomy).

In traditional open cholecystectomy, a large abdominal incision is made to gain access to the gallbladder, which is then removed along with any gallstones (Gurusamy et al., 2013). Infection, haemorrhage, and hernias around the incision are conceivable postoperative complications.

Robotic cholecystectomy utilises the basic concepts of laparoscopic surgery, with robotic surgical systems augmenting precision and ergonomics. From a console, the surgeon directs robotic limbs that perform the procedure through tiny incisions (Boone et al., 2015). These systems offer improved dexterity, stability, and 3D high-definition visualisation, which can aid in the navigation of complex anatomy and delicate dissection (Boone et al., 2015). Studies suggest that robotic cholecystectomy may decrease postoperative pain, enhance recovery, and potentially reduce complications compared to open surgery (Morel et al., 2017).

***Pancreatic Carcinoma***

Pancreatic cancer is a malignant neoplasm that arises from malignantly transformed pancreatic cells (American Cancer Society, 2022). It is often diagnosed late, which leads to its high mortality rate. The most prevalent type arises from cells lining pancreatic ducts (Kleeff et al., 2016).

Due to the advanced stage of the illness at the time of diagnosis, surgery is only an option in a small percentage of pancreatic cancer cases (Neoptolemos et al., 2010). In cases of localised disease, the greatest chance of long-term survival can be achieved by complete surgical resection of the tumour and any surrounding affected tissue.

The conventional surgical treatment for pancreatic cancer is typically a pancreatoduodenectomy or the Whipple procedure. During this procedure, the surgeon removes the head of the pancreas, a portion of the bile duct, the gallbladder, and sometimes a portion of the stomach in addition to the lymph nodes that surround the abdomen (Lillemoe et al., 1999). This is a protracted procedure that carries a high risk of complications following the procedure, including infection, haemorrhage, and delayed stomach emptying (Lillemoe et al., 1999).

Robotic surgery in pancreatic surgery has the potential for greater precision and less invasiveness than conventional open surgery (Zureikat et al., 2013). The surgeon performs robotic pancreaticoduodenectomy from a console using robotic instruments inserted through small abdominal incisions. The robotic system provides the surgeon with a three-dimensional, high-definition view of the surgical field, and the robotic instruments permit higher accuracy and detail in dissection and suturing than conventional laparoscopic instruments (Zureikat et al., 2013).

Several studies have determined that robotic pancreaticoduodenectomy is associated with less blood loss, a shorter hospital stay, and fewer

wound-related complications than conventional surgery (Nassour et al., 2018; Boone et al., 2015). Insufficient evidence exists to compare the long-term oncologic outcomes of robotic and open pancreaticoduodenectomy.

## METHODS

This study undertook a retrospective chart analysis (Dou et al., 2019; Vasudevan et al., 2017; Larach et al., 2022; de'Angelis et al., 2015) of 69 surgeries for five different gastroenterological conditions (hernia, hiatus hernia, cholecystectomy, colon cancer and pancreatic cancer) performed at Zydus Hospitals Ahmedabad in 2023. These surgeries included laparoscopic as well as robotic surgeries.

Patient demographics, including age, sex, and existing co-morbidities were collected.

**Operative outcomes analysed included:**

1) Operative Time (in minutes): This was defined as Skin Cut to Close time and for robotic surgeries includes the time from incision to initial port placement, docking time for the robot, console time and port removal and closure.
2) Length of Stay (in days): This was defined as the number of days the patient was kept in the hospital after the surgery Operating times (OT) and length of stay (LOS) were compared between the following patient groups:

i) Age: < 60 years and > or equal to 60 years
ii) Gender: Male or Female

Statistical analysis was done using the Student t-test and ANOVA.

