JOURNAL OF COMPLEMENTARY MEDICINE RESEARCH

Journal of Complementary Medicine Research, ISSN: 2146-8397 Vol. 13, No. 2, 2022 (pp. 77-81)

RESEARCH ARTICLE

WWW.JOCMR.COM

Minimally Invasive Surgery: Features, Opportunities, Prospects

***[1]Elita A. Tsitsaeva, [2]Madina M. Goplacheva, [3]Anastasia O. Rastorgueva, [4]Ildus R. Khasanov, [5]Ivan V. Kuznecov**

[1]Federal State Budgetary Educational Institution of Higher Education «Astrakhan State Medical University» of the Ministry of Healthcare of the Russian Federation, The street Bakinskaya,121. Index 414000

[2]Kabardino-Balkar State University named after H. M. Berbekov,Russia, 360004 Kabardino-Balkarian Republic, Nalchik Chernyshevskogo str 173

[3]Ogarev Mordovia State University, 68 Bolshevistskaya Str., Saransk, Republic of Mordovia, Russia, 430005

[4]Federal State Budgetary Educational Institution of Higher Education 'Chuvash State University named after I. N. Ulyanov'. Short name: FGBOU VO 'CHSU named after I. N. Ulyanov'. Legal address: 15 Moskovsky Ave., Cheboksary, 428015, Chuvash Republic, Russia

[5]Tyumen State Medical University, Tyumen, Russian Federation

ABSTRACT

In modern conditions, approaches to performing surgical interventions have undergone significant changes. Among various innovative techniques, minimally invasive surgery rightfully occupies one of the leading places, since it allows to reduce the time of the operation, increase the speed of recovery of the patient after the intervention, reduce the risk of postoperative complications, etc.

By now, minimally invasive surgery has been adopted by medical specialists from various industries, since with its help it is possible not only to solve the main task – to restore the patient's lost health, but also to optimize the operational process itself, increasing its efficiency. For this reason, it is of interest to consider the features of minimally invasive surgical technologies, their capabilities in various specialized medical areas, as well as prospects for future use.

Corresponding Author: eltsi7788@mail.ru

How to cite this article: Tsitsaeva EA, Goplacheva MM, Rastorgueva AO, Khasanov IR, Kuznecov IV. Minimally Invasive Surgery: Features, Opportunities, Prospects Journal of Complementary Medicine Research, Vol. 13, No. 2, 2022 (pp. 77-81).

KEYWORDS:
Key achievements,
Minimally invasive surgery,
Opportunities,
Surgical procedures.

ARTICLE HISTORY:
Received Feb 27,2022
Accepted Mar 29,2022
Published Apr 27 ,2022

DOI:
10.5455/jcmr.2022.13.02.15

INTRODUCTION

Minimally invasive surgical procedures are increasingly included in modern operative medical practice. Their advantage is undeniable, since the surgeon has the opportunity to perform the task assigned to him, reducing both the time of the operation itself and reducing the negative impact on the patient, which can be expressed through the volume of analgesic, consumed by the latter during the operation, the speed of postoperative recovery, etc. The areas in which minimally invasive surgical technologies are used are quite diverse, since the technologies under consideration allow surgeons to introduce, among other things, various operational innovations that positively affect the quality of operations performed.

The purpose of the work is to consider the features, possibilities and prospects of minimally invasive surgery.

MATERIALS AND METHODS

The paper presents a review of the literature on minimally invasive surgical techniques, as well as the possibilities of their use in various diseases. Analytical and comparative research methods were used in the generalization of the obtained material.

RESULTS

Minimally invasive surgery (MIS) allows for surgical interventions in which surgical incisions are minimized in order to injure body tissues less. This type of surgery is usually performed using thin needles and an endoscope for visual inspection of the operation.[1]

The goal (MIS) is to reduce postoperative pain and blood loss, accelerate recovery and reduce scarring.

It is well known that minimally invasive surgical procedures are performed using video cameras and hand tools, which are inserted after incisions with a diameter of 0.5 to 10 mm in the anterior abdominal cavity of a person. The most popular minimally invasive surgery is laparoscopic cholecystectomy, used to remove the gallbladder using laparoscopy procedures. In addition, many common surgical procedures, such as inguinal hernia, appendicitis, reflux and abdominal hernia, can be performed using laparoscopy [2]. Laparoscopic surgery can be used to remove a person's spleen or adrenal glands and oncological surgery, mainly for colon surgery.

