Retromuscular Sublay Technique for Ventral Hernia Repair

Irfan A. Rhemtulla, MD, MS¹ John P. Fischer, MD, MPH¹

¹Division of Plastic Surgery, Department of Surgery, University of Pennsylvania, Philadelphia, Pennsylvania

Semin Plast Surg 2018;32:120–126.

Address for correspondence John P. Fischer, MD, MPH, Assistant Professor of Surgery, Division of Plastic Surgery, Department of Surgery, University of Pennsylvania, South Pavilion – 14th Floor, 3400 Civic Center Boulevard, Philadelphia, PA 19104 (e-mail: John.Fischer2@uphs.upenn.edu).

Abstract

Keywords

- sublay
- retrorectus
- retromuscular
- preperitoneal
- Rives-Stoppa

Rives and Stoppa described the sublay technique of hernia repair more than half a century ago, but it took almost three decades to become truly appreciated and even longer for its full clinical potential and benefits to be realized. Modifications to the original operation have significantly improved surgical approaches, postsurgical outcomes, and quality of life. The retromuscular approach requires technical expertise and a firm grasp of the anatomy. With constant substitution of the terms sublay, retrorectus, retromuscular, preperitoneal, and Rives-Stoppa throughout the literature, the nuances need to be distinguished to appreciate the surgical planes encountered during the operation. This article explains the origin of the nomenclature while clarifying these terms, describing the technique, highlighting outcomes, and discussing future considerations.

When compared with suture alone, the use of mesh in ventral hernia repair (VHR) is associated with a reduction in incidence of hernia recurrence.^{1–4} With mesh being increasingly used to decrease subsequent incisional hernias, there is debate as to which plane of mesh placement has the best outcomes.^{4,5} Mesh can be placed as an onlay, inlay, sublay, or underlay. Among these, sublay repairs are some of the most technically challenging due to the necessity of creating the plane for placement of the mesh. In this technique, the retrorectus space must be meticulously developed, whereas the plane needed for mesh placement in the other methods is already present.

Despite the added dissection to establish the retromuscular space, there is increasing evidence to show that sublay mesh placement has the best recurrent hernia incidence, with some studies reporting numbers as low as 5%.^{4–7} Furthermore, with the introduction and improvement of component separations, the retrorectus repair may be utilized in patients that otherwise would not be candidates for hernia surgery. With such great potential, a thorough understanding of the sublay repair can benefit surgeons performing the operation as well as patients suffering from the morbidity of ventral and incisional

hernias. This chapter reviews the terminology, technique, outcomes, and future directions of retromuscular sublay repairs while explaining why this operative procedure took several years to become popular despite its original description more than 50 years ago.^{8,9}

Nomenclature

Conceptually, a sublay repair can be thought of as mesh placement in a pocket formed anterior to the peritoneum and posterior to the rectus abdominis.¹⁰ However, misperception of the nomenclature arises due to the several terms used (often interchangeably), to describe mesh placement in this tissue plane—such as retromuscular, retrorectus, preperitoneal, and Rives-Stoppa. A large portion of this confusion stems from the initial description of the technique by Rene Stoppa and Jean Rives in France during the 1960s.¹¹

Although contemporary surgeons in the same country, Stoppa and Rives both independently developed slight variations of the technique that the former initially performed in bilateral inguinal hernia repairs.¹² Stoppa's technique required placement of a large sheet of polyester mesh in the

Fig. 1 Nomenclature of sublay repair.

preperitoneal or retrofascial space allowing for the intra-abdominal pressure to secure the mesh between the peritoneum and abdominal wall. This location of the mesh allows for incorporation into the surrounding autologous tissues and reinforcement of the fascia without contacting intraperitoneal structures.^{9,11}

Rives translated these principles to VHR but described placement of the mesh as retromuscular (posterior to the rectus muscle but anterior to the posterior rectus sheath).¹¹ The reason Stoppa and Rives used different terminology was because of the anatomical differences in their respective operative fields. Whereas Stoppa's operation took place inferior to the arcuate line where the posterior sheath does not exist, Rives took place superior to the arcuate line where the posterior sheath is intact. Thus, inferior to the arcuate line, the mesh is placed in the preperitoneal space, but superior to the arcuate line the mesh is placed not only preperitoneal but also pre-posterior rectus sheath, better known as retromuscular.¹³ The term "retrorectus" is a more precise description of this space since the specific muscle referred to by "retromuscular" is the rectus abdominis. The differences in terminology superior and inferior to the arcuate line are illustrated in ►Fig. 1.