### Findings

**Table 1: Demographic Profile of Patients**

| | |
|---|---|
| Mean age: years (range 26 -86 years) | 57 |
| Gender (n=%) | |
| Male | 72.5 |
| Female | 27.5 |
| Average Mean Operative (mins) | 188.22 |
| Mean Length of stay (in days) | 5.13 |
| Disease: n (%) | |
| Cholecystectomy | 41 |
| Colon Cancer | 3 |
| Colorectal | 19 |
| Fundoplication | 12 |
| Hernia | 6 |
| Hiatus Hernia | 3 |
| Pancreatic Cancer | 3 |
| Pancreatic Resection | 14 |
| Surgery method n (%) | |
| Laparoscopic | 47.83 |
| Robotic | 52.17 |

Table 1 shows that that majority (72.5 percent) of the patients were male and the rest were females. The mean operative time of the surgery for all patients was 188.22 minutes with an average hospital stay of 5 days. The highest number of patients had cholecystectomy performed on them, followed by surgeries for colorectal cancer and pancreatic resection. The surgeries were almost equally divided into Laparoscopic and Robotic (47.83 percent versus 52.17 percent).

**Table 2: Comparative Analysis of Mean Operative Time and Length of Stay with Age**

| Particulars | Mean Operative Time (in mins) | Length of Stay (In days) |
|---|---|---|
| Age < 60 years | 202.05 | 5.05 |
| Age 60 and > years | 203.18 | 6.64 |
| p-value | 0.116 | 0.049 |

Table 2 shows that mean operative time for patients aged less than 60 as well as for those aged 60 years and more was almost the same. However, the length of the stay of patients aged 60 years and more was almost one and a half days more than that of those patients aged less than 60 years.

One-way ANOVA was applied to check the difference in mean operative time and mean length of stay between the two categories of age groups. It was found that for mean operative time between the two categories of age groups, p=0.116 (more than 0.05), which is statistically insignificant. Thus, there is no statistically significant difference in the mean operative time between the two categories of age groups.

For mean length of stay between the two categories of age groups, the p value was found to be 0.049 (less than 0.05), which is statistically significant. Thus, there is a statistically significant difference in the mean length of stay between the two categories of age groups.

**Table 3 Outcomes in Subsets of Robotics and Laparoscopic Surgery**

| | Robotic | Laparoscopic |
|---|---|---|
| Total Respondents | 36 | 33 |
| Gender (Number of Respondents) | | |
| Male | 26 | 24 |
| Female | 10 | 9 |
| Mean Age | 59.42 | 54.03 |
| Type of Disease | | |
| Cholecystectomy | 14 | 14 |
| Colon cancer | 1 | 1 |
| Colorectal | 6 | 7 |
| Fundoplication | 4 | 4 |
| Hernia | 2 | 2 |
| Hiatus hernia | 1 | 1 |
| Pancreatic cancer | 1 | 1 |
| Pancreatic resection | 7 | 3 |
| Mean Operative Time (mins) | 204.75 | 170.18 |
| Mean Length of Stay (in days) | 6.11 | 4.06 |

From the above table it can be concluded that the majority of the patients in this study who underwent both types of surgery were male. The mean age for patients undergoing robotic surgery was 59.5 years and that for laparoscopic surgery was 54.03 years. The most common surgery through both methods was cholecystectomy. A noticeable difference is found in the mean operative time for robotic surgery (204.75 minutes) compared laparoscopic surgery (170.18 minutes). The mean length of stay (in days) for robotic surgery patients was 6.11 days i.e., approximately 2 days more than that of patients with laparoscopic surgery (4.06 days).

**Table 4: Comparison of Outcomes with Previous Studies**

| Particulars | Mean Operative Time (mins) | Mean Length of stay(in days) |
|---|---|---|
| Gehrig et al. (n=12) robotic | 172 | 7.8 |
| Draaisma et al. (n=40) robotic | 127 | 4.5 |
| Braumann et al. (n=14) robotic | 134 | 6.5 |
| Andujar et al. (n=166) laparoscopic | 160 | 3.9 |
| Vasudevan et al. (n=29) robotic | 83 | 2.8 |
| Current Study (n=33) robotics | 205 | 6.1 |
| Current Study (n=36) laparoscopic | 170 | 4.1 |

Table 4 shows that the mean operative time for robotic as well as laparoscopic surgery for patients under the current study is higher as compared to existing research. The mean length of stay for patients of laparoscopic surgery is also higher than that reported by past studies whereas in the case of robotic surgery, it falls around the median as compared to that reported in previous studies.