Among the key achievements (MIS) should be highlighted:

- reduced incision sizes to create access; in the case of laparoscopy, three to four incisions with a maximum diameter of 10 mm each are usually required, but in the case of single-port access (SPA), only one incision with a diameter of 120 mm is created;
- faster and easier access to some tissues, which at one time would have been impossible to obtain using classical surgical procedures;
- faster, easier and less painful recovery compared to classical surgery;
- minimal risks of postoperative complications (such as: bleeding, postoperative pain or unaesthetic scars)-
- reduction of the cost of surgery, especially in the postoperative period, i.e. a shorter recovery and treatment period, hence minimal costs;
- reducing the time of surgical intervention, therefore, reducing the amount of analgesic administered.[3]

Currently, the methods (MIS) are extended to neurosurgery, gynecology, orthopedics, urology and cardiovascular surgery.

Unlike open surgical methods, MIS procedures require an understanding of additional psychomotor skills related to ergonomics, ambidexterity, tactile abilities and overcoming the fulcrum effect; the entire presentation must be performed using indirect two-dimensional vision.[4]

MIS has experienced a surge in popularity over the past few decades due to rapid technological advances and a growing consensus in the clinical community. According to a report on laparoscopic devices recently published by Global Industry Analysts, 7.5 million laparoscopies were performed worldwide in 2015.[5] For a number of operations, such as appendectomy, tubal ligation, cholecystectomy, gastric bypass, myomectomy and prostatectomy, more than 90% of interventions are currently performed using minimally invasive approaches with projected growth rates of up to 15% in the next 5-10 years. The main reason for this paradigm shift is a significant reduction in injuries to the patient's body as a result of minimizing or even eliminating surgical incisions.

Reducing physical trauma, in turn, leads to a number of additional benefits for the patient: lower frequency of postoperative complications, reduction of pain, faster recovery, shorter duration of hospital stay, minimal cosmetic changes, reduced psychological impact and overall improvement in quality of life.[6]

However, choosing MIS over open surgery also means accepting a number of potential disadvantages from the surgeon's point of view. These include limited workspace and field of vision; lack of tactile feedback; loss of stereo vision and depth perception; decreased hand-eye coordination; long learning curves and training periods; increased work time and increased costs.

Thanks to the latest advances in medical and surgical technologies, such complications are gradually being overcome, which makes it possible to apply minimally invasive procedures in hospitals and clinics around the world. The latest high-resolution miniature cameras now provide surgeons with a detailed overview of the operating space, providing stereo vision and optimal illumination of hidden targets regardless of their location in the body. In some cases, it is even possible to access and view certain anatomical areas better than with open interventions.

Minimally invasive tools have also been designed and engineered to ensure that routine tasks are performed safely and accurately, even in a confined space. Moreover, modern imaging technologies and image processing techniques provide accurate guidance and navigation throughout the intervention. improving accuracy and safety while speeding up the procedure .[7]

The latest navigation systems offer radical improvements in the way information is collected, displayed and integrated into the surgical workflow through augmented reality and multimodal image registration. Virtual reality simulations have revolutionized the training of new practitioners by providing new ways to speed up the learning process. Finally, advances in robotics have greatly contributed to increasing the dexterity and skill of the surgeon thanks to articulated instruments and platforms for human and robot collaboration.

When eliminating or reducing the size of the incision on the body, the accessibility and visibility of the operating space is sharply limited. While in open surgery the target can be easily exposed, in MIS it is necessary to use other means to get a clear picture of the operation. First, you need to get good lighting in the dark. The surgical field should also be viewed in color and with high resolution so that the surgeon can distinguish possible important details of the tissue. Moreover, it is often necessary to reach the goal by long winding paths in order to use the natural openings and passages of the body.

In the second half of the 20th century, fiber optics for the first time served as the basis for the development of the first flexible endoscopes, gastroscopes, ureteroscopes and colonoscopes. In modern versions of these devices, either a bundle of optical fibers illuminated by a xenon lamp or LEDs located directly at the tip of the sight are most often used for lighting.