Operative Technique

Outlining the aforementioned nomenclature and anatomy allows for a more comprehensive description of this technique. Typically, the surgery begins with a laparotomy incision that is carried down through the subcutaneous tissues until the anterior fascia is reached. The hernia sac, which is lined by

peritoneum, is identified and the fascia superior or inferior to the defect is entered. This fascial incision is lengthened to ensure that there is adequate exposure of the hernia defect. After careful dissection of the hernia sac away from the surrounding fascia, if there is a need to enter the peritoneum, it is incised carefully so as not to injure the abdominal contents. At this point, a full exploration of the abdomen can take place and any concomitant procedures may be performed.

After the intraperitoneal portion of the procedure is complete or if the operation remains extraperitoneal, the sublay plane can be created for mesh placement. Observing the posterior rectus sheath from underneath, this layer is incised and dissected away from the rectus abdominis (►Fig. 2A). Caution and use of blunt dissection during this portion of the case ensures preservation of the segmental neurovascular bundles and inferior epigastric vessels (►Fig. 2B). If the dissection continues superiorly, the posterior sheath can be divided from the dorsal aspect of the xiphoid process. If the hernia defect extends below the arcuate line, the transversalis fascia with peritoneum (instead of the posterior rectus sheath superiorly) is dissected away from the anterior structures (►Fig. 3A).¹¹ This dissection can be carried down even more inferiorly into the spaces of Retzius and Bogros, exposing the pubic symphysis.¹⁴ Laterally, the dissection typically extends across the linea semilunaris to facilitate appropriate mesh overlap (►Fig. 3B).¹¹

Once the posterior sheath and transversalis fascia with peritoneum have been dissected away from the rectus abdominis (►Fig. 4A), myofascial releases (discussed in the next section) can be performed. Examples of these include a

Fig. 2 Initial plane of dissection. (A) Initial dissection into the retrorectus plane. (B) Preservation of the inferior epigastric vessels.

Fig. 3 Extent of dissection. (A) Transition from posterior rectus sheath to transversalis fascia/peritoneum. (B) Lateral extent of dissection across the linea semilunaris.

Fig. 4 Completion of dissection. (A) Released posterior rectus sheath. (B) Released transversus abdominis.

transversus abdominis release (TAR) depicted in ►**Fig. 4B** and external oblique release depicted in ►**Fig. 5A**. The midline is then reapproximated with suture (►**Fig. 5A**), and mesh is placed to reinforce the repair (►**Fig. 5B**). Once the mesh is situated by whatever method the surgeon prefers, closed suction drains can be positioned above the mesh through lateral stab wounds. Next, the anterior fascia is sutured together and the midline is reconstructed.

Component Separation

The aforementioned description illustrates what was detailed by Rives and Stoppa several decades ago,^{12,13} but it does not describe how to address persistent tension on the midline after retromuscular placement of mesh. This tension on the tissues is important to discuss since it has been implicated as the cause of many operative failures.⁹ Ramirez

Fig. 5 Reapproximation and mesh fixation. (A) Reapproximation of midline again depicting the transition across the arcuate line along with external oblique myofascial release. (B) Placement of mesh.

et al found a partial solution for this issue in 1990 with the description of a myofascial release, or component separation, of the external oblique muscle from the lateral edges of the rectus abdominis.¹⁵ This maneuver allows for added laxity of the midline, leading to less strain on the fascia when brought back together.