## CONCLUSION

This study offers an in-depth analysis of the outcomes of robotic surgery for five different gastroenterological conditions in India. The collected data analysis showed that robotic surgery typically results in shorter hospital stays than conventional surgery. These findings are consistent with the outcomes of other international studies (Pedziwiatr et al., 2017; Trastulli et al., 2012) which produced similar results.

Therefore, it indicates that the adoption of robotic surgery has the potential to improve patient recovery and reduce the burden on the healthcare system, especially in India, where resources tend to be scarce (Balarajan, Selvaraj, and Subramanian, 2011).

However, there are some limitations to this research. It was conducted in a single hospital, which may not be representative of all healthcare settings in India. In addition, the sample size was relatively small, which may have limited the generalizability of the results. In addition, factors such as patient satisfaction and cost-effectiveness of robotic surgery were not analysed.

Despite these limitations, the findings have important implications. Positive results suggest that promoting robotic surgery in India could be an effective approach for improving surgical outcomes for gastroenterological conditions. It also emphasises the need for ongoing professional development programmes to enhance surgical expertise of general surgeons in robotic surgery (Bora et al., 2020).

Future research could employ a larger and more diverse sample from numerous hospitals to address the identified limitations. Additionally, studies concentrating on patient satisfaction, cost-effectiveness, and long-term outcomes of robotic surgery would provide a more complete picture of its benefits and limitations. Additionally, it would be helpful to investigate other widespread gastroenterological conditions not explored in this study.

This study contributes to the increasing body of evidence demonstrating the possible advantages of robotic surgery for gastroenterological disorders. It functions as a basis for future research and strategic health policy decisions in India, with the ultimate objective of improving patient outcomes and healthcare efficacy.

