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Original Research Article

Minimally Invasive Versus Open Surgical Approaches in Abdominal and Urological Surgery A Systematic Comparative Assessment

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Abstract: ***Background***: The concept of minimally invasive surgery (MIS) has led to the revolution of abdominal and urological surgery, with minimized operative morbidity, and equivalent oncological and functional effects. Although it is widely used, there is still a lack of uniformity in the clinical outcomes of the populations and the healthcare systems. ***Objectives:*** In order to compare the two methods of surgery (minimally invasive and open) in abdominal and urological surgeries in a systematic way, it is suggested to combine published evidence with secondary institutional records and local patient-reported outcomes. ***Materials and Methods***: Peer-reviewed clinical trials and observational studies that were published in the previous period between 2010 and 2024 were arranged in a structured comparative assessment. Tertiary-care hospital secondary data and a small sample survey of postoperative patient (n = 60) were included to measure the operative time, complications, length of stay, and patient satisfaction. Research analyses were done descriptively and in the context of set benchmarks. ***Results:*** Minimally invasive techniques were associated with reduced postoperative pain and shorter hospital stay and functional recovery compared to open surgery. Complication rates, especially wound related morbidity, were reduced in MIS cohorts. Institutional outcomes were consistent with international evidence, although the length of operation was slightly higher during the initial phase of learning. Results of the survey showed that MIS procedures are more satisfactory to patients. ***Conclusion***: In both abdominal and urological surgery, minimally invasive surgery has perioperative benefits over open operations. Although the results depend on the experience of the surgeons and the institutional case volume, MIS is a preferred approach, when properly applied.

Keywords: Minimally invasive surgery; Open surgery; laparoscopy; Urology; abdominal surgery; Surgical outcomes.

INTRODUCTION

Innovation in surgery has always looked at minimizing the morbidity of the patient and maintaining therapeutic efficacy. The development of the traditional open surgery into the practices of minimally invasive surgery has been one of the paradigm shift changes in contemporary surgical practice in the last three decades of history. Optical

developments, instrumentation, and care given to patients during pre- and post-surgery have seen the surgeons carry out more complicated surgery using smaller incisions reducing surgical trauma. This has led to a situation where laparoscopic and robotic-assisted techniques are increasingly utilized in abdominal and urological procedures, which are associated with less tissue disturbance, better visualization and better postoperative recovery rates (1,2).

Minimally invasive procedures have proved to have obvious benefits compared with open procedures in the area of abdominal surgery. It has been documented in many studies that the laparoscopic procedures led to decreases in postoperative pain, reduced length of hospitalization, faster bowel resumption, and decreased wound complications (1,7). These advantages have been incorporated into patient satisfaction and reduced use in healthcare resources. Surgery in the form of cholecystectomy, appendectomy and colorectal operative procedures have also been migrating towards minimally invasive platforms where the post-operative results are similar or better than those of open surgery when the procedures are not performed in patients who are poorly selected (7). Like the success of minimally invasive techniques in abdominal surgery, mirroring transformative trends have emerged in urological surgeries. The principles that underpin MIS smaller incisions, reduced tissue handling, and enhanced visualization have translated effectively into procedures such as nephrectomy, prostatectomy, and pyeloplasty.

On the same note, urologic surgery has experienced a significant change as the use of minimally invasive procedures has been embraced. Technological advances in laparoscopic and robotic-assisted surgery have redefined the treatment of prostate, kidney and bladder pathologies. Specifically, radical prostatectomy with robotic assistance and laparoscopic partial nephrectomy have shown similar oncological efficacy to open surgery and better functional outcomes, such as less blood loss, less transfusion, and postoperative continence and sex lives in those populations (3,5). Robotic platforms, which provide superior magnification and accuracy, have further facilitated the capability of complicated reconstructive as well as oncological surgeries in urology.

Although this has been documented, the implementation of minimally invasive surgery (MIS) is still not very uniform. There are some determinants to surgical decision-making, such as surgeon experience, the presence of specialized equipment, the infrastructure of an institution, patient factors, and economic factors (10,12). Learning curve related to MIS especially robotic surgery may affect the time spent on the operation and postoperative complications, which may restrict its application in low-volume hospitals (12). Also, cost issues, particularly during the situation where limited resources are available, still influence the decision between least invasive and open procedures. Notably, a significant percentage of the available evidence on the topic of MIS is based in countries with high income and tertiary centers with high volume. This casts doubts on the external validity and generalizability of such results to developing regions, where the demographics of patients, the presentation of the disease, and the healthcare delivery systems may be very different (10). The lack of access to the high-quality technology and formal training programs could also impact the performance in those environments.

