Comparative Prospective Study of Ventral Hernia Repair: Laparoscopic Versus Open Technique

Authors
Maurya RK1, Singh RK2, Mishra KB3, K. Vishal4, Ziauddin4
1,2,3Professor, 4Resident
Department of General Surgery, GSVM Medical College Kanpur, Uttar Pradesh India

Abstract
Background: Repair of ventral hernia has changed dramatically over past decades with introduction of laparoscopy. The objective of this study is to compare outcome of patients after laparoscopic and open hernia repair in terms of duration of surgery, postoperative pain, hospital stay, return to normal activities, and recurrence of hernia.

Methods: This was a prospective observational comparative study in GSVM Medical college Kanpur. Total no of patient were 60, out of 60, 30 patients were operated by laparoscopic and 30 patients by open method.

Results: The mean age for laparoscopic repair group was 36.53 years and for open group was 46.76 with p value >0.05. Laparoscopic hernia repair requires mean duration of surgery 94.2 min and open hernia repairs requires 80.83 with p value <0.05. Post operative pain, hospital stay and return to normal activities were significantly low in laparoscopic group as compared to open group. There were fewer complications in laparoscopy group.

Conclusions: The findings of our study shows that laparoscopic repair requires longer duration of surgery, shorter hospital stays, lesser analgesia, fewer complications, and early return to normal activities. Hence it can be considered as the procedure of choice for ventral hernia repair.

Keywords: Ventral hernia, open ventral hernia repair, laparoscopic ventral hernia repair.

Introduction
Ventral hernia is defined by a protrusion through the anterior abdominal wall fascia. These defects can be categorized as spontaneous (primary) or acquired or by their location on the abdominal wall. Epigastric hernias occur from the xiphoid process to the umbilicus, umbilical hernias occur at the umbilicus, and hypogastric hernias are rare spontaneous hernias that occur below the umbilicus in the midline. Acquired hernias typically occur after surgical incisions and are therefore termed incisional hernias.1 Prospective studies have reported an incidence of between 7.4 and 11%.2 Surgical repair can be done by open and laparoscopic method. Almost 50% of incisional hernias develop within the first 2 years after the primary surgery, and 74% develop after 3 years.3 The recurrence rate of incisional hernia with primary suture repair is approx 50% and has been reduced upto 10- 23% after the introduction of prosthetic material in hernia repair.4 To reduce recurrence rate of open mesh repair of incisional hernia, leblanc in 1993 introduce laparoscopic incisional hernia repair using a synthetic mesh.5
In this modern era of surgery patient wants less hospital stay with best cosmesis hence laparoscopic surgery has gained paramount importance due to its minimally invasive technique.

**Objectives of Study**
1. To study “duration of surgery” between laparoscopic and open ventral hernia repair.
2. To study “postoperative pain” after laparoscopic and open ventral hernia repair.
3. To study “post operative hospital stay” after laparoscopic and open ventral hernia repair.
4. To study “return to normal activites” after laparoscopic and open ventral hernia repair.
5. To study “recurrence of ventral hernia” after laparoscopic and open ventral hernia repair.

**Materials and Methods**

**Study Design:** Prospective non randomized study.

**Source and method of Collection of Data**
Patients admitted with ventral hernia during January 2017 to October 2018 at G.S.V.M Medical College & L.L.R and associated hospitals, Kanpur are taken up for study with the help of relevant history, clinical examination and appropriate investigations.

**Inclusion Criteria**
1. Patients admitted in the departments of general surgery and diagnosed to have ventral hernia between 18 to 60 yrs age.
2. Patients who would be informed about the study, would have read understood and signed the patient informed consent and would be willing to submit postoperative follow up and evaluations.

**Exclusion Criteria**
1. BMI more than 30kg/m2.
2. Large hernia defects size more than 10cm.
3. Recurrent incisional hernia (Previous mesh plasty).
4. Patient having tubercular abdomen, abdominal malignancy, ascites, medical and surgical contra indication to general anaesthesia.
5. Patients having inguinal, femoral, obturator, parastomal, and lumbar hernia are not included in study.