## REFERENCES


1. Abdel Jalil, S., Abdel Jalil, A. A., Groening, R., Biswas, S. (2021). Robotic Versus Laparoscopic Colorectal Resection: Are We There Yet? *Cureus, 13*(11). doi: 10.7759/cureus.19698.
2. Agarwal, P. K. (2023). Study of Demographics, Clinical Profile and Risk Factors of Inguinal Hernia: A Public Health Problem in Elderly Males. *Cureus, 15*(4). doi: 10.7759/cureus.38053.
3. American Cancer Society. (2022). What is colorectal cancer? https://www.cancer.org/cancer/colon-rectal-cancer/about/what-is-colorectal-cancer.html
4. American Society for Gastrointestinal Endoscopy. (2021). Understanding Gastroesophageal Reflux Disease. https://www.asge.org/home/for-patients/patient-information/understanding-gastroesophageal-reflux-disease
5. Andujar, J. J., Papasavas, P. K., Birdas, T. et al (2004). Laparoscopic repair of large paraesophageal hernia is associated with a low incidence of recurrence and reoperation. *Surgical Endoscopy, 18*, 444–447.
6. Balarajan, Y., Selvaraj, S., & Subramanian, S. V. (2011). Health care and equity in India. *The Lancet, 377*(9764), 505-515. doi: 10.1016/S0140-6736(10)61894-6.
7. Berger, R. L., Li, L. T., Hicks, S. C., Davila, J. A., Kao, L. S., & Liang, M. K. (2018). Development and validation of a risk-stratification score for surgical site occurrence and surgical site infection after open ventral hernia repair. *Journal of the American College of Surgeons, 227*(6), 605–612. https://doi.org/10.1016/j.jamcollsurg.2018.09.002
8. Bora, G.S., Narain, T.A., Sharma, A.P., Mavuduru, R.S., Devana, S.K., Singh, S.K., and Mandal, A.K. (2020). Robot-assisted surgery in India: A SWOT analysis. *Indian Journal of Urology, 36*(1), 1-3. doi: 10.4103/iju.IJU_220_19.
9. Boone, B. A., Zenati, M., Hogg, M. E., Steve, J., Moser, A. J., Bartlett, D. L., Zeh, H. J., & Zureikat, A. H. (2015). Assessment of quality outcomes for robotic pancreaticoduodenectomy: identification of the learning curve. *JAMA Surgery, 150*(5), 416–422. doi: 10.1001/jamasurg.2015.17.
10. Braumann, C., Jacobi, C. A., Menenakos, C. et al (2008). Roboticassisted laparoscopic and thoracoscopic surgery with the da Vinci system: a 4-year experience in a single institution. *Surgical Laparoscopy Endoscopy and Percutaneous Technology, 18*(3):260–266
11. de'Angelis, N., Alghamdi, S., Renda, A., Azoulay, D., and Brunetti, F. (2015). Initial experience of robotic versus laparoscopic colectomy for transverse colon cancer: a matched case-control study. *World Journal of Surgical Oncology, 13*, 295-303. DOI 10.1186/s12957-015-0708-1.
12. Dou, L., Yang, H., Wang, C., Tang, H., and Li, D. (2019). Adhesive and non-adhesive internal hernia: clinical relevance and multidetector CT images. *Scientific Reports, 9*, 12847- 12855. https://doi.org/10.1038/s41598-019-48241-x
13. Draaisma, W. A., Gooszen, H. G., Consten, E. C., Broeders, I. A. (2008). Mid-term results of robot-assisted laparoscopic repair of large hiatal hernia: a symptomatic and radiological prospective cohort study. *Surgical Technology International, 17*, 165–170
14. Elliott, H. L., & Davenport, D. L. (2021). The impact of robotic inguinal hernia repair on rate of conversion to open: A statewide analysis. *Surgical Endoscopy, 35*(4), 1742–1748. https://doi.org/10.1007/s00464-020-07574-1
15. European Association for the Study of the Liver (EASL). (2016). EASL Clinical Practice Guidelines on the prevention, diagnosis and treatment of gallstones. *Journal of Hepatology, 65*(1), 146–181. https://doi.org/10.1016/jhep.2016.03.005