This research will close this gap by combining international evidence and results of secondary data collected using a local tertiary hospital and patient-report outcome of a survey. This study aims to place the available findings on minimally invasive and open surgery practices into a demographic and medical context through systematic comparisons of the two practices in abdominal and urological settings by critically summarizing available literature on the relationship between the two surgery types to offer clinically pertinent information on the need to implement either within a variety of surgical practices.

MATERIALS AND METHODS

Study Design and Setting

This research involved comparative observational research design which utilized secondary evidence which included published clinical research studies and institutional surgical outcome data and patient-reported survey results. The study was done in a tertiary-care teaching hospital that has well-developed general surgery and urology units. The institutional data analysis covered the study period between January 2021 and December 2023. The methodology plan was made in such a way that it permitted a contextual comparison of the minimally invasive and open surgical procedures considering a realistic clinical practice pattern (1,10).

Population and Sampling Method

The institutional element involved adult patients (18 years and above) who had an abdominal or urological surgical procedure of their choice throughout the study. The operations in the abdominal region were cholecystectomy and appendectomy and urological operations were nephrectomy and prostatectomy. The sample size was 120 surgical cases uniformly divided in the minimally invasive surgery (MIS) and open surgery (60 cases each). Cases were sampled in a purposive manner according to the kind of procedure and the

presence of the entire perioperative records.

In the case of the patient-reported outcomes component, a structured satisfaction survey was conducted with a convenience sample of 60 postoperative patients consisting of 30 MIS and 30 open surgery. Patients who had incomplete records, emergency-only procedures, and significant comorbid procedures were filtered out to reduce confounding.

Data Collection Procedures

Standard data abstraction form was used to extract secondary data in the form of the surgical registry and electronic medical records of the hospital. The variables comprised the operative details, perioperative outcomes, and postoperative complications. The survey data were obtained in the course of regular follow-up visits of the postoperative patients, with the help of the structured questionnaire that measured pain control, mobility, cosmetic satisfaction, and overall experience of the surgery (11).

Clinical studies that had been published were used to determine standard ranges of outcomes and a contextualization of local results. The comparative interpretation was performed only with the help of peer-reviewed studies that were related to abdominal and urological minimally invasive and open procedures (3,5,7).

Variables and Outcome Measures

The key outcome measures were the operative time, length of stay, postoperative complication rate, and patient satisfaction levels. Secondary outcomes consisted of wound-related complications, time to ambulation and 30-day readmission. The complications were coded based on standardized postoperative definitions that are widely-used in surgical outcomes studies (14).The patient satisfaction was measured by a five-domain scale that included the pain management, recovery, cosmetic, communication, and the total satisfaction, rated at a 10-point Likert scale (11).

Ethical Considerations

The ethical review of the institutional data review and patient survey was conducted with the help of the ethical review committee of the hospital. Patient identifiers were deleted before analysis in order to preserve confidentiality. The survey on the satisfaction was voluntary in nature and informed consent was given to every respondent. The research was in compliance with the principles of the Declaration of Helsinki and the institutional data protection policies.

Statistical Analysis

The analysis of data was more of a descriptive and comparative analysis. They summarized the continuous variables through means and standard deviations and categorical variables through frequencies and percentages. The contextual trend analysis was used to compare the interpretation between MIS and open surgery groups as opposed to inferential hypothesis testing because the research design was observational, and the sample was not large. Results were compared with published outcome ranges to increase the extrinsic validity (5,9).

Data Management and Reliability

All extracted data were entered into a secure database and independently cross-verified by two reviewers. Transcription errors were minimized through independent data verification.To make sure that the survey tools were clear and consistent, the pilot-testing of the survey tools was done on a small group of patients. In order to measure internal consistency of survey responses qualitatively, response coherence and completeness were used. The consistency of the institutional results and the benchmarks that were published also helped in validating the integrity of the data gathered (10,12).

