



TAPP vs. TEP vs. rTAPP: What Does the Evidence Show?

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Alexandra Argiroff and Diego Camacho

Introduction

For a growing number of hernia surgeons, laparoscopic inguinal hernia repair is the go-to operation, even for primary unilateral hernias. It has similar recurrence and complication rates as the open repair [1] and less postoperative pain with faster recovery time [2]. So how do you choose the appropriate minimally invasive technique?

Laparoscopic surgery for repair of inguinal hernias with mesh has been used for over 25 years, since it was first described in 1991 by Shultz [3]. The technique originally trialed was the transabdominal preperitoneal approach or TAPP. Two years later, a second and currently commonly used technique was described by McKernan—the totally extraperitoneal (TEP) approach [4]. There is a plethora of evidence describing the two operations and comparing the laparoscopic inguinal hernia repair to the traditional open repair with mesh. The two surgical techniques, appropriate use, complications, and comparison of laparoscopic to open inguinal hernia repair are discussed in previous chapters in this book.

The newest minimally invasive technique, or the robotic transabdominal preperitoneal (rTAPP) inguinal hernia repair, also has a growing volume of data in the literature, albeit preliminary and descriptive in most cases. The rTAPP is discussed in a previous chapter as well.

Once the surgeon and patient have decided to proceed with a minimally invasive surgery to repair his or her inguinal hernia, which method is the best? Is there a clear front-runner? Or is one technique better in a particular patient or clinical scenario?

A. Argiroff (✉) · D. Camacho
Department of Surgery, Minimally Invasive and Laparoscopic General Surgery,
Montefiore Medical Center, Bronx, NY, USA
e-mail: dicamach@montefiore.org

The aim of this chapter is to look at the current data and evidence available comparing the TEP and TAPP techniques for inguinal hernia repair with mesh, as well as a comparison of the laparoscopic repairs to the rTAPP.

While there are several studies, including randomized controlled trials and meta-analyses, comparing open and laparoscopic inguinal hernia repairs, there is less data directly comparing the two laparoscopic techniques. There are even fewer studies comparing laparoscopy to the newer rTAPP. In addition to landmark papers, the most current published data will be discussed in this chapter to see what evidence is available to help choose the right minimally invasive technique for both the surgeon and patient.

TEP vs. TAPP

What Type of Evidence Is Currently Available?

First, we will present what evidence is currently published, along with overall results from those articles. Then each end point will be examined separately with data in support of TEP or TAPP.

While not numerous, there are several head-to-head studies between TEP and TAPP in the literature, with significantly more articles published in the last 10 years. The 2005 Cochrane review comparing TAPP to TEP identified one prospective randomized controlled trial (RCT) and eight comparative studies [5]. In 1996, Schrenk et al. compared TEP, TAPP, and Shouldice technique among 86 randomized patients [6]. They found less immediate postoperative pain in the TAPP group when compared to TEP; however, there were similar operation times, complications, and return to work. There was one recurrence in the TAPP group, but it was not statistically significant ($p = 0.6$). This study had low power with only 24 patients in the TEP and 28 patients in the TAPP group.

Many of the articles included in the 2005 Cochrane review occurred during the learning curve for laparoscopic hernia repair [5]. There has been a burst of new studies published since then. In fact, a 2013 meta-analysis of RCTs comparing TEP and TAPP [7] found seven total RCTs [6, 8–13] for 516 patients and 538 hernia defects to analyze. An eighth RCT was published just after the meta-analysis in the same year [14]. In the 2013 meta-analysis, Antoniou et al. found shorter recovery time but higher operative morbidity for the TEP group.

The meta-analysis also observed a high rate of morbidity in general for both laparoscopic procedures (11.9% for TEP, 24.8% for TAPP), which the authors mostly attributed to two of the seven trials. Pokorny et al. included postoperative use of analgesics as a morbidity, and when this was removed, the operative morbidity decreased drastically to a more commonly accepted rate. Dedemadi et al. also found a high rate of operative morbidity, but this study exclusively looked at repair of recurrent hernias, which carries higher risks of morbidity [15].