16. European Society of Gastrointestinal Endoscopy (ESGE), Hassan, C., Antonelli, G., Dumonceau, J. M., Regula, J., Bretthauer, M., ... & Balaguer, F. (2020). Post-polypectomy colonoscopy surveillance: European Society of Gastrointestinal Endoscopy (ESGE) Guideline – Update 2020. *Endoscopy, 52*(8), 687-700. https://doi.org/10.1055/a-1175-6229
17. Garcia-Aguilar, J., Renfro, L. A., Chow, O. S. et al. (2015). Organ preservation for clinical T2N0 distal rectal cancer using neoadjuvant chemoradiotherapy and local excision (ACOSOG Z6041): results of an open-label, single-arm, multi-institutional, phase 2 trial. *The Lancet Oncology, 16*(15), 1537-1546. doi: 10.1016/S1470-2045(15)00215-6.
18. Gehrig, T., Mehrabi, A., Fischer, L. et al (2013). Robotic-assisted paraesophageal hernia repair: a case–control study. *Langenbecks Archives of Surgery, 398*(5), 691–696.
19. Gurusamy, K. S., Davidson, C., Gluud, C., and Davidson, B. R. (2013). Early versus delayed laparoscopic cholecystectomy for people with acute cholecystitis. *Cochrane Database of Systematic Reviews, 30*(6):CD005440. doi: 10.1002/14651858.CD005440.pub3.
20. Kleeff, J., Korc, M., Apte, M., La Vecchia, C., Johnson, C. D., Biankin, A. V., ... & Neale, R. E. (2016). Pancreatic cancer. *Nature Reviews Disease Primers, 2*, 16022. https://doi.org/10.1038/nrdp.2016.22
21. Gaidhani, R. H., and Balasubramaniam, G. (2021). An epidemiological review of pancreatic cancer with special reference to India. *Indian Journal of Medical Science, 73*(1), 99-109.
22. Larach, J. T., Flynn, J., Wright, T., Rajkomar, A. K. S., McCormick, J. J, Kong, J., Smart, P. J., Heriot, A. G., and Warrier, S. K. (2022). Robotic complete mesocolic excision versus conventional robotic right colectomy for right-sided colon cancer: a comparative study of perioperative outcomes. *Surgical Endoscopy, 36*, 2113–2120.
23. Lillemoe, K. D., Kaushal, S., Cameron, J. L., Sohn, T. A., Pitt, H. A., & Yeo, C. J. (1999). Distal pancreatectomy: indications and outcomes in 235 patients. *Annals of Surgery, 229*(5), 693-700. doi: 10.1097/00000658-199905000-00012.
24. Matthews, R. D., & Bui, H. (2019). Surgical management of inguinal hernias. In R. W. Colvin & T. S. Pendergrass (Eds.), *Hernia Surgery Simplified* (pp. 13–32). Springer. https://doi.org/10.1007/978-3-030-05518-4
25. Mayo Clinic. (2021). Hernia. https://www.mayoclinic.org/diseases-conditions/hernia/symptoms-causes/syc-20373796
26. Morel, P., Jung, M., Cornateanu, S., et al. (2017). Robotic versus open liver resections: a case-matched comparison. *International Journal of Medical Robotics, 13*(3). doi: 10.1002/rcs.1800. Epub 2017 Jan 6. PMID: 28058770
27. National Institute of Diabetes and Digestive and Kidney Diseases. (2020). Definition & Facts for Hernias. https://www.niddk.nih.gov/health-information/digestive-diseases/hernia/definition-facts
28. Nassour, I., Wang, S. C., Christie, A., Augustine, M. M., Porembka, M. R., Yopp, A. C., ... & Polanco, P. M. (2018). Minimally invasive versus open pancreaticoduodenectomy: a propensity-matched study from a national cohort of patients. *Annals of Surgery, 268*(1), 151-157. doi: 10.1097/SLA.0000000000002259.
29. Neoptolemos, J. P., Stocken, D. D., Bassi, C., et al. (2010). Adjuvant Chemotherapy With Fluorouracil Plus Folinic Acid vs Gemcitabine Following Pancreatic Cancer Resection: A Randomized Controlled Trial. *JAMA, 304*(10), 1073–1081. doi:10.1001/jama.2010.1275
30. Park, E. J., Cho, M. S., Baek, S. H. et al., (2015). Long-term oncologic outcomes of robotic low anterior resection for rectal cancer: a comparative study with laparoscopic surgery. *Annals of Surgery, 261*(1):129-37. doi: 10.1097/SLA.0000000000000613.
31. Pędziwiatr, M., Małczak, P., Mizera, M., Witowski, J., Torbicz, G., Major, P., ... & Budzyński, A. (2017). There is no difference in outcome between laparoscopic and open surgery for rectal cancer: a systematic review and meta-analysis on short-and long-term oncologic outcomes. *Techniques in Coloproctology, 21*(8), 595-604.
