1 Overview of Past, Present, and Future of Incisional Hernia Repair

Karl A. LeBlanc

Introduction

The minimally invasive surgical repair of ventral and incisional hernias has its roots in the retromuscular repair promoted by Rives and Stoppa many years ago [1, 2]. This repair placed mesh between the peritoneum and the rectus muscles via an open approach. Transfascial sutures fixed the prosthetic in place. The long-term results were favorable. This repair continues to be used in the appropriate situations. With the advent of laparoscopic surgery in the late 1980s and early 1990s, the early believers in this technology adopted these methods to the repair of inguinal and incisional hernias. Interestingly the first known mention of a repair of any hernia laparoscopically was attributed to Dr. P. Fletcher at the University of the West Indies in 1979 [3].

The purpose of this textbook is to provide the current methods as recommended by the thought leaders of these repairs. The various options laparoscopically and robotically assisted are presented in the chapters. We have also tried to focus on the pre-, intra-, and postoperative care of these patients. The surgeon should have knowledge of all of the aspects of the care of these patients. We have tried to provide this information.

Laparoscopic Repair

The first successful repair of an incisional hernia using the laparoscopic method was by this author in 1991. The tenets of the procedure mimicked those of the Rives-Stoppa repair. A small series of patients was reported in 1993 [4]. Since this initial report there has been a slow but steady increase in the utilization of this methodology to repair these hernias. It is now commonplace to repair midline hernias as well as those located in the other regions of the abdominal cavity laparoscopically.

The development and growth of the laparoscopic incisional and ventral hernia repair fueled concomitant development of a large variety of prosthetic materials specifically designed for placement of mesh into the abdominal cavity with contact with the intestine. These are called the tissue-separating meshes. "Improved" products have replaced many of these materials over the years but several of them are still available. This is extensively reviewed in Chap. 5, "Implants Used for Hernioplasty."

As with any surgical field, there has been and continues to be areas of controversy. The first controversy revolved around the clinical benefit of the laparoscopic approach to the repair of these hernias. This technique does provide bene-

K. A. LeBlanc
Surgeons Group of Baton Rouge,Our Lady of the Lake Physician Group, Clinical Professor, Surgery, Louisiana State University Health Sciences Center, Baton Rouge, LA, USA

K. A. LeBlanc (ed.), *Laparoscopic and Robotic Incisional Hernia Repair*,
https://doi.org/10.1007/978-3-319-90737-6_1

fit especially in the reduction in infection [5–10]. Other controversies have included the need and/or benefit of closure of the fascial defect. Most recently, the concern of the placement of any mesh material against the intestine has resulted in techniques to place the prosthetic material in the preperitoneal space. These are discussed in the various chapters of this textbook.

Current Surgical Robot Repair

The first surgical robot resulted from combining a few computer technologies to result in the founding of Intuitive Surgical, Inc. (ISI) based in Sunnyvale, CA, in 1995. The first prototype of their surgical robot was called Lenny (derived from Leonardo da Vinci). After successful feasibility demonstration, the Mona (derived from the Mona Lisa) was the second prototype. It was the first prototype to be used in human testing. Further refinements led to the development of the da Vinci® Standard surgical system. These initial robots had only three arms and were initially marketed and sold in Europe in 1999. They achieved FDA clearance in the United States in 2000 for general surgical applications. Clearance for thoracic and urological procedures followed 1 year later. The fourth arm was added to the system in 2003.

Continued refinements resulted in the release of the da Vinci S® product in 2006 (Fig. 1.1). The arms were lighter and smaller with improved visualization with high-definition video. In 2009, the da Vinci Si® was released (Fig. 1.2). This continued on the improvements for the surgeon console, among others, as well as higher resolution 3D magnification. This was also introduced with the available integration of a second surgeon console to allowing operators to use the system in unison. This required a "passing off" of the controls between consoles enhancing surgeon training and collaboration.