**Methodology**
All patients were evaluated by obtaining proper history and detailed physical examination and routine investigations. All patients received antibiotic prophylaxis just before surgery.

**Procedure for open surgery**
Almost all the patients were operated under spinal anaesthesia. Foley’s catheterization and nasogastric tube were occasionally used. Patients were placed in supine position. Skin incision was made according to the site and size of the defect and type of hernia. The hernia sac was dissected out and reduced and the defect assessed. When there were adhesions, sac was opened and contents were reduced. In onlay repair, polypropylene mesh is sutured over the anterior rectus sheath. The mesh is fixed at its four corners with non absorbable sutures. Suction drain was placed in few cases based on the surgeon’s choice. Skin and subcutaneous tissue closed in layers.

**Procedure for laparoscopic surgery**
All the patients were operated under general anaesthesia. Nasogastric tube was placed for upper abdominal hernia and a Foley’s catheter for lower abdominal hernias. Both are removed after the procedure on the operating table. Patient position: Patient is in supine position without any tilt. Position of surgical team: The operating surgeon stands to the left of the patient with the camera man on his right or left depending on the location of hernia.
Operative technique: Pneumoperitoneum established by verres needle in palmer’s point, 2 to 3cm below the left costal margin in the midclavicular line. A 10 mm camera port is place at this point and the intraabdominal pressure is maintained at 12 mm Hg. Two additional 5mm ports are placed depending on the type of hernia under direct vision. Adhesiolysis was done using sharp dissection or monopolar diathermy.

Mesh is unfolded so that polyester side facing abdominal wall and blue side coated with polyurethane facing abdominal viscera mesh was fixed transfacially at corner with suture (polypropylene 1-0) provided along with mesh with help of spinal or cobbler needle absorbable tackers also used to fix mesh all around and corner. At the completion of the procedure, the ports are withdrawn under vision. 10 mm port is closed with 2-0 polyglactin. Skin closed with ethilon 3-0. A compression dressing is placed in the area of defect to reduce the incidence of post operativeseroma.

Mesh used: In open we used polypropylene mesh and in laparoscopy we used dual or composite mesh.

All patients were followed postoperatively 1st 2nd week and 3rd 6th and 12th months for any complications. Postoperative pain was compared using visual analog score (VAS). In VAS 0 signifies worst pain and 10 signifies no pain at all.

Statistical analysis: chi-square or fischer’s exact test has been used for categorical variables and T test for continuous variables. A P-value <0.05 taken as significant. SPSS version20 was used for statistical analysis.

Results
The study consist of 30 patients undergone open ventral hernia repair (ovhr) and 30 patients undergone laparoscopic ventral hernia repair (lvhr).

Age Distribution of Patients Studied
Table – 1

| Age in years | Open group | Laparoscopic group |
|--------------|------------|--------------------|
|              | Number (n) | Percentage (%)     | Number (n) | Percentage (%) |
| 21 – 30      | 2          | 6.6                | 5          | 16.6          |
| 31 – 40      | 7          | 23.3               | 15         | 50            |
| 41 – 50      | 11         | 36.1               | 9          | 30            |
| 51 – 60      | 9          | 30                 | 1          | 3.4           |

Mean age 46.76 36.53
SD 8.57 6.45

P = >0.05 (statistically not significant)

The maximum number of patients in open group i.e.20 (66.1%) are in the age group of (41-60) while in the laparoscopy group there are in the age group of 31-50 i.e.24 (80%). The mean age of the patients in open group is 46.76 years whereas in laparoscopy group it is 36.83 years.
Gender Distribution

Table 2

| Gender | Open group | Laparoscopic group |
|--------|------------|--------------------|
|        | Number     | Percentage         | Number   | Percentage |
| Male   | 17         | 56.6               | 12       | 40         |
| Female | 13         | 43.4               | 18       | 60         |
| Total  | 30         | 100                | 30       | 100        |

P = 0.098 (statistically not significant)

Out of the 30 patients in open group 17 (56.6%) are male while 13 (43.4%) are females whereas in laparoscopy group. Out of 30 patients 12 (40%) are male while 18 (60%) are females.