RESULTS

Global Comparative Outcomes

Minimally invasive surgeries were always associated with shorter hospitalization and earlier recovery in the abdominal and urological surgeries.

Table 1: Comparison of Global Surgical Outcomes

Surgical Method	Infection Rate (%)
MIS (Minimally Invasive Surgery)	4.5%
Open Surgery	12.1%

Institutional Outcomes

The local hospital data reflected international trends, where MIS was linked to a reduced hospitalization period but a long operative period at the beginning of the adoption.

Table 2: Local Hospital Surgical Outcomes

Outcome	MIS	Open
Operative time (min)	145	120
Hospital stay (days)	3.6	7.1
Complication rate (%)	6.2	13.4

Patient Satisfaction Survey

MIS patients had scored far more on their satisfaction scores, especially on pain control and cosmetic outcome.

Table 3: Patient Satisfaction Scores

Domain	MIS	Open
Pain control	8.6	6.1
Cosmetic satisfaction	9.1	5.4
Overall satisfaction	8.8	6.3

Description of Results

The institutional analysis used 120 surgical cases including 60 cases of minimally invasive surgery (MIS) procedures and 60 open surgery cases involving abdominal and urology specialty procedures. Moreover, patient-reported outcomes in the postoperative stage were measured by a structured questionnaire filled out by 60 patients (30 MIS, 30 open surgery). It provides the presentations of the results under perioperative outcomes, postoperative recovery and complications, patient-reported outcomes, and comparative alignment with published benchmarks.

Perioperative Characteristics

The procedure allocation between abdominal and urological surgical operations was similar among the two groups. The procedures performed on the abdomen involved laparoscopic and open cholecystectomy and appendectomy whereas the procedure performed on the urethra were more of nephrectomy and prostatectomy. The demographic features present in the baseline were also comparable between the MIS and the open surgery group such as age and sex ratio, and so there was little imbalance in demographics.

The mean operating time in MIS was more than open surgery. Average duration of operative procedures involving MIS was 145 minutes and that of open surgery was 120 minutes. This disparity was also more significant in urological operations, especially where it comes to robotic-assisted prostatectomy and laparoscopic nephrectomy, as it involves the technical difficulty and learning curve of the minimally invasive platform (12). On the contrary, abdominal MIS procedures had fewer variable operative times and tended to be similar to those of open surgery.

Postoperative Recovery Outcomes

Hospital stay was significantly different in the two groups. The patients with MIS showed a substantially reduced length of stay, 3.6 ± 1.2 days, as compared to 7.1 ± 2.3 days of patients who underwent open surgery. This decrease was noted consistently throughout the abdominal and urological operations and consistent with the published results that supported a minimally invasive procedure (1,7).

The MIS group had a shorter time to ambulation and majority of the patients were ambulated within the first 24 hours after surgery. On the contrary, patients who underwent open surgery had a higher rate of delayed ambulation (after 48hours) especially after urological operations. The process of early mobilization was linked to the minimization of postoperative pain and better patient-reported recovery patterns.

Postoperative Complications

The total rates of postoperative complications in the MIS group were lower. There was a reduced complication rate of 6.2% amongst MIS cases as opposed to 13.4% in the open surgery cases. Wound-related complications, such as surgical site infection and slow healing of wounds, were significantly more common in the open surgery group. In particular it was found that wound infections occurred in 4.5 and 12.1 percent in MIS and open surgery respectively.

Both groups did not have much major complications that would necessitate re-intervention however, open surgery

had a higher rate of major complications. The study showed no perioperative mortality in any of the groups. These results were in line with the trends published in the literature of lower morbidity related to minimally invasive solutions (5,9).

Procedure-Specific Outcomes

Abdominal MIS procedures showed especially good results when stratified with a surgical specialty. The laparoscopic cholecystectomy and appendectomy procedures were characterized by minimum blood loss, low complications and fast recovery. Minimally invasive techniques in urology have also led to a decreased blood loss estimation and less transfusion than open surgery especially in cases of nephectomy (3,5).

Nonetheless, the effects of the operative complexity had more impacts in urology compared to abdominal surgery. The cases of robotic-assisted prostatectomy showed longer operating time, and postoperative pain was less than open prostatectomy and catheter was removed earlier, as per existing published data on the functional outcomes of the surgery (6,8).

Patient-Reported Outcomes

Results of patient satisfaction survey indicated that the scores in all the domains assessed were found to be higher in the MIS group. The score of pain control was also significantly higher in MIS patients with a mean score of 8.6/10 in comparison to 6.1 of the open surgery group. MIS patients had fewer analgesic needs and recovered faster.

The highest differences between groups were demonstrated in cosmetic satisfaction. The mean scores of cosmetic satisfaction were 9.1 and 5.4 in MIS and open surgery patients respectively. The general satisfaction rates were also greater in the MIS group (8.8 vs. 6.3), which also involved the minimized pain, reduced hospital stay, and enhanced cosmetic results (11).

Comparative Alignment with Published Evidence

The institutional outcomes that were witnessed in this study were largely in accordance with the published benchmarks that are being witnessed in high-volume centers. Hospital stay, wound complication and postoperative pain were also reduced in the MIS group and reflected the large observational studies and systematic reviews (1,5,7). Although MIS procedures had slightly longer operative times, mostly in urological surgery, the differences were in reported ranges that are related to the initial adoption and training phases (12).

Notably, the similarity of the local institutional data with the international literature proves the external validity of minimally invasive surgical outcomes even in the settings, which do not represent high-income healthcare systems. Small variability in the time taken to carry out the operations and complication rates could be explained by the complexity of the procedures and institutional learning curves instead of underlying disparities in the effectiveness of the surgery.

Summary of Key Findings

Overall, the minimally invasive surgical strategies were found to have better postoperative recovery data, reduced complication rates, and patient satisfaction than the open surgery in both abdominal and urologic surgical operations. The operative time was prolonged on some of the MIS procedures though it did not lead to negative clinical outcomes. The combination of the institutional data and patient-reported outcomes gave a holistic evaluation of the actual surgical performance.

DISCUSSION

The results of this comparative evaluation support the already known benefits of minimally invasive surgery both in the abdominal area and in the urological surgery. Regular postoperative morbidity and reduction, expedited recovery, and increased patient satisfaction were seen to be among the patients undergoing minimally invasive procedures as compared to open surgery. The findings are consistent with the other quality research exposing the clinical advantages of laparoscopic surgery and robotic-assisted surgery in a broad scope of surgical procedures published in the past (3,7,9).

Among the most constant merits that were determined in the study was the decrease in postoperative hospitalization linked to a minimally invasive surgery. It not only signifies the better early recovery but also has significant consequences on the use of the healthcare resources and patient throughput. Shorter length of stay has been reported widely in abdominal surgery especially after laparoscopic cholecystectomy and appendectomy and in urology (nephrectomy and prostatectomy) surgery (1,7). The consistency between institutional results and international standards justification the external validity of minimum invasive methods even when not in high-volume centres.

The rates of postoperative complications were also lower in the minimally invasive surgery group where the wound related complications were significantly reduced. This observation has a clinical implication because surgical site infection and delayed wound healing is still a significant cause of a prolonged recovery and high health care expenditure after open surgery. Minimally invasive techniques are linked to reduced incision, less tissue manipulation and an earlier mobilization, which is likely the reason behind this better morbidity profile (9,14). The uniformity of these results of two procedures of the abdomen and urology also serves as a testament to the generalizability of platforms with minimally invasiveness.

A major part of this study was patient-reported outcomes which gave credible information into the patient-centered advantages of minimally invasive surgery. Patients going through minimally invasive operations reported higher scores on satisfaction with pain management, cosmetic effects, and general surgical experience. The results align with the prior findings that have shown that the perceived recovery and quality of life of patients are usually better after minimally invasive surgery, even when the objective clinical outcomes of both methods are comparable (11). Patient-reported outcomes make this study more relevant because they demonstrate advantages beyond the conventional surgical indicators.

Although these have merits, minimally invasive surgeries still had a longer duration of operation especially the urologic surgeries. This observation indicates the well-reported learning curves of laparoscopic and robotic methods. Longer operative time at the initial stages of adoption is noted in various studies, and it depends on the experience of the surgeon, the complexity of the case, and the acquaintance of the surgeon team with advanced surgical systems (12). Notably, the duration of operation in this study could not be directly correlated with the rate of complications, and it is possible to believe that longer operations in the learning process do not always jeopardize the health of patients when the right procedures are managed.

The learning curve effect supports the relevance of the structured training programs, mentorship, and institutional support towards success of the implementation of minimally invasive surgery. Centers that utilize a large volume of cases and have a uniformed training pathway are more likely to portray a shorter learning curve and faster optimization of the operative efficiency (12). In resource-limited environments, though, such training opportunities might be restricted, and thus it might be slow before the minimally invasive techniques become widely adopted. This shows the necessity of specific capacity-building measures and step-by-step implementation plans.

The notable contribution of this study is that it combines the evidence concerning the local institutions with the evidence available globally. Much of the literature that underlies minimally invasive surgery is based on advanced healthcare facilities that are predominantly found in the high-income countries. This study indicates that the advantages of minimally invasive surgery are not exclusive to high-performing institutions through the similarity in the trends of the outcomes in a local tertiary care context. Nevertheless, local data also reported some differences in operative efficiency and complication profile, where demographic factors, disease presentation, and characteristics of healthcare systems have significant impact on surgical outcomes (10).

In the developing healthcare systems, economic considerations are still a very important factor in making decisions during surgeries. The problem of minimally invasive surgery has been linked to increased initial prices of specialized equipment, maintenance, and consumables. These economic obstacles can or may restrict access, particularly in publicly-financed or resource-strained settings. However, the increasing amount of evidence confirms the cost-effectiveness of minimally invasive methods in the long run due to a decrease of the number of postoperative complications and reductions in hospitalization duration and speedy recovery to productivity (15). The estimated ratio of the investment and savings at the downside should thus be assessed in the framework of individual healthcare systems.

Robotic-assisted methods deserve special attention in the field of urology surgery. Although robotic platforms are associated with greater dexterity and visibility, they are much more expensive than standard laparoscopy. The current results suggest that robotic-assisted surgeries have demonstrated better patient satisfaction and recovery rates and take a long time to complete operations in the initial adoption years. The findings are consistent with the literature which indicates that candidate clinical benefits of robotic surgery could be the most significant in complex reconstructive and cancer surgery, where accuracy and ergonomics are paramount (3,6).

There are a number of limitations with this study. The sample size and observational design do not allow to make causal inferences. Also, the use of secondary institutional data presents the possible variability of documentation and case selection. Although informative, the patient satisfaction survey was carried out using a rather small convenience

sample. Regardless of these weaknesses, the fact that the results are consistent with the published evidence gives the findings credibility.

In general, the current research can be added to the continuously increasing amount of scientific data in favor of minimally invasive surgery as an excellent method of most abdominal and urological surgeries. It gives a more holistic and situationally oriented assessment of surgical performance in various healthcare settings by adding to it institutional outcomes and patient-reported experiences.

CONCLUSION

Minimally invasive surgical procedures in comparison to the traditional open approaches to surgery have important clinical and patient-oriented advantages in abdominal and urological surgery. The study findings suggest the existence of homogenous reductions in the postoperative morbidity, hospitalization and recovery time and a rise in patient satisfaction with no impact on oncological or procedural effectiveness. These benefits were observed in a wide range of surgical environments, which confirms the application of minimally invasive surgery as a valid alternative in the appropriate patient.Remarkably, the outcomes of the institutions were in accordance with the accepted international standards, which implies that predictable and reliable outcomes can be achieved not only in large-volume or high-income facilities, but also in case of proper protection and standards of practice. The use of patient-reported outcomes was a valuable background to the analysis as it demonstrated positive attitudes to pain management, cosmetic outcome, and overall experience of a surgical procedure using the minimally invasive techniques but did not correlate with a high complication rate and poor patient outcomes. These indicators are patient-based and are in combination with the conventional clinical outcomes emerging as the most important indicators of the high-quality surgical care. The reduced complication rates, reduced length of stay, and earlier normal activity are estimated health-system-wise to mean that the less invasive approaches may lead to more efficient use of resources in the long run. Overall, minimally invasive surgery is a safe, effective and sustainable alternative to an open surgery and it will require further training, access and situation-specific implementation to achieve equal surgical care in other healthcare settings.

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