A xenon light source provides broad-spectrum light and is usually supplemented with a thermal (infrared) filter to avoid overheating of the cable and the tip and reduce the risk of damage to the target tissue. Before the advent of charge-coupled devices (CCD), coherent fiber-optic beams were also used to transmit images back to the viewer. In most modern installations, high-resolution CCD cameras are used to transmit a live video stream to a flat screen via an analog-to-digital converter and a processing unit.[8]

Advanced laparoscopes, usually based on rod lens systems, have also benefited from the use of cameras, eliminating the need for a surgeon to look into a binocular eyepiece, minimizing discomfort and stress. The operation can also be viewed by the entire surgical team, thereby improving team interaction and collaboration. In addition, the use of digital cameras means that videos can be recorded and saved for future use. Image processing can be performed in real time, allowing the surgeon to adjust properties such as contrast or brightness to improve the visibility of the scene. Newer laparoscopic systems can also use a CCD array at the end of the endoscope, which allows you to remove lenses from inside the endoscope rod. These modern installations are almost universally used in surgical departments.

One of the main problems associated with video information systems is the loss of stereopsis, that is, the perception of depth and three-dimensionality. This happens when a three-dimensional (3D) image is projected onto a two-dimensional screen, and is often the cause of impaired hand-eye coordination and erroneous movements of instruments. The use of multiple image processing channels and cameras solves this problem and allows one to record stereo images, while providing high-resolution images that can be displayed on a 3D monitor.[9]

3D data can be recovered from non-video cameras using image processing algorithms, such as computer or photometric stereo, which extract depth information and allow reconstructing and displaying a 3D image. It is important to note that although 3D imaging improves productivity and reduces surgery time, high-definition (HD) images are still necessary to obtain optimal clinical results.

As for surgical instruments, the specialists were faced with the task of developing instruments for MIS that would be compact enough to fit into trocars or endoscopes, and that could work in a limited space: the size of the instruments should be minimized without compromising their functions. A number of surgical instruments have been converted to minimally invasive equivalents, leading to products such as Endo Stitch for suturing (Medtronic, Dublin, Ireland); Endo Catch packages (Medtronic) for waste extraction; endo-grips (MetroMed Healthcare, Taiwan) and needle guides (LiV Instruments, Estech, San Ramon, California, USA).[10]

All of these devices have been used for years and relatively well cope with simple tasks. In particular, crosslinking devices and endoscopic crosslinking devices, such as MicroCutter XCHANGE (Cortica, New York, New York, USA), have made it possible to perform operations such as hemostatic resection of the intestine, closure of gastrotomy and sudden anastomosis, with increased reliability and have better performance compared to manual stitching or clips.

Another specific category of instruments widely used in MIS is aimed at delivering energy for tissue ablation, vascular sealing and wound cauterization. Examples range from simple electrodes that heat tissue by passing current, to harmonic scalpels - instruments that convert electrical energy into mechanical motion, effectively cutting tissue using high-frequency blade vibrations.

For cauterization, radiofrequency ablation systems and electrosurgery with argon amplification provide an effective current supply to improve results and shorten the operation time. Lasers are also sometimes used to ablate tissues or tumors. In prostatectomy, laparoscopic laser surgery causes less morbidity compared to traditional transurethral resection of the prostate, although sometimes open surgery is preferred .[11]

In fact, despite the fact that energy delivery technology is successfully used in everyday life, it is necessary to take into account a number of safety considerations. Due to the limited field of view, there is a risk of burning the wrong area or inadvertently activating the electrodes above, as well as the possibility of direct and capacitive coupling, which can also cause overheating and burns.

These advances have improved the condition of many minimally invasive procedures, as well as allowed for operations that have never been performed endoscopically before, such as cholecystectomy using translumenal endoscopic surgery with a natural opening (NOTES) or 'keyhole' neurosurgery under visual control to remove a brain tumor.

The potential of NOTES, in particular, has attracted widespread attention in the clinical community, since no skin incision is required to access the body. However, it is limited by the limitations imposed by the small size, great flexibility and high maneuverability required for endoscopic instruments. Indeed, most minimally invasive instruments are much more difficult to manipulate than conventional instruments.[12-15].

It is often difficult to achieve tool triangulation, flexibility and traction while avoiding clutter. The tip of the tools does not have the same degree of articulation as the human wrist, and does not have the same ability to grab objects and manipulate them. The need for frequent replacement of endoscopic devices also increases the duration of the operation and can cause discomfort in the patient.

Robotics offers some solutions to the above-mentioned problems and has proven to be a viable option to eliminate the limitations associated with ISU. In robotic surgery, instruments are moved not directly by the surgeon, but with the help of special controllers and software. The tools can be supplemented with motors and end effects, improving the user's ability to rotate, move and manipulate in minimally invasive procedures. By providing articulation, tremor filtering and imitation of tactile sensations, the surgeon's dexterity and eye-hand coordination are increased, thereby subjectively improving surgical efficiency.