The more compact da Vinci Xi® system was introduced in 2014 (Fig. 1.3). This system has enhanced abilities to more easily dock the robot and other significant enhancements such as the ability to place the trocars closer together. Double docking (placement of trocars on the opposite of the abdo-

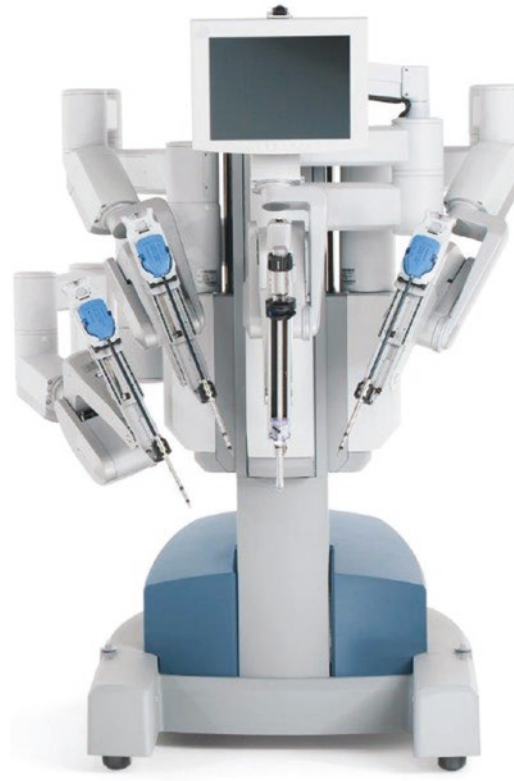

Fig. 1.1 S patient cart

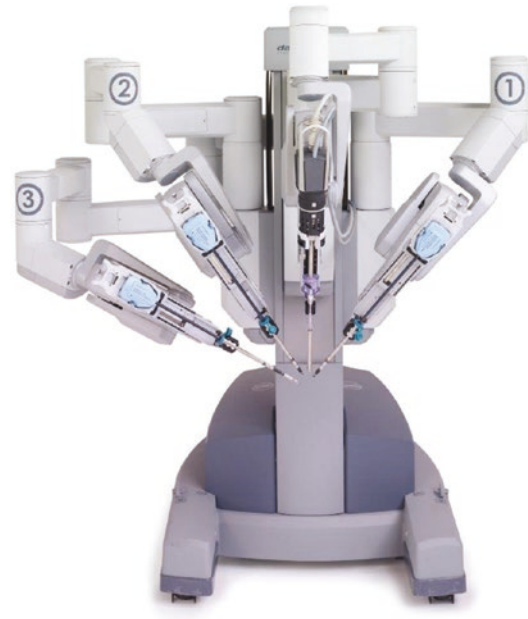

Fig. 1.2 Si patient cart

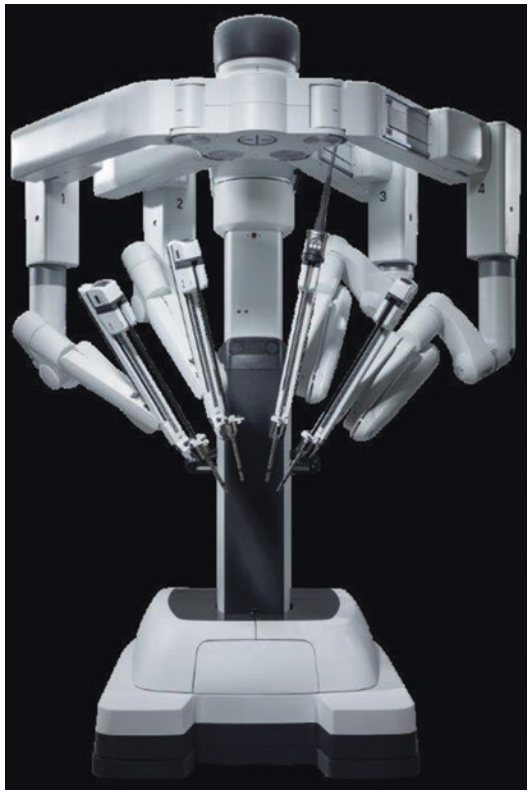

Fig. 1.3 Xi patient cart

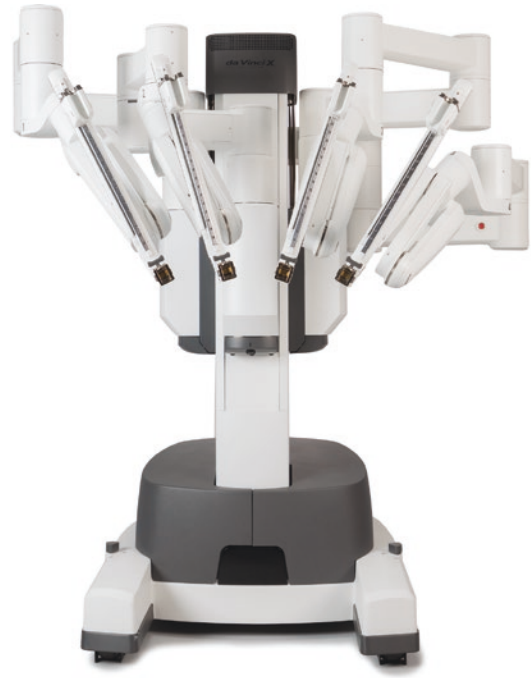

Fig. 1.4 X patient cart

men) no longer required the movement of entire robot as the boom could be rotated in position. Additionally, instruments and the camera could be interchanged between trocars, making multi-quadrant abdominal surgery much more feasible. This system has an available integrated operative table, TruSystem™ 7000dV (Trumpf Medezin Systeme, Saalfeld, Germany) that allows its motion to coincide with the robot via direct computer communication. This allows repositioning of the operating table while maintaining the anatomical orientation of the patient relative to the arms of the robot.

Just released in 2017 was the 5th generation of robot, the da Vinci X® (Fig. 1.4). This system mimics the da Vinci Xi® platform in many ways such as the thinner, enhanced arms, laser guidance, 3DHD vision, and the second surgeon console. There are a few sacrifices in the ease of deployment and docking but the goal is to create a price point for emerging markets. All of the above products have received the CE and FDA 510(k) clearances. However, the Standard and da Vinci S® systems are discontinued and are no longer supported by the company. All three of the currently supported products feature dual surgeon consoles, laser technology for fluorescent imaging, and single-site operative capability.

The robotic platform to perform surgery has been used in the urological and gynecological arenas for many years. The potential value of the robot-assisted repair was explored as early as 2003 [11]. In this porcine model it was shown that the intracorporeal suturing of a mesh to the posterior fascia was feasible. A small French study involving 11 patients was the first report of mesh fixation with suturing with the robot in humans [12]. It appeared that this method might not be associated with the chronic postoperative pain that is seen in the laparoscopic method. Another later study of 13 patients also showed that this was feasible with good results [13]. In that study, there was one recurrence, but no patient experienced chronic suture pain. In 2014, the FDA approved the repair of hernias using the ISI Si robot. Since then there has been tremendous