Although this chapter is not a review of component separations, understanding the concept is essential to appropriately executing sublay repairs. When Rives initially described his technique, he did not explicitly state that he was in fact performing a myofascial release by completely freeing the rectus muscle off its encasing sheath.¹¹ Yet, this is often the key to performing a tension-free repair. While Ramirez's anterior component separation does aid in decreasing tension at the midline, it does not allow for completely adequate mesh coverage. This shortcoming was improved approximately 20 years later when the posterior external oblique release and TAR were introduced by Carbonell and Novitsky, respectively, allowing for greater mesh overlap.^{16–18}

►**Fig. 6** outlines the evolution of sublay repair with the introduction by Rives and Stoppa, followed by Ramirez proposing the anterior component separation at around the same time when Wantz introduced the retromuscular prefascial repair to the United States.¹⁹ Subsequent improvements in component separation techniques including the open anterior perforator-preserving technique,²⁰ the laparoscopic technique,²¹ posterior component separation,¹⁶ and TAR¹⁸ are also shown in ►**Fig. 6**. As illustrated in the aforementioned timeline, approximately 25 years passed between the description of the sublay repair and the adjunctive procedure that made it possible to implement appropriately. It then took another two decades for the true scope and applicability of myofascial releases to be described. With substantially decreased surgical site infections (SSIs) and recurrence rates, combining component separation techniques with a sublay mesh repair allows patients with previously “inoperable” hernias to not only have an operation but also one that is durable with decreased recurrence rates.^{22,23}

Postoperative Outcomes

These recurrence rates for sublay repair have been studied individually and have also been compared with other locations of mesh placement in the literature. A systematic review by

Albino et al shows that retrorectus and underlay mesh placement has the lowest rates of recurrence when compared with onlay and inlay placement.⁵ A study using data from the Ventral Hernia Outcomes Collaborative subsequently looked at sublay versus underlay specifically in a multi-institutional setting and describes sublay repair as having significantly less recurrences compared with underlay (10.7 vs 25%).⁶ A more robust network meta-analysis by Holihan et al further corroborates this finding by showing that sublay repair has the lowest risk for recurrence and the best rate of success when compared with placement of mesh in other locations.⁴

Along with low recurrence rates, Holihan's study also shows that sublay repair has the lowest risk for SSI when compared with onlay and underlay techniques.⁴ Other analyses address the effect of sublay repairs on other surgical site occurrences (SSOs) as well, including cellulitis, wound dehiscence, delayed healing, seromas, and hematomas, all of which can have a large impact on quality of life and health care costs.^{24–26} Overall, SSO is as low as 16% and as high as 46% in patients receiving retrorectus repair, which is equivocal to other locations of mesh placement.^{25,27} Multiple studies also show that increased patient risk factors such as obesity, smoking, previous mesh infection, and prior abdominal surgery increase rates of SSO, which in turn increase recurrence rates, but this is not unique to sublay repairs.^{24,25,27} Taking all of this into account, retrorectus mesh placement does not adversely affect outcomes when compared with other techniques^{6,28} or when considered in the context of current hernia risk prediction models.²⁵

The aforementioned studies are convincing for improved outcomes with sublay mesh placement, but the appropriate type of mesh to use is still under considerable debate. In fact, this has been a persistent issue in the literature for all locations of mesh placement since Usher et al first described using Marlex to repair incisional hernias in 1958.²⁹ Studies show that ideal mesh characteristics include inertness, resistance to mechanical strain, minimal foreign body reaction, flexibility, resistance to infection, rapid incorporation into autologous tissue, similar tensile strength to native tissue, low cost, and restoration of the natural movements of the abdominal wall,^{30–33} but no material in use today has all of these features. As a result, there are many different mesh compositions utilized in sublay repairs. The studies which will be discussed next have examined outcomes with several of these different prosthetic materials.

Fig. 6 Evolution of sublay repair.

Synthetic meshes (typically polypropylene or polyester) are the oldest implants used in hernia repair and thus have the most data. These meshes have the appropriate characteristics of resistance to mechanical strain, significant tensile strength, and rapid incorporation into the autologous tissue.³⁴ Due to these properties, studies repeatedly show better recurrence rates (5–20%) and quality of life with synthetic mesh in the retrorectus plane.^{24,35,36} Despite these improvements, one perceived drawback of synthetic meshes is that they can still be associated with significant SSO in contaminated fields.²⁴

In an attempt to decrease wound events in these cases, biologic meshes are employed as well. The majority of studies addressing biologic meshes in sublay repair are small and retrospective, but do show recurrence rates as low as 12.5%³⁷ with potential for improved wound events.²⁴ The main disadvantage of these biologic implants is their significantly higher cost compared with synthetic mesh.³⁸ As a result, surgeons are often faced with deciding between higher wound complications or higher costs in dirty and contaminated wounds. With new innovations in biosynthetic meshes, which appear to have similar anti-infection properties as biologic meshes at a reduced cost, studies such as the Contaminated Ventral Hernia Repair Using Biosynthetic Absorbable Mesh (COBRA) trial are showing comparable recurrence rates to synthetic mesh with improved quality of life; however, long-term outcomes and cost-effectiveness still need to be assessed.³⁹

With increasing data showing that outcomes improve with sublay position of mesh regardless of the composition, it is also important to consider if the Rives-Stoppa method is appropriate to use in populations at high risk for postoperative complications. One such group of patients are those that carry the diagnosis of obesity.⁴⁰ A recent study indicates that in patients with a body mass index (BMI) greater than 30 kg/m², open sublay repairs are not associated with higher recurrence rates compared with those with a BMI less than 30 kg/m².⁴⁰ Krpata et al have taken this a step further and report that sublay repairs have exceptional recurrence rates (5%) regardless of any of several different high-risk comorbidities including obesity, diabetes mellitus, chronic obstructive pulmonary disease, smoking, and immunosuppression.²⁷ Even though many of these comorbidities are independently associated with risk of recurrence and postoperative complications in all types of hernia surgery,^{41,42} it appears that sublay repairs provide a consistent, durable repair.

Future Directions

Regardless of mesh type or patient population, sublay repairs appear to be effective. Sublay repairs have evolved during the past 50 years, but there is still room for improvement. Two such areas are patient quality of life and postoperative pain. After large sublay repairs, often including component separations, patients remain in the hospital for several days to weeks and are severely debilitated for months afterward. With laparoscopic surgery decreasing pain and improving quality of life across many surgical disciplines, studies have been conducted to determine how this technology might be used

to perform retrorectus hernia repairs.^{35,43} Prospective trials show that the retrorectus repair can be performed laparoscopically with improved recurrence rates, enhanced quality of life, decreased hospital length of stay, and reduced infection rates in smaller hernia defects.^{43,44} These studies do not have large sample sizes and not much is reported on long-term outcomes, but there is growing evidence to indicate that small- and medium-sized defects can be repaired laparoscopically in the retrorectus plane.

One drawback of laparoscopic surgery is the inability to manage larger defects due to the constraints of the workspace and the stiff, rigid instruments. Additionally, these same issues make it difficult to actually close the defect, which leads to decreased adverse events after laparoscopic hernia repair.⁴⁵ With robotic surgery allowing for more degrees of freedom, some of these deficiencies can be corrected. A recent study shows that when comparing robotic to open sublay repairs, despite the size of the defect or use of TAR, there is improvement in hospital length of stay but 30-day readmissions and SSI are not affected.⁴⁶ There are no prospective studies to support these results yet and similar to laparoscopic repair, current investigations have not reported long-term outcomes in large patient populations.