However, only one of the studies strictly compared TEP to TAPP [13], while the rest compared laparoscopic to open and included a subanalysis of the two

laparoscopic groups [6, 8–12]. Many of the articles had significant weaknesses, and only three of the seven trials had a Jadad score of 3–4 [7]. Overall, there were no long-term differences between TEP and TAPP. The authors concluded the current data was insufficient to recommend one over the other, and the decision should depend on the expertise of the surgeon. More rigorous randomized studies are needed to make a more definitive conclusion [7].

Two of the more recent prospective randomized trials include a much larger number of patients than the 52 patients in the 1996 Schrenk trial. In 2011, Krishna et al. published data from their one medical center from the first 100 randomized patients and compared intraoperative data, postoperative complications, pain, and recurrence during an average follow-up period of 29.5 months [13]. They found a statistically significantly lower pain score for the TEP group when compared with the TAPP group, which likely correlated with the higher satisfaction scores for the TEP group. They found no other major differences, and there were no major complications or recurrences in either cohort.

In a follow-up study in 2013, Bansal et al. evaluated data from those first 100 patients plus 3 more years of surgeries, for a total of 314 patients randomized to TEP ($n = 160$) and TAPP ($n = 154$) [14]. In addition to the primary end points from the first study, they also looked at long-term outcomes, such as chronic groin pain and quality of life. Like the first 100 patients, this study showed increased postoperative pain for the TAPP group. There were also similar rates of chronic groin pain and comparable long-term quality of life at 3 months postoperative [14].

In addition to the RCTs and the meta-analysis, there have been several comparative studies and population-based analyses published since the 2005 Cochrane review. This includes two from the Swiss Registry [16, 17] and two from the Herniated database [15, 18], each with a large number of patients.

There is conflicting data among all of the studies, so we will look at each end point separately and evaluate the most current evidence. We will focus on evidence from the 2013 meta-analysis above and the most recent RCTs comparing TEP to TAPP for primary hernia. We also look at results from the prospectively collected data of patients who underwent laparoscopic inguinal hernia repair in the Herniated Registry (17,587 patients) and Swiss Association of Laparoscopic and Thoracoscopic Surgery (4552 patients) [17, 19].

Complications

In the early experience with laparoscopic techniques for inguinal hernia repair, TAPP had higher rates of more severe complications, including visceral injury, vascular injury, and postoperative hernia [20]. However, that was during the beginning of the learning curve for laparoscopic inguinal hernia repairs. In the last 10 years, severe complications are now rarely reported for either technique.

For minor postoperative complications, the results are mixed. The 2013 meta-analysis found higher rates of operative complications with TEP [7], but the individual complications were not delineated in the article. Likewise, the data from the

Bansal et al. RCT and Swiss Registry population-based data reported by Gass et al. observed increased rates of short-term complications with TEP [14, 17]. In both studies, seroma was the most common complication associated with TEP.

Conversely, Köckerling et al. reported increased rates of complications for TAPP from the Herniated Registry. Again, seroma was the most common complication by far [19]. This data corroborated similar findings from the 2005 Cochrane review that also found statistically significantly higher rates of complications with TAPP [5].

Of the more current articles, only Gass et al. make the recommendation for TAPP over TEP secondary to complication rate. As the majority of the complications reported are seromas treated conservatively, many of the authors continue to recommend that the surgeon choose the operation he or she has the most experience with.

Operative Time

The varied operative time from each study reflects the different training, experience, and comfort level of individual surgeons and centers with TEP and TAPP. For example, the Butler et al. trial observed significantly increased operating time with TEP [9], while the more recent Bansal et al. trial reported longer times for TAPP [14].

Again, the Herniated and Swiss registries found opposite results, with the former reporting longer operating times for TAPP [19] and the latter for TEP [17]. No statistically significant difference was found between the two groups in the meta-analysis [7].