growth in the utilization of the da Vinci systems for hernia repair. This is particularly evident in the repair of incisional and ventral hernias of all types due to the articulation of the wrists allowing easier intra-abdominal suturing than laparoscopic instrumentation.

Although not released at the time of this writing, the da Vinci SP® single-port system may be introduced after the publication of this textbook (Fig. 1.5). It will allow the introduction of articulated instruments and the camera through a single port that requires a diameter of approximately 2.5 cm. It cannot be known of this will be beneficial in the repair of incisional hernias at this time, but one could speculate that surgeons will endeavor to adapt these methods to benefit their patients.

The only other surgical robot approved for use in the United States is the Senhance™ system by TransEnterix, Inc. (Morrisville, NC, USA). Unlike the current generations of the ISI robots, this robot provides haptic feedback and eye tracking of the surgeon (Fig. 1.6). This allows the surgeon to move his or her eyes and the camera movements correspond to their movements. Additionally, it does not require the use of a specific optical system and each arm has a separate "cart" rather than all arms on one cart as does the da Vinci systems. It does not have the degrees of movement of the da Vinci systems and more mimics traditional laparoscopic instruments without a wrist.

Fig. 1.5 SP patient cart (The da Vinci SP® is still in development, is not 510(k) cleared, and the safety and effectiveness of the product has not been established. The technology is not currently for sale in the US)

Future Surgical Robotic Systems

Due to the very large market and potential for financial success, there are several other companies that are actively engaged in the development of newer systems that could allow repair of ventral (and other) hernias. It is not really known if all will be easily used for hernia repair. Each, it would seem, will seek to differentiate themselves in many different ways whether it be enhanced capabilities or pricing. Most likely, the next one to market will be the SPORT surgical system by Titan Medical, Inc. (Toronto, Canada) (Fig. 1.7). It is a single-port system with multi-articulating instruments. It is not currently available for sale.