Distribution of Duration of Surgery

Table 3

| Duration of surgery (mins) | Open group | Laparoscopic group |
|----------------------------|------------|--------------------|
|                            | Number     | Percentage         | Number   | Percentage |
| 61-80                      | 16         | 53.4               | 3        | 10.0       |
| 81-100                     | 14         | 46.6               | 17       | 56.6       |
| >120                       | 0          | 0                  | 9        | 30         |
|                            | 0          | 0                  | 1        | 3.4        |
| Mean                       | 80.83min   | 94.2min            |

P = 0.001 (statistically significant)

In open group, most of the surgeries i.e. 16 (53.4%) patients the duration of surgery was 61-80 minutes, while in laparoscopic group 17 (56.6%) patients the duration of surgery was 81–100 minutes. The mean duration of surgery in open group is 80.83 minutes while in laparoscopic group it is 94.2 minutes.

Distribution of Post Operative Pain

P = <0.01 (statistically significant)

In open group 25(83.34%) patients the postoperative pain evaluated by visual analog score lasted for 4-10 days, while in laparoscopy group 27(90%) patients it was for 1–4 days. The mean duration of pain was 5.66 days in open group while it is 3.23 days in laparoscopy group.
Distribution of Vas for pain at 1st 3rd and 3rd Month

Table 3

| Variables          | Mean | P value |
|--------------------|------|---------|
| VAS score at day 1 | 4.56 | 5.56    | <0.05 |
| VAS score at day 3 | 6    | 8.1     | <0.05 |
| VAS score at 3 mo  | 8    | 9       | <0.05 |

p(<.05) value is significant for VAS at day 1, 3, 3rd month.

Distribution of Post Operative Complications

Z=5.30, p=<0.05(statistical significant)

Postoperative seroma was seen in 15 (50%) patients in open group, while it was present in 5 (16.6%) in laparoscopy group. All patients in laparoscopy group, the seroma reduced with conservative management in less than 10 days. In the open group, in 13 patients the seroma was managed conservatively, while in 2 patients, aspiration was done. Superficial wound infections was seen in 4 (19.5%) patients in open group, while it was present in 1 (3.3%) in laparoscopy group. Superficial infections in both group were managed conservatively by dressing and antibiotics. 1 (3.3%) patient had mesh infection, requiring daily debridement and in hospital treatment for around 20 days. 2 (6.6%) patients had superficial necrosis of flap margins treated by minor debridement and daily dressing. With a P value of <0.05 laparoscopic ventral hernia repair was much better in terms of complications.
Distribution of Lenth of Hospital Stay

P value =<0.05 (Statistically significant)

In open group, length of hospital stay for most of the patients i.e. 25(83.4%) was 5-9 days, while in laparoscopy group most of the patients i.e. 26 (86.6%) was for less than 5 days.

Distribution of Return to Normal Activity

Table 4

| Return to normal activity (days) | Open group | Laparoscopic group |
|---------------------------------|------------|--------------------|
|                                 | Number (n) | Percentage (%)     | Number (n) | Percentage |
| 1 – 5                           | 1          | 3.3                | 23         | 76.6       |
| 6 – 10                          | 26         | 86.7               | 6          | 20         |
| >10                             | 3          | 10                 | 1          | 3.4        |
| Total                           | 30         | 100                | 30         | 100        |

P value =<0.05 (statistically significant)

In open group, majority of the patients i.e. 26 (86.7%) patients took 6- 10 days to return to their normal activity, while in laparoscopy group almost all the patients i.e. 29 (96.6%) took less than 10 days for the same. In open group mean time for return to normal activity is 9.43 days while in laparoscopic it is 5.26 days.