DISCUSSION

It is also necessary to consider the practical possibilities of using MIS technologies. So, this technology is used today for surgical intervention caused by the diagnosis of "acute spontaneous intracerebral hemorrhage". Such a hemorrhage causes a significant reduction in the patient's life and the onset of disability. It affects about 2 million people worldwide every year, and the 30-day mortality rate from acute spontaneous intracerebral hemorrhage is approximately 40%.

Minimally invasive puncture surgery can reduce the volume of hematoma, reduce the mortality rate of patients and improve the prognosis of patients with acute spontaneous intracerebral hemorrhage. Its treatment with minimally invasive surgery is aimed at "layer-by-layer reduction of intracranial pressure, dilution and drainage of hematoma and transformation of a large hematoma into a small hematoma", which leads to accurate treatment of patients with intracerebral hemorrhage.

Currently, invasive puncture microsurgery can be divided into soft channel technology and hard channel technology; the drainage tube material and surgical procedures of the two are different, and each technology has its advantages and disadvantages. Currently, hard channel technology is widely used only in China. Large samples, multicenter and high-quality randomized controlled clinical trials are needed to determine the effectiveness of the rigid channel technology.[12]

Minimally invasive hematoma drainage with suction is suitable for patients with intracerebral hemorrhage in the early stages. Before surgery, it is necessary to carefully assess the condition and vital signs of the patient and accurately determine the location of the hematoma using computer tomography. Using adequate monitoring, the hematoma should be thinned and slowly aspirated in order to steadily reduce intracranial pressure and turn a large hematoma into a smaller hematoma.

Postoperative complications such as recurrent bleeding and intracranial infection should be actively prevented, extubating should be performed at the right time, and treatment with mild hypothermia or free radical removal agents should be considered. Precision treatment using minimally invasive surgery can effectively reduce swelling, reduce intracranial pressure, and weaken brain tissue damage.

Another area of application of MIS technology is minimally invasive surgery for esophageal and gastric cancer that optimizes the patient's recovery without compromising the quality of oncological resection. Laparoscopic and thoracoscopic surgery has not been as widely adapted for resections of esophageal and stomach cancers as for colorectal surgery. This may partly be due to the complexity of operations, as well as the lack of data on long-term results in patients who underwent surgery with minimally invasive access.

Also, laparoscopic total and subtotal gastrectomy is safe, provides better perioperative results and at least equivalent oncological results compared to open gastrectomy. During esophageal resection, MIS include hybrid esophagectomy (laparoscopic mobilization of the stomach with open thoracotomy or thoracoscopic mobilization with laparotomy ± cervical incision) and total MIS (laparoscopic and thoracoscopic). There is also growing interest in the use of robotic platforms for esophagectomy. Both hybrid esophagectomy and total esophagectomy show better perioperative results and at least equivalent survival results compared to open surgeries.[16]

MIS is also used for pancreatoduodenal resection (PD), a complex operation with three complex reconstructions. A recent study compared the results of patients who underwent surgery using MIS technology, as well as those who underwent open pancreato-duodenectomy (OPD). It was determined, which showed that there was significantly less postoperative stay and less blood loss in the MIS group. It also reported the benefits of MIS, including a greater likelihood of receiving adjuvant chemotherapy, a lower rate of local relapses, and a higher rate of R0 resections due to better visibility and increased surgical accuracy.[17]

MIS has proven its feasibility and safety and has shown promising results. However, minimally invasive pancreato-duodenal resection (MIPD) is a technically complex operation, and to fully master this technique requires the development of appropriate professional skills.[18]

CONCLUSION

The achievements of medicine in the field of (MIS) are increasing every year. Modern cameras can provide 3D images in HD format and provide an overview of the operating field comparable to an open operation, compensating for the loss of stereo vision and representing a definite improvement compared to optical fiber. Flexible videoscopes allow the surgeon to achieve hidden goals even in tortuous ways and have allowed new methods to appear using natural orifices of the body. Efforts should be aimed at providing a more natural visualization of 3D scenes, as well as at increasing the resolution of images while reducing the size of cameras.

Thanks to imaging technology, it is really possible to plan operations and train the surgeon in advance; provide guidance and navigation during the intervention, increasing the confidence of the surgeon and the safety of the operation; carry out accurate diagnoses, biopsies and postoperative examinations in a minimally invasive way.

Author Contributions

All authors contributed in reviewing the final version of this paper.