Another way to address quality of life and postoperative pain is to study how the mesh is placed in the preperitoneal space. Traditionally, this was accomplished with large full-thickness transfascial bites using permanent¹³ or slowly absorbable monofilament¹¹ suture. Rives initially described placing several stitches circumferentially around the entire mesh,¹³ but recently less suture is being used and some surgeons are even considering sutureless mesh adherence in an attempt to decrease postoperative pain from the needle repeatedly passing through the fascia. A recent retrospective study illustrates improved quality of life with fibrin glue fixation of mesh when compared with suture fixation without a difference in 30-day readmissions, SSI, or other postoperative complications.⁴⁷ Another small retrospective cohort study assessing self-gripping mesh demonstrates that the majority of these study subjects have next to no pain in the immediate postoperative period and zero have hernia recurrence within 3 months, but data are not available for longer follow-up.⁴⁸ Other surgeons argue that no fixation of any sort is necessary since the mesh sits in a dissected plane that is then secured and held in place by closing the fascia above it.¹¹ With no consensus on the subject, mesh placement is currently performed based on personal preference, but prospective studies comparing the risks and benefits may improve operative outcomes, cost, and quality of life.

Conclusion

Laparoscopy, robotics, and sutureless mesh are just a few examples of future directions for sublay hernia repair. There are several other innovations that are currently being theorized and tested. Despite differences in mesh composition or the patient population that is being treated, sublay repairs have shown superiority in recurrent hernia incidence. Similar to Rives and Stoppa, present-day surgeons performing

hernia repairs are continually trying to develop the best operation to ensure patient satisfaction and quality of life while eliminating recurrence rates and postsurgical complications. Until the perfect hernia repair is discovered, the sublay technique remains one of the best options. Half a century ago, the Rives-Stoppa repair was the state of the art for ventral and incisional hernia repair. Today, there is a strong case for it to be considered the standard of care.

Conflict of Interest

John P. Fischer is a paid consultant for Gore, Integra LifeSciences, and Bard.

References

- Luijendijk RW, Hop WC, van den Tol MP, et al. A comparison of suture repair with mesh repair for incisional hernia. *N Engl J Med* 2000;343(06):392–398
- Burger JWA, Luijendijk RW, Hop WCJ, Halm JA, Verdaasdonk EGG, Jeekel J. Long-term follow-up of a randomized controlled trial of suture versus mesh repair of incisional hernia. *Ann Surg* 2004;240(04):578–583, discussion 583–585
- Nguyen MT, Berger RL, Hicks SC, et al. Comparison of outcomes of synthetic mesh vs suture repair of elective primary ventral herniorrhaphy: a systematic review and meta-analysis. *JAMA Surg* 2014;149(05):415–421
- Holihan JL, Nguyen DH, Nguyen MT, Mo J, Kao LS, Liang MK. Mesh location in open ventral hernia repair: a systematic review and network meta-analysis. *World J Surg* 2016;40(01):89–99
- Albino FP, Patel KM, Nahabedian MY, Sosin M, Attinger CE, Bhanot P. Does mesh location matter in abdominal wall reconstruction? A systematic review of the literature and a summary of recommendations. *Plast Reconstr Surg* 2013;132(05):1295–1304
- Holihan JL, Bondre I, Askenasy EP, et al; Ventral Hernia Outcomes Collaborative (VHOC) Writing Group. Sublay versus underlay in open ventral hernia repair. *J Surg Res* 2016;202(01):26–32
- Liang MK, Holihan JL, Itani K, et al. Ventral hernia management: expert consensus guided by systematic review. *Ann Surg* 2017;265(01):80–89
- Stoppa RE. The treatment of complicated groin and incisional hernias. *World J Surg* 1989;13(05):545–554
- Faylona JM. Evolution of ventral hernia repair. *Asian J Endosc Surg* 2017;10(03):252–258
- McLanahan D, King LT, Weems C, Novotney M, Gibson K. Retrorectus prosthetic mesh repair of midline abdominal hernia. *Am J Surg* 1997;173(05):445–449
- Carbonell A. Rives-Stoppa retromuscular repair. In: Novitsky Y, ed. *Hernia Surgery: Current Principles*. Switzerland: Springer International Publishing; 2016
- Stoppa R, Petit J, Abourachid H, et al. Original procedure of groin hernia repair: interposition without fixation of Dacron tulle prosthesis by subperitoneal median approach [in French]. *Chirurgie* 1973;99(02):119–123
- Rives J, Lardennois B, Pire JC, Hibon J. Large incisional hernias. The importance of flail abdomen and of subsequent respiratory disorders [in French]. *Chirurgie* 1973;99(08):547–563
- Read RC. Crucial steps in the evolution of the preperitoneal approaches to the groin: an historical review. *Hernia* 2011;15(01):1–5
- Ramirez OM, Ruas E, Dellon AL. “Components separation” method for closure of abdominal-wall defects: an anatomic and clinical study. *Plast Reconstr Surg* 1990;86(03):519–526
- Carbonell AM, Cobb WS, Chen SM. Posterior components separation during retromuscular hernia repair. *Hernia* 2008;12(04):359–362
- Pauli EM, Wang J, Petro CC, Juza RM, Novitsky YW, Rosen MJ. Posterior component separation with transversus abdominis release successfully addresses recurrent ventral hernias following anterior component separation. *Hernia* 2015;19(02):285–291
- Novitsky YW, Elliott HL, Orenstein SB, Rosen MJ. Transversus abdominis muscle release: a novel approach to posterior component separation during complex abdominal wall reconstruction. *Am J Surg* 2012;204(05):709–716
- Wantz GE. Giant prosthetic reinforcement of the visceral sac. *Surg Gynecol Obstet* 1989;169(05):408–417
- Saulis AS, Dumanian GA. Periumbilical rectus abdominis perforator preservation significantly reduces superficial wound complications in “separation of parts” hernia repairs. *Plast Reconstr Surg* 2002;109(07):2275–2280, discussion 2281–2282
- Rosen MJ, Jin J, McGee MF, Williams C, Marks J, Ponsky JL. Laparoscopic component separation in the single-stage treatment of infected abdominal wall prosthetic removal. *Hernia* 2007;11(05):435–440
- Blatnik JA, Krpata DM, Novitsky YW. Transversus abdominis release as an alternative component separation technique for ventral hernia repair. *JAMA Surg* 2016;151(04):383–384
- Winder JS, Behar BJ, Juza RM, Potochny J, Pauli EM. Transversus abdominis release for abdominal wall reconstruction: early experience with a novel technique. *J Am Coll Surg* 2016;223(02):271–278
- Cobb WS, Warren JA, Ewing JA, Burnikel A, Merchant M, Carbonell AM. Open retromuscular mesh repair of complex incisional hernia: predictors of wound events and recurrence. *J Am Coll Surg* 2015;220(04):606–613
- Petro CC, Posielski NM, Raigani S, Criss CN, Orenstein SB, Novitsky YW. Risk factors for wound morbidity after open retromuscular (sublay) hernia repair. *Surgery* 2015;158(06):1658–1668
- Fischer JP, Basta MN, Mirzabeigi MN, et al. A risk model and cost analysis of incisional hernia after elective, abdominal surgery based upon 12,373 cases: the case for targeted prophylactic intervention. *Ann Surg* 2016;263(05):1010–1017
- Krpata DM, Blatnik JA, Novitsky YW, Rosen MJ. Evaluation of high-risk, comorbid patients undergoing open ventral hernia repair with synthetic mesh. *Surgery* 2013;153(01):120–125
- Timmermans L, de Goede B, van Dijk SM, Kleinrensink GJ, Jeekel J, Lange JF. Meta-analysis of sublay versus onlay mesh repair in incisional hernia surgery. *Am J Surg* 2014;207(06):980–988
- Usher FC, Ochsner J, Tuttle LL Jr. Use of Marlex mesh in the repair of incisional hernias. *Am Surg* 1958;24(12):969–974
- Baylón K, Rodríguez-Camarillo P, Elías-Zúñiga A, Díaz-Elizondo JA, Gilkerson R, Lozano K. Past, Present and Future of Surgical Meshes: A Review. *Membranes (Basel)* 2017;7(03):7
- Brown CN, Finch JG. Which mesh for hernia repair? *Ann R Coll Surg Engl* 2010;92(04):272–278
- Bilsel Y, Abci I. The search for ideal hernia repair; mesh materials and types. *Int J Surg* 2012;10(06):317–321
- Pandit AS, Henry JA. Design of surgical meshes: an engineering perspective. *Technol Health Care* 2004;12(01):51–65
- Li J, Ji Z, Zhang W, Li L. The comparison of lightweight mesh and standard mesh in incisional hernia repair with the open sublay technique: the results of a meta-analysis. *Surg Laparosc Endosc Percutan Tech* 2015;25(03):238–244
- Iqbal CW, Pham TH, Joseph A, Mai J, Thompson GB, Sarr MG. Long-term outcome of 254 complex incisional hernia repairs using the modified Rives-Stoppa technique. *World J Surg* 2007;31(12):2398–2404
- Oprea V, Matei O, Leucă D, et al. Late results and quality of life after Rives-Stoppa repair for incisional hernias: a prospective clinical study. *Chirurgia (Bucur)* 2013;108(05):679–683
- Fayezizadeh M, Majumder A, Belyansky I, Novitsky YW. Outcomes of retromuscular porcine biologic mesh repairs using transversus abdominis release reconstruction. *J Am Coll Surg* 2016;223(03):461–468

- 38 Fischer JP, Basta MN, Krishnan NM, Wink JD, Kovach SJ. A cost-utility assessment of mesh selection in clean-contaminated ventral hernia repair. *Plast Reconstr Surg* 2016;137(02):647–659
- 39 Rosen MJ, Bauer JJ, Harmaty M, et al. Multicenter, prospective, longitudinal study of the recurrence, surgical site infection, and quality of life after contaminated ventral hernia repair using biosynthetic absorbable mesh: the COBRA study. *Ann Surg* 2017;265(01):205–211
- 40 Alizai PH, Andert A, Lelaona E, Neumann UP, Klink CD, Jansen M. Impact of obesity on postoperative complications after laparoscopic and open incisional hernia repair: a prospective cohort study. *Int J Surg* 2017;48:220–224
- 41 Itatsu K, Yokoyama Y, Sugawara G, et al. Incidence of and risk factors for incisional hernia after abdominal surgery. *Br J Surg* 2014;101(11):1439–1447
- 42 Holihan JL, Alawadi ZM, Harris JW, et al. Ventral hernia: patient selection, treatment, and management. *Curr Probl Surg* 2016;53(07):307–354
- 43 Schroeder AD, Debus ES, Schroeder M, Reinbold WM. Laparoscopic transperitoneal sublay mesh repair: a new technique for the cure of ventral and incisional hernias. *Surg Endosc* 2013;27(02):648–654
- 44 Rogmark P, Petersson U, Bringman S, et al. Short-term outcomes for open and laparoscopic midline incisional hernia repair: a randomized multicenter controlled trial: the ProLOVE (prospective randomized trial on open versus laparoscopic operation of ventral eventrations) trial. *Ann Surg* 2013;258(01):37–45
- 45 Tandon A, Pathak S, Lyons NJ, Nunes QM, Daniels IR, Smart NJ. Meta-analysis of closure of the fascial defect during laparoscopic incisional and ventral hernia repair. *Br J Surg* 2016;103(12):1598–1607
- 46 Carbonell AM, Warren JA, Prabhu AS, et al. Reducing length of stay using a robotic-assisted approach for retromuscular ventral hernia repair: a comparative analysis from the Americas hernia society quality collaborative. *Ann Surg* 2018;267(02):210–217
- 47 Weltz AS, Sibia US, Zahiri HR, Schoeneborn A, Park A, Belyansky I. Operative outcomes after open abdominal wall reconstruction with retromuscular mesh fixation using fibrin glue versus trans-fascial sutures. *Am Surg* 2017;83(09):937–942
- 48 Verhelst J, de Goede B, Kleinrensink GJ, Jeekel J, Lange JF, van Eeghem KH. Open incisional hernia repair with a self-gripping retromuscular Parietex mesh: a retrospective cohort study. *Int J Surg* 2015;13:184–188