Postoperative Pain

It is widely accepted now that laparoscopic surgery has reduced early postoperative pain compared to open repair [21–24]. Is there an advantage to one laparoscopic technique over the other in regard to short-term pain? Krishna et al. found reduced acute pain the TEP group, which correlated with increased patient satisfaction scores [13]. The follow-up study by Bansal et al. confirmed that finding with a larger powered RCT [14]. The authors attributed the increased pain for the TAPP group to closure of the umbilical port fascia.

Other studies either did not report immediate postoperative pain or found the pain scores to be equivalent between TEP and TAPP [7].

Chronic Groin Pain

There are few well-structured studies on long-term outcomes comparing the two laparoscopic inguinal hernia repairs. Bansal et al. reported equal rates of chronic groin pain for TEP and TAPP with a median follow-up time of 36.5 months

(range, 3–60 months; 90.4% follow-up rate at 12 months, 23% at 4 years) [14]. Although the average follow-up time in the meta-analysis varied widely (3 months to 3 years), they also did not find a statistically significant difference [7].

Recurrence

The great “best groin hernia repair” debate ultimately is looking for the lowest risk of recurrence. The landmark “VA study” in 2004 by Neumayer et al. showed a significantly higher recurrence rate after laparoscopic repair (10.1%) versus open repair (4.9%) with an odds ratio of 2.2 [25]. This study was largely criticized for the wide range of experience of the surgeons correlating to vastly different complication and recurrence rates within the study. Systematic review and several meta-analyses have since deposed that conclusion, and in skilled hands, there is no difference in recurrence rates between open and laparoscopic repair (McCormack 2003; McCormack NICE 2004) [1].

Likewise, after the 1990s, there is no data showing a significant difference in recurrence rates between TEP and TAPP, although there is a trend for more recurrence in TAPP repairs. In RCTs, Bansal et al. reported one recurrence in the TAPP group [14], and Butler et al. reported two recurrences in the laparoscopic arm but did not specify whether they were from the TEP or TAPP repairs [9]. Interestingly, the Herniated and Swiss registries did not report recurrences as an end point in their articles on primary hernia repair [17, 19].

Quality of Life

Only one RCT attempted to compare long-term follow-up with laparoscopic inguinal hernia patients using quality of life as a primary end point. Using the quality of life assessment proforma (SF-36), Bansal et al. evaluated 214 of the 314 randomized patients immediately preoperatively and at 3 months postoperatively. While they found an improvement in quality of life before and after surgery (with regard to mental health, social functions, physical functions, etc.), there was no statistically significant difference between TEP and TAPP [14].

Cost

The setup in the operating room for TEP and TAPP is similar with regard to consumable operating room supplies. In their trial, Butler et al. found a slightly higher cost for TEP compared to TAPP. Their technique for TEP used a balloon dissector, which at that time cost \$125 and was the reason for the slightly higher cost [9]. On the other hand, Bansal et al. did not use a balloon dissector to create a preperitoneal space, and cost was the same for both groups in that trial [14]. Overall, the Antoniou et al. meta-analysis also showed equivalent costs, although operative technique differed among the RCTs [7].

TEP vs. TAPP for Recurrent Hernia

Recurrent inguinal hernias account for 10–15% inguinal hernia surgeries [25]. Laparoscopic repair for recurrent inguinal hernias is the go-to operation for repairing a recurrence from an open repair. Studies, including a meta-analysis in 2013, actually showed improved results—lower incidence of wound infection and shorter sick leave for patients—with laparoscopic technique for recurrences [26]. It even observed no difference in other complication rates or operation time between open and laparoscopic surgery. It did not differentiate between TEP and TAPP.

Most papers comparing TEP and TAPP looked exclusively at primary inguinal hernias, and recurrent hernias were excluded from the studies. However, three recent articles looked at TEP versus TAPP for recurrent hernias alone. One RCT published in 2006 by Dedemadi et al. randomized patients to TAPP ($n = 24$), TEP ($n = 26$), or Lichtenstein ($n = 32$) repair and confirmed the advantages of a laparoscopic approach [8]. While the analysis of the data compares each laparoscopic repair to the open group, and not TEP to TAPP directly, the comparison can be extrapolated, and there was no statistically significant difference in operative time, acute pain, recovery time, complications, or recurrence.