Distribution of follow up after Surgery

Table 5

| Follow up months | Open group | Laparoscopic group |
|------------------|------------|--------------------|
|                  | Number (n) | Percentage (%)     | Number (n) | Percentage |
| 1 – 10           | 10         | 33.4               | 14         | 46.6       |
| 11 – 20          | 20         | 66.6               | 16         | 53.4       |
| Total            | 30         | 100                | 30         | 100        |
| Mean             | 11.33 months | 11.03 months      |

P value =>=0.05 (statistically not significant)

The mean follow up in open group is 11.33 months, while in laparoscopy group is 11.03 months.
Distribution of Intraoperative Complications

Table 6

| Complication      | Open group | Laparoscopic group |
|-------------------|------------|-------------------|
|                   | Number (n) | Percentage (%)    | Number (n) | Percentage (%) |
| Bowel injury      | 1          | 3.3               | 0          | 0              |
| Bleeding          | 0          | 0                 | 1          | 3.3            |

In open group 1(3.3%) patient had bowel injury. There was no spillage and hence a mesh was placed.

In laparoscopy group 1(3.3%) had an accidental injury to inferior epigastric artery was controlled by a transfascial suture. Drain was placed which was removed on postoperative day 3.

Discussion

The present study includes a total of 60 patients, 30 in the open group and 30 in the laparoscopy group. In one of the largest studies conducted by Carbajo et al\(^6\) there were a total of 60 patients, 30 in open group and 30 in laparoscopy group. In one of the recent RCT conducted by Itani et al\(^7\) in 2010, a total of 146 patients are randomized such that 73 patients underwent conventional repair and 73 underwent laparoscopic repair.

In the present study, the mean age is comparable between the two groups: 46.76 yrs. in open group and 36.53 yrs. in laparoscopy group. In the study conducted by Misra et al\(^8\) in 2006 the mean age of the patients in open group is 45.2 yrs. and laparoscopy group is 45.96 yrs. In the study conducted by Barbaros et al\(^9\)the mean age in laparoscopy group was 50.7 yrs. and in open group was 54.1 yrs.

In the present study of ventral hernia consisting of epigastric, umbilical, para umbilical and incisional hernias, majority of the patients in open group had incisional hernia (43.4%) while in laparoscopy group majority were umbilical hernia (46.7%).

In our study, male to female ratio was 1:1.03 which is comparable to studies by Goel et al\(^10\) (1981) reported male to female ratio as 1:1.25, and Shukla et al\(^11\) (1998) reported ratio 1:9.19,20

Higher incidence in female population is explained as the gynecologic surgeries are the leading cause of incisional hernia.
In the present study most of the patients were males in open (56.6%) whereas in laparoscopy group most were females (60%). In the study conducted by Itanii et al7 majority were men in both open (91.8%) and laparoscopy (91.8%) groups. In the study conducted by Misra et al8 about 80% were females in both the groups.

In the present study, majority of patients i.e. 15(50%) had defect size less than 3x3 cms. in open group whereas in laparoscopy group 18(60%) patients had defect size less than 3x3 cms. In the study conducted by Rogmark et al12 the mean defect size was 25cm2 in open group and 36cm2 in laparoscopy group. In the study conducted by Navarro et al13 mean defect size was 45.2cm2 and 37.2cm2.

The operating time is one of the detrimental factors in the assessment of the effectiveness of the procedure. In the present study, the mean operating time was 80.83mins in open group and 94.2mins in laparoscopy group. The above values (P = <0.05) are significant statistically.

In the study conducted by Asencio et al14 and Eker et al15 reported lesser operating times in open group. In the studies conducted by Olmi et al16 and Carbajo et al6, showed significant reduced time in laparoscopic surgery when compared to conventional surgery.

Laparoscopic approach carries the risk of intestinal or bladder injury intraoperatively. In the present study 2 events of intra operative complications have occurred. One bowel injury are reported in open group and the one intra operative complication that occurred in the laparoscopy group is the bleeding from the inferior epigastric artery, which was controlled by transfascial sutures. Studