JOURNAL OF COMPLEMENTARY MEDICINE RESEARCH

Journal of Complementary Medicine Research, ISSN: 2146-8397 Vol. 13, No. 1, 2022 (pp. 82-86)

RESEARCH ARTICLE WWW.JOCMR.COM

Development of Innovations in the Field of Surgical Operation Technologies: Minimally Invasive Approaches and the Digital Future

[1*]Valentina Y. Sakharova, [2]Ruslan S. Khutaev, [3]Karina M. Idalova, [4]Anastasia A. Mirgorodets, [5]Elena N. Kucheryavenko, [6]Yuri N. Dorofeev

[1] Federal State Budgetary Educational Institution of Higher Education

"St. Petersburg State Pediatric Medical University Ministry of Health of the Russian Federation

[2] Litovskaya St., St. Petersburg, 194100

[2]Medical Institute of ChSU named after A.A. Kadyrov

[3]64024 Grozny, Sheripova str.32

[3]Astrakhan State Medical University , 414000,Street Bakinskaya 121

[4] Tambov State University named after G. R. Derzhavin, Medical Institute,Russia, Tambov region, Tambov Sovetskaya 93

[5] Faculty of Pediatrics, Dentistry and Pharmacy, I.S. Turgenev Oryol State University, 95 Komsomolskaya st., Oryol, 302026

[6]Tyumen State Medical University, Tyumen, Russia

ABSTRACT

Surgery has its origins in ancient times, thanks to traditional surgical operations millions of lives around the world have been saved today. Surgery at all times assumed and today it assumes direct contact with organs, and tissue dissection was as one of the main methods of surgical intervention. However, in modern conditions, there has been a paradigm shift in the methodology of surgery. The development and implementation of a number of innovations initiated the emergence of minimally invasive surgery, which influenced the methods of abdominal surgery. The use of endoscopic techniques, imaging and advanced instruments have raised surgical practice to a new height. Computers and robotics are also opening up a promising future for simplifying complex procedures and improving the accuracy of micro-scale operations. Accordingly, in modern conditions, it is possible to observe a synthesis of innovative technologies, digitalization and traditional approaches to performing surgical operations, which in the future may enter into the usual practice of surgeons and significantly increase the percentage of successful surgical interventions.

Corresponding Author e-mail: valya22442@mail.ru

How to cite this article: Sakharova VY, Khutaev RS, Idalova KM, Mirgorodets AA, Kucheryavenko EN, Dorofeev YN (2022). Development of Innovations in the Field of Surgical Operation Technologies: Minimally Invasive Approaches and the Digital Future. Journal of Complementary Medicine Research, Vol. 13, No. 1, 2022 (pp. 82-86).

INTRODUCTION

Minimally invasive methods in surgical practice began to be introduced at the beginning of the twentieth century. In particular, in 1901, the Russian doctor D.O. Ott performed an endoscopic examination of the abdominal cavity through a vaginal incision using a mirror and an expander.

In the future, endoscopy was used by practitioners in 1985 and subsequent years for cholecystectomy. The minimally invasive surgical approach that has been recognized by the leading medical surgical centers of the world as the most priority method for performing operations to remove gallstones from the gallbladder.[1]

Later laparoscopy was also adopted during other cavity operations, which made it possible to reduce the volume of the surgical field without losing the quality of the surgical intervention.[2]

Every year digitalization brings more and more innovations to surgical practice, which makes it possible to expand the range of operations, performed using minimally invasive technologies. Accordingly, the future of surgery, in our opinion, is firmly connected with artificial intelligence, which contributes to improving the quality of work of practicing surgeons and increases the survival rate of patients and the percentage of their full recovery, reducing the time of their postoperative recovery.

The purpose of the work is to develop innovations in the field of surgical operation technologies: minimally invasive approaches and the digital future.

KEYWORDS:
Computer technologies,
Digital future,
Endoscopy
Innovations,
Minimally invasive surgery.

ARTICLE HISTORY:
Received Jan 29, 2022
Accepted Feb 28, 2022
Published Mar 12, 2022

DOI:
10.5455/jcmr.2022.13.01.15

MATERIALS AND METHODS

To write the paper, an array of literature was analyzed on various approaches to the organization of minimally invasive surgical interventions, including those using digital technologies. Comparative and analytical research methods were used to generalize and systematize the collected information.

RESULTS

The types of minimally invasive surgery that surgeons use in their practice today are quite diverse. In particular, laparoscopic cholecystectomy (LC) has become the preferred method of treatment of gallstone disease in recent years.[3] LC offers more significant benefits associated with less postoperative pain, shorter hospital stay and the fastest recovery of patients.

Laparoscopic appendectomy is also quite common, which becomes the preferred choice for any condition of appendicitis, while the skills of the surgeon should be improved to minimize iatrogenic complications.[4]

The main concepts of another intervention option - laparoscopic hernioplasty - are the placement of the underlying mesh and the distribution of intra-abdominal pressure over the area of the superimposed mesh. Benefits include reduced hospital-ization time, minimal dissection, and lower wound infection. Initially, laparoscopic hernioplasty was used as a standard approach for strangulated hernias. Currently, indications for laparoscopic hernioplasty are expanding to relieve symptoms, prevent complications and treat acute complications.

The recurrence rate in laparoscopic hernioplasty is lower than in open plastic surgery, from 0 to 17% with medium- and long-term follow-up. Surgical site infections significantly decreased with the laparoscopic approach with a frequency of 1.1% compared to 10% with open operation. This superiority is confirmed by smaller incisions, a reduction in the number of direct contacts, minimal dissection and fewer exposed tissues.[5]

Laparoscopic bariatric surgeries are also of interest. Laparoscopic sleeve gastrectomy (LSG) is recognized as an innovative and new surgical approach to the treatment of obesity. The large curvature of the stomach is resected to get a narrow and tubular stomach; thus, the hormone ghrelin, which stimulates hunger, is removed. This technique attracts attention by the fact that anastomosis and intestinal bypass surgery are not required.

Other options for bariarthric surgery include biliopancreatic diversion (BPD) and biliopancreatic diversion with duodenal switching (BPD/DS). Both procedures require a two-stage operation, which begins with a sleeve gastrectomy and leaves the pylorus intact.[6]

Transluminal endoscopic surgery through natural openings (NOTES), "surgery without scars" or "surgery without incisions" is considered a new surgical method in recent years and a new chapter of minimally invasive surgery. Initially, the NOTES manipulations were performed on pigs in 2000. Later, in 2004, the first human transgastric appendectomy was performed in India.

Each access path has its advantages and disadvantages. For example, transvaginal access is easy to perform, simple sutures (conventional sutures), easy closure and minimal complications. Thus, this method applies only to a subset of patients (for example, adult women). Instead, ventricular access is easy to perform with precautions; however, the main task of the current instrument is closure, and complications are fatal (bleeding and peritonitis). A special device for closing the stomach can solve these problems. The actual tasks of NOTES in recent years are the safety and optimal procedure of peritoneal access, including the prevention of infection due to the high risk of contamination.

Consequently, NOTES represents a revolutionary and innovative era of surgery with minimal access, based on modern endoscopy and laparoscopy techniques. In the future, NOTES may be a promising option to replace the traditional approach and perform a complex procedure with accurate and excellent results.

One of the options for minimally invasive technologies today is laparoscopic surgery with a single incision (SILS) [7].

In several studies, the authors compared single-incision and laparoscopic cholecystectomy due to the many potential benefits. In addition to the higher cost, longer surgery time and sophisticated technique, SILS has proven to be a safe and feasible procedure with reduced postoperative pain and improved cosmetic results.[8]

In several meta-analyses comparing SILS and conventional laparoscopic appendectomy, the time of surgery, complications, wound infection and duration of hospitalization were considered. They concluded that there were no significant differences between the two groups in the treatment of appendicitis. Thus, SILS appendectomy has not proven to be either better or more profitable than conventional laparoscopic appendectomy; nevertheless, SILS appendectomy is technically feasible, safe and reliable.

Indian specialists introduced Hernioplasty using SILS in 2005. In a comparative study between SILS hernioplasty and the traditional approach, excellent results were reported with respect to postoperative pain, length of hospital stay and improved cosmetics when using SILS technique. There were no differences in concomitant diseases and duration of surgery. Thus, the researchers concluded that there were no differences in cosmetic results and postoperative pain in both SILS and traditional laparoscopic hernioplasty groups.[9]

The concept of laparoscopic surgery with a single incision is a potential and new method in the future, similar to how laparoscopic surgery was used two decades ago. The goals of the new approach are feasibility, safety and clinical benefits .[10]

Cosmetic improvement is not the main task of SILS. The new method should be an innovation for every laparoscopic surgeon and continue research to improve results. The current limitations of SILS are related to technical issues such as triangulation, retraction, embedded vision, crowding of tools, ergonomics, tools, cost and safety. Further developments are widely available in these areas to overcome the limitations. More research is needed with new updates and wider dissemination to reduce costs and show the advantages of SILS over the traditional approach.

It is also necessary to focus on the features of transanal endoscopic microsurgery and transanal minimally invasive surgery. Until the 1980s, surgeons performed local excision (LE) of the distal rectum through a posterior parasacral incision, transsphincter and transanal. Conversely, these methods are associated with higher complications, such as recto-cutaneous fistula and anal incontinence.

Along with numerous limitations and side effects, Gerhard Buss introduced the first transanal endoscopic microsurgery (TEM) in 1983, deliberately expanding LE to the proximal rectum. Compared to LE, TEM has a higher quality of resection, fewer relapses and increased survival. Nevertheless, TEM requires a rigid proctoscope, laparoscopic camera and specialized instruments; thus, the complexity of the procedure and the high cost burdened both surgeons and patients.[11]

Technology is undergoing various changes along with surgical skills with today's progress in minimally invasive surgery. A recent approach was developed in 2009 and was called transanal minimally invasive surgery (TMIS). This method creates coexisting laparoscopic instruments, including 360-degree high-resolution optics and triangulated instruments; therefore, TMIS is believed to provide improved resection quality and increase relapse-free survival.

In several literature sources, these methods have been compared in many aspects, such as morbidity, complications, recurrence rate and repeated surgery. The researchers reported equivalent results despite the latest TMIS approach. Wider visualization and flexibility of tools without changing the position are beneficial for TMIS. These advantages make it possible to obtain a larger sample and reduce the operation time.[12]

Other authors[13] concluded that the quality of samples and perioperative complications are equally effective. Although TMIS provided less work time and settings. The main task of both techniques is suturing. To overcome difficulties, an endoscopic stapler, intra- and extracorporeal suturing are recommended. Tool collisions and inadequate suture tension remain a burden for surgeons to achieve optimal results.

Future developments are still desirable to improve clinical outcomes, reduce unreasonable costs and operator flexibility.

DISCUSSION

The trend of transition from minimally invasive surgery to "non-invasive" is increasing these days. As a result, the development of robotic surgery goes in parallel with the main direction of surgery: improving patient safety and improving results [14]. Robotic surgery was applied as a military project by the National Aeronautics and Space Administration (NASA) in 1970 to provide medical care to astronauts on spacecraft without the presence of a surgeon. Over the past four decades, robotic surgery has been growing rapidly in the medical industry, and it is on the way to its perfection.[15]

The concept of robotic surgery a hundred years ago could have been beyond human capabilities and unreasonable. This irrationality was changed in 1985, when specialists performed a neurosurgical biopsy under the control of computed tomography (T). This approach was also used by another group of specialists to perform transurethral resection of the prostate gland. However, the limitations associated with this operation were not suitable for dynamic surgical purposes (for example, gastrointestinal surgery). In parallel with these developments, another robotic surgical technique was proposed, approved by the US Food and Drug Administration (FDA) – it was a machine designed for endoprosthetics and was widely used in the USA and Europe.

Two surgical telemanipulators were invented and approved by the FDA in the following years: Zeus and Da Vinci system. Zeus, consisting of three hands, consisting of two hands, acted as the surgeon's hands. The third arm was a voice-controlled navigation camera called "Automated Endoscopic System for Optimal Positioning" (AESOP).

It was first used for fallopian tube anastomosis at the Cleveland Clinic, USA, in July 1998. Later, Zeus was widely used in surgery of the digestive tract, including appendectomy, hernioplasty, colectomy, etc.

Jacques Himpens and Gi Cardier used Da Vinci for cholecystectomy in Belgium in 1997. Subsequently, the success of the previous operation began to attract another operation in Germany, where a mitral valve replacement was performed. Later, in 2003, Zeus and the da Vinci system were merged when Computer Motion and Intuitive Surgical merged. The next updated version of da Vinci made this system the most widely used robotic surgery worldwide.[16]

Da Vinci consists of four installed robot manipulators. This upgraded version has adjustable finger loops, adjustable intraocular distance and a padded headrest depending on the needs of the surgeon. High accuracy is achieved thanks to three-dimensional (3D) visualization, jitter prevention, motion scaling and an advanced user interface. However, the lack of tactile feedback is the main disadvantage of this system.

Currently, many competitor robots are widely available and are at various stages of development. The advantages of robotic surgery are beneficial and overcome the barriers of laparoscopic surgery.

Robotic surgery minimizes iatrogenic complications, improves visualization, eliminates hand tremor, clarifies the position, and processes microanastomoses. The limitations of this promotion are associated with high costs, lack of benefits and tactile feedback. The first transcontinental remote tele-surgery using a robot was performed in 2002, where a cholecystectomy was performed by specialists from New York to a patient in France. The operation was performed for 54 minutes without complications and complications.

A two-center joint and retrospective study comparing robotic and laparoscopic cholecystectomy did not reveal significant clinical differences. However, the pain score at discharge was lower in the robotic care group ($p = 0.010$).

Developing robotic platforms continue to grow as medical needs are met. Engineers and developers apply the latest updates to expand the capabilities of robots. These trends tend to shift upwards together with the goal of transforming the traditional approach into fully robotic surgery in modern practice. Numerous studies have shown further improvement of the latest technologies to increase the effectiveness of surgical operations. There are several expectations in different aspects in the future. Overcoming the high cost is the main task of recent robotic surgery, followed by special robotic training and fundamental recommendations initiated by the Society of Robotic Surgery. Consequently, the fate of robotic surgery depends on overcoming limitations to prove its feasibility, safety, cost reduction and clinical benefits.[17]

In recent years, exponential interest in virtual reality (VR) and augmented reality (AR) has been observed in the field of medicine. These technologies have been applied in other industries, including telecommunications, aviation, aerospace, games, etc. Although the introduction of VR and AR is considered a newborn in the medical era. Virtual reality is a computer-generated artificial technology for merging images and environments with real-time interaction. Meanwhile, AR overlays the generated data on a real or live image to enrich the actual image. These technologies offer a huge interaction and combine fragments between the real and digital worlds. Subsequent advancement improves digital healthcare and clinical practice, resulting in increased patient safety and improved outcomes.

The similarity of VR and AR lies in their fundamental science, which allows you to create three-dimensional (3D) digital impressions. Virtual reality uses a three-dimensional environment created by computers and changes human sensory perception with the help of a head-mounted display (HMD), stereo devices and gloves for data transmission. On the other hand, AR generates a digital image on real images captured by a camera and projected by a computer or video projector.

However, the differences between VR and AR are in providing digital 3D experiences. Virtual Reality provides full immersion through HMD with a virtual interactive environment. On the other hand, a holographic or transparent display overlays the real world and it is seen creating an immersive digital experience. In addition, the digital display of both technologies provides various information about the patient's condition, anatomical anomalies and detailed measurements. These advantages allow the surgeon to investigate and analyze the patient's current problem, thereby increasing the accuracy, efficiency and safety of the surgeon and improving treatment outcomes.

The projected use of VR and AR provides a multidimensional study of medical data. They can reconstruct and visualize the patient's problems, and then simulate the procedure using digital 3D images. Shafi Ahmed, an oncologist surgeon, successfully conducted the first live broadcast of VR in 2016 at the Royal College Hospital. Augmented reality has also found clinical application in surgery of the pancreas and hepatobiliary system, which took place in 2013.

Following the latest 5G connection technology, the prospects of VR and AR will accelerate and, undoubtedly, turn the surgical approach into a fully virtual procedure. An integrated data center in VR and AR makes it possible to turn medical care into digital.[18]

Three-dimensional reconstructed information about the patient, along with virtual modeling of surgical approaches and possible outcomes, is almost in the hands of the medical period. Future research and improvements are aimed at maximizing the use of existing technologies, including robotic hand gestures, tactile feedback and virtual display, to solve current problems in these areas. Thus, the promotion of VR and AR is more attractive due to their improved skills, which can be followed by other technologies that will become easily accessible, effective and improve the goals of surgical progress, the quality of life for each patient.

In recent years, artificial intelligence (AI) has penetrated medicine and predisposes to it. AI is a machine-based algorithm with reasoning and cognitive abilities to perform everyday human tasks such as problem solving, object recognition, word recognition, and decision making. The wave of enthusiasm for AI increases the role of medical professionals in reducing the number of human errors in the examination, diagnosis and treatment of patients. In particular, Cornell University reported on the outstanding accuracy of using a deep learning algorithm for detecting metastases in lymph nodes in breast cancer.

The use of artificial intelligence in surgery allows surgeons to make complex decisions, including multimodal therapy, the timing of surgical intervention and the type of surgical intervention. In addition, surgeons are expected to anticipate surgical risks prior to surgery and the likelihood of mortality and morbidity with each decision. Other AI influence is also significant on image-based procedures such as endoscopy and radiology.

Later, surgeons can complement the real-time decision-making process during surgery based on AI analysis of intraoperative progress in real time with vital signs, anatomical tracking, time solutions and real-time video to calculate the current percentage of adverse events, mortality and morbidity. This is followed by postoperative data that are integrated with the patient's condition to assess the main vital signs, assess postoperative needs, relapse rates and potential adverse events.

Although the hype around AI in the medical industry may be its own trap due to inflated expectations. This technology cannot provide answers to all questions and does not fully work without human intervention. Future expectations of replacement surgeons in all aspects of the patient's decision may be highly exaggerated, and in the future they cannot be ignored. Human judgment in the field of medicine still has an advantage over the development of artificial intelligence technologies in recent years. However, AI at a young age is silent about the current situation. Perhaps in the future, artificial intelligence will move to creating evidence-based clinical judgments in real time and optimizing the safety and quality of life of patients.

CONCLUSION

In the future, there will be further advances in surgery technologies that will change the current practice. The main development of parallel surgical abilities will not be completely reversed from semi-assisted to fully autonomous. Surgeons, scientists and engineers must collaborate to fundamentally change the current work in order to develop another breakthrough and improve the condition of patients and cost-effectiveness.

REFERENCES

1. M.J. Mack Minimally invasive and robotic surgery J. Am. Med. Assoc., 285 (2001), pp. 568-572
2. A.G. Harrell, B.T. Heniford Minimally invasive abdominal surgery: lux et veritas past, present, and future Am. J. Surg., 190 (2005), pp. 239-243
3. S. Lee-Kong, D.L. Feingold The history of minimally invasive surgery Semin. Colon Rectal Surg. (2013), pp. 3-6

4. A.G. Budiarti, A.M. Muhar Changes in glutamic oxaloacetic transaminase serum (sgot) and glutamic pyruvic transaminase serum (sgpt) value in laparoscopic cholecystectomy patient at usu hospital Sumatera Med J (2020), pp. 1-5
5. S. Connor, O.J. Garden Bile duct injury in the era of laparoscopic cholecystectomy Br. J. Surg., 93 (2006), pp. 158-168
6. W.J. Lee, C.P. Chan, B.Y. Wang Recent advances in laparoscopic surgery Asian J. Endosc. Surg. (2013), pp. 1-8
7. J. Otero, A.T. Huber, B.T. Heniford Laparoscopic hernia repair Adv. Surg., 53 (2019), pp. 1-19
8. P.D. Colavita, V.B. Tsirline, I. Belyansky, A.L. Walters, A.E. Lincou, R.F. Sing, *et al*. Prospective, long-term comparison of quality of life in laparoscopic versus open ventral hernia repair Ann. Surg. (2012), pp. 714-723
9. P. Armijo, A. Pratap, Y. Wang, V. Shostrom, D. Oleynikov Robotic ventral hernia repair is not superior to laparoscopic: a national database review Surg. Endosc., 32 (2018), pp. 1834-1839
10. K.M. Coakley, S.M. Sims, T. Prasad, A.E. Lincourt, V.A. Augenstein, R.F. Sing, *et al*. A nationwide evaluation of robotic ventral hernia surgery Am. J. Surg., 214 (2017), pp. 1158-1163
11. L. Gu, X. Huang, S. Li, D. Mao, Z. Shen, P.A. Khadaroo, *et al*. A meta-analysis of the medium- and long-term effects of laparoscopic sleeve gastrectomy and laparoscopic roux-en-y gastric bypass BMC Surg., 20 (2020), pp. 1-10
12. W. Lynn, A. Ilczyszyn, S. Rasheed, J. Davids, R. Aguilo, S. Agrawal Laparoscopic roux-en-y gastric bypass is as safe as laparoscopic sleeve gastrectomy: results of a comparative cohort study Ann Med Surg, 35 (2018), pp. 38-43
13. S. Li, ling, E. Zhao, L. Zhao, Z. Wang, kai, W. Li Transvaginal natural orifice transluminal endoscopic surgery in the diagnosis of ascites of unknown origin Gastrointest. Endosc., 89 (2019), pp. 872-877
14. S. Rajapandian, C. Bhushan, S.C. Sabnis, M. Jain, P.P. Raj, R. Parat asharthi, *et al*. Single incision multiport versus conventional laparoscopic inguinal hernia repair: a matched comparison J. Minimal Access Surg., 14 (2018), pp. 44-51
15. B.S. Peters, P.R. Armijo, C. Krause, S.A. Choudhury, D. Ol eynikov Review of emerging surgical robotic technology Surg. Endosc., 32 (2018), pp. 1636-1655
16. C. Cao, R.J. Cerfolio Virtual or augmented reality to enhance surgical education and surgical planning Thorac. Surg. Clin., 29 (2019), pp. 329-337
17. N. Segaran, G. Saini, J.L. Mayer, S. Naidu, I. Patel, S. Alzubaidi , *et al*. Application of 3d printing in preoperative planning J. Clin. Med., 10 (2021), p. 917
18. R. Mirnezami, A. Ahmed Surgery 3.0, artificial intelligence and the next-generation surgeon Br. J. Surg., 105 (2018), pp. 463-465
19. D.A. Hashimoto, T.M. Ward, O.R. Meireles The role of artificial intelligence in surgery Adv. Surg., 54 (2020), pp. 89-101