REFERENCES

1. Tsui C, Klein R, Garabrant M . Minimally invasive surgery: national trends in adoption and future directions for hospital strategy. Surg Endosc 2013;27:2253–7
2. Smith R, Day A, Rockall T, et al . Advanced stereoscopic projection technology significantly improves novice performance of minimally invasive surgical skills. Surg Endosc 2012;26:1522–7
3. Mamelak AN, Nobuto T, Berci G. Initial clinical experience with a high-definition exoscope system for microneurosurgery. Neurosurgery 2010;67:476–83
4. J.E. Oor, M.J. Wiezer, E.J. Hazebroek Hiatal hernia after open versus minimally invasive esophagectomy: a systematic review and meta-analysis 23 (8) (2016), pp. 2690-2698
5. D.E. Low, M.K. Kuppusamy, D. Alderson, I. Cecconello, A.C. Chang , G. Darling, et al. Benchmarking complications associated with esophagectomy Ann. Surg., 269 (2) (2019), pp. 291-298
6. H.J. Brenkman, K. Parry, F. Noble, R. van Hillegersberg, D. Sharl, et al. Hiatal Hernia After Esophagectomy for Cancer, 103 (4) (2017), pp. 1055-1062
7. C. Mariette, S.R. Markar, T.S. DabakuyoYonli, B. Meunier, D. Pezet , D. Collet, et al. Hybrid minimally invasive esophagectomy for esophageal cancer N. Engl. J. Med., 380 (2) (2019), pp. 152-162
8. M.M. Hennessy, I. Ivanovski, E. Spartalis, D. Chrysikos, A. Athana siou Diaphragmatic hernia following esophagectomy for esophageal cancer: a systematic review J Buon, 24 (5) (2019), pp. 1793-1800
9. M.N. Wente, C. Bassi, C. Dervenis, A. Fingerhut, D.J. Gouma, J.R. Izbicki, et al. Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS) Surgery, 142 (2007), pp. 761-768
10. T. de Rooij, J. van Hilst, D. Boerma, B.A. Bonsing, F. Daams, R.M. van Dam, et al. Impact of a nationwide training program in minimally invasive distal pancreatectomy (LAELAPS) Ann Surg, 264 (2016), pp. 754-762
11. J. van Hilst, M. Korrel, T. de Rooij, S. Lof, O.R. Busch, B. Groot Koerkamp, et al. Oncologic outcomes of minimally invasive versus open distal pancreatectomy for pancreatic ductal adenocarcinoma: a systematic review and meta-analysis Eur J Surg Oncol, 45 (2019), pp. 719-727
12. S. Klompmaker, J. van Hilst, U.F. Wellner, et al. Outcomes after minimally-invasive versus open pancreatoduodenectomy: a pan-European propensity score matched study Ann Surg, 271 (2) (2020), pp. 356-363
13. Markov A, Ponomarev A, Zavatskij M, Stepanova K, Krylov S, Naumov M. Preservation of Bone Tissue Quality during the Usage of Synthetic

Bioactive Calcium Phosphate Mineral Coating for Prevention of Metallic Construction Migration. JBBBE 2020; 46:67–74.

14. Nenasheva, E. V., Larina, A. O., Achmad, H., Timokhina, T., & Markov, A. Bioelectronic Implants and Their Role in Modern Medicine. Journal of Pharmaceutical Research International. 2020; 32(33), 23-31.

15. Malyutin, V. G., Sevagina, V. O., Kokotov, V. A., Goncharov, V. V., Markov, A., & Shalneva, K. N. Improvement of Biomedical Structural Polymers by Synthetic Biology Methods. Journal of Pharmaceutical Research International. 2021; 33(17), 31-38.

16. E. Aguayo, J. Antonios, Y. Sanaiha, et al. Readmission and resource use after robotic-assisted versus open pancreaticoduodenectomy: 2010-2017 J Surg Res, 255 (2020), pp. 517-524

17. J.D. Beane, M. Zenati, A. Hamad, M.E. Hogg, H.J. Zeh 3rd, A.H. Z ureikat Robotic pancreatoduodenectomy with vascular resection: outcomes and learning curve Surgery, 166 (1) (2019), pp. 8-14

18. B.K. Goh, T.Y. Low, Y.X. Koh, et al. Changing trends and outcomes associated with the adoption of minimally invasive pancreatic surgeries: a single institution experience with 150 consecutive procedures in Southeast Asia J Minimal Access Surg, 16 (4) (2020), pp. 404-410