In population-based data, the Swiss Registry reported that although there was significantly higher intraoperative complication rate and operative time for TEP, the postoperative complications and conversion rates to open surgery were similar to TAPP [16]. There was no long-term follow-up in this group, so late recurrence or complication rates are unknown, and the authors did not recommend one operation over the other for repair of recurrent groin hernia.

The Herniated database evaluated laparoscopic repair of recurrent inguinal hernias in 2246 patients. TAPP was associated with increased rate of postoperative seroma (odds ratio 3.1), but that did not mean a higher rate of reoperation [18]. Overall, there was no major difference between the two methods.

Robotic Transabdominal Preperitoneal (rTAPP) vs. TAPP

Although there are descriptions of robot-assisted TEP for inguinal hernia repair [27], the vast majority of robotic inguinal hernia repairs are done in a TAPP fashion. The description and outcomes for rTAPP are discussed in another chapter. Furthermore, the use of the robot for concurrent inguinal hernia repair with other procedures (prostatectomy, etc.) and those outcomes has been described by several case series; however, that will also be discussed in another chapter.

However, there are currently only two case series in the literature that directly compare traditional laparoscopic hernia repair to rTAPP. Both series retrospectively examine a single surgeon's experience at his institution for consecutive laparoscopic and rTAPP procedures.

Just published in July 2017, Kudsi et al. compared a single surgeon's experience with laparoscopic TEP vs. rTAPP. A total of 118 patients underwent a hernia repair, and the operative time and complication rates were nearly identical in both

groups [28]. One factor to consider is that robotic teams may differ in their efficiency, and surgeon's experiences may vary considerably. Nevertheless, many hernia surgeons primarily perform TEP, so data from this comparison is important. And although it is the largest series examining data from a surgeon's transition from TEP to rTAPP, they are two different operations. A more appropriate way to compare laparoscopy with robot-assisted inguinal hernia repair would be to look at TAPP vs. rTAPP.

Published in the *Journal of Robotic Surgery* in 2016, Herman et al. looked at 63 consecutive patients who underwent a laparoscopic TAPP ($n = 24$) or rTAPP ($n = 39$) [29] between 2012 and 2014. They showed longer operative time (77.5 vs. 60.7 min, $p = 0.001$), and room time was longer for the rTAPP group. Pain scores (2.5 vs. 3.8) and recovery room time were significantly less for the robotic group.

They also compared operative cost, looking at direct cost (disposables), net revenue, and contribution margin (facility net revenue minus direct costs). Direct cost and contribution margin were less for the laparoscopic TAPP; however, the authors did not find the difference significant enough to recommend one over the other without further investigation [29]. Capital costs, including the robotic system and laparoscopic towers, were not included in the cost analysis. This is a major flaw in the study as a single robotic platform can cost up to 2.5 million dollars, not including annual maintenance fees. As more robotic platforms come to market, this will likely decrease. Furthermore, the cost per case is difficult to determine based on a onetime purchase and depends on the case volume at that center.

Overall, there is a dearth of evidence in looking at rTAPP vs. laparoscopic hernia repair, and future research is needed to make a recommendation.

Conclusion

While a lot of data and results were presented in this chapter, much of it is conflicting when comparing TEP to TAPP. There is no strong or reproduced evidence looking at laparoscopic inguinal hernia repair versus rTAPP. All three operations are safe and feasible, and one may have more utility than another in a particular situation. For instance, with a larger, more difficult to reduce inguinal hernia, the TAPP adds the ability to examine the peritoneal contents. If a robot-assisted ventral hernia repair is being performed at the same time, it is safe and reasonable to repair an inguinal hernia at the same time with rTAPP. Ultimately, it still remains a case-by-case basis, and the most important factor with outcomes is surgeon comfort with an operation.

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