Little is known about the other companies that are in various stages of development. Cambridge Medical Robotics, Ltd. (Cambridge, England) has a working prototype of the Versius (Fig. 1.8). Each arm of the robot has three joints similar to the human arm and is on individual carts that allow the position to be similar to a standard laparoscopic procedure.

Other companies that are known at the time of the writing of this chapter are listed in Table 1.1. It is unknown if any of these robots will allow use in the repair of hernias. The reader is referred to the Internet for future offerings from these companies.

Fig. 1.6 Senhance system

Fig. 1.7 Titan SPORT system

Fig. 1.8 Versius (this company-provided photo is intentionally dark)

Table 1.1 Known surgical robotic companies

Company	Location
Auris	San Carlos, CA, USA
Avatera Medical	Jena, Germany
Medtronic, Inc.	Minneapolis, MN, USA
Meere	South Korea
Micro Medical Instruments	Calci, Italy
Verb Surgical, Inc.	Mountain View, CA, USA

Conclusion

The laparoscopic approach to the repair of incisional and ventral hernias continues to be refined and improved. The continual development of newer mesh products indicates the response of industry to the ongoing needs of the surgeons and their patients. The introduction of the robot to repair these hernias is seen as another advancement. The current and future offerings in this technology appear to signal the continued adoption of this method of repair. Surgeons interested in the future of hernia surgery should follow these developments closely.

References

1. Rives JJ, Flament JB, Delattre JF, et al. La chirurgie moderne des hernies de l'aine. Cah Med. 1982;7:13.
2. Stoppa RE. The treatment of complicated groin and incisional hernias. World J Surg. 1989;13(5):545–54.
3. Ger R. The management of certain abdominal herniae by intra-abdominal closure of the neck of the sac. Ann R Coll Surg Engl. 1982;64:342–4.
4. LeBlanc KA, Booth WV. Laparoscopic repair of incisional abdominal hernias using expanded polytetrafluroethylene: preliminary findings. Surg Laparosc Endosc. 1993;3(1):39–41.
5. Itani KMF, Hur K, Kim LT, Anthony T, Berger DH, Reda D, Neumayer L, Veterans Affairs Ventral Incisional Hernia Investigators. Comparison of laparoscopic and open repair with mesh for the treatment of ventral incisional hernia: a randomized trial. Arch Surg. 2010;145(4):322–8.
6. Sauerland S, Walgenbach M, Habermalz B, et al. Laparoscopic versus open surgical techniques for ventral or incisional hernia repair. Cochrane Database Syst Rev. 2011;3:CD007781.
7. Zhang Y, Zhou H, Chai Y, al e. Laparoscopic versus open incisional and ventral hernia repair: a systematic review and meta-analysis. World J Surg. 2014;38(9):2233–40.
8. Al Chalabi H, Larkin J, Mehigan B, McCormick P. A systematic review of laparoscopic versus open abdominal incisional hernia repair with meta-analysis of randomized controlled trials. Int J Surg. 2015;20:65–74.
9. Arita NA, Nguyen MT, Nguyen DH, et al. Laparoscopic repair reduces incidence of surgical site infections for all ventral hernias. Surg Endosc. 2015;29(7):1769–80.
10. Savitch SL, Shah PC. Closing the gap between the laparoscopic and open approaches to abdominal wall hernia repair: a trend and outcomes analysis of the ACS-NSQIP database. Surg Endosc. 2016;30(8):3267–78.
11. Schluender S, Conrad J, Divino CM, Gurland B. Robot-assisted laparoscopic repair of ventral hernia with intracorporeal suturing. Surg Endosc. 2003;17(9):1391–5.
12. Tayar C, Karoui M, Cherqui D, Fagniez PL. Robot-assisted laparoscopic mesh repair of incisional hernias with exclusive inracorporeal suturing: a pilot study. Surg Endosc. 2007;21(10):1786–9.
13. Allison N, Tieu K, Snyder B, Pignazzi A, Wilson E. Technical feasibility of robot-assisted ventral hernia repair. World J Surg. 2012;36(2):447–52.