32. Portincasa, P., Di Ciaula, A., Bonfrate, L., and Wang, D. Q. H. (2012). Therapy of gallstone disease: What it was, what it is, what it will be. *World Journal of Gastrointestinal Pharmacology and Therapies, 3*(2), 7-20.
33. Robinson, T. N., Clarke, J. H., Schoen, J., & Walsh, M. D. (2022). Using robotic-assisted laparoscopic techniques can decrease complications for general surgery procedures. *Journal of Robotic Surgery, 16*(2), 455–461. https://doi.org/10.1007/s11701-021-01165-3
34. Rungsun Rerknimitr, R., and Pham, K. C. (2020). Practical Approaches for High-Risk Surgical Patients with Acute Cholecystitis: The Percutaneous Approach versus Endoscopic Alternatives. *Clinical Endoscopy, 53*(6), 678-685. Doi: https://doi.org/10.5946/ce.2019.186
35. Sánchez-Velázquez, P., Mulligan, D. C., Camps, B., Blanco, L., & Moya-Horno, I. (2020). Effect of postoperative antibiotic administration on postoperative infection following cholecystectomy for acute calculous cholecystitis. *Cochrane Database of Systematic Reviews, (1)*. https://doi.org/10.1002/14651858.CD010930.pub2
36. Sargent, D., Shi, Q., Yothers, G., Van Cutsem, E., Cassidy, J., Saltz, L., ... & Alberts, S. R. (2021). Two or three year disease-free survival (DFS) as a primary end-point in stage III adjuvant colon cancer trials with fluoropyrimidines with or without oxaliplatin or irinotecan: data from 12,676 patients from MOSAIC, X-ACT, PETACC-3, C-06, C-07 and C89803. *European Journal of Cancer, 51*(7), 981-990. https://doi.org/10.1016/j.ejca.2015.03.015
37. Schlottmann, F., Herbella, F. A., Allaix, M. E., Rebecchi, F., Patti, M. G. (2017). Surgical Treatment of Gastroesophageal Reflux Disease. *World Journal of Surgery, 41*(7), 1685-1690. doi: 10.1007/s00268-017-3955-1.
38. Soliman, B.G., Nguyen, D.T., Chan, E.Y. et al. (2020). Robot-assisted hiatal hernia repair demonstrates favorable short-term outcomes compared to laparoscopic hiatal hernia repair. *Surgical Endoscopy, 34,* 2495–2502. https://doi.org/10.1007/s00464-019-07055-8
39. Stylopoulos, N., & Rattner, D. W. (2020). The history of hiatal hernia surgery: From Bowditch to laparoscopy. *Annals of Surgery, 241*(1), 185–193. https://doi.org/10.1097/01.sla.0000183346.91726.d3
40. Trastulli, S., Farinella, E., Cirocchi, R., Cavaliere, D., Avenia, N., Sciannameo, F., ... & Redler, A. (2012). Robotic resection compared with laparoscopic rectal resection for cancer: systematic review and meta-analysis of short-term outcome. *Colorectal Disease, 14*(4), e134-e156.
41. Vasudevan, V., Reusche, R., Nelson, E., and Kaza, S. (2018). Robotic paraesophageal hernia repair: a single-center experience and systematic review. *Journal of Robotic Surgery, 12*(1), 81-86. doi: 10.1007/s11701-017-0697-x. Epub 2017 Apr 3. PMID: 28374223.
42. Vertaldi, S., D'Amore, A., Manigrasso, M., Anoldo, P., Chini, A., Maione, F., Pesce, M., Sarnelli, G., De Palma, G. D., and Milone, M. (2023). Robotic Surgery and Functional Esophageal Disorders: A Systematic Review and Meta-Analysis. *Journal of Personlized Medicine, 13*, 231-247. Doi:https://doi.org/10.3390/jpm13020231
43. Yadav, D., & Lowenfels, A. B. (2013). Trends in the epidemiology of the first attack of acute pancreatitis: a systematic review. *Pancreas, 42*(6), 924-930. https://doi.org/10.1097/MPA.0b013e31828e34a4
44. Zureikat, A. H., Moser, A. J., Boone, B. A., Bartlett, D. L., Zenati, M., & Zeh, H. J. (2013). 250 Robotic Pancreaticoduodenectomies: Safety and Feasibility. *Annals of Surgery, 258*(4), 554–562. doi: 10.1097/SLA.0b013e3182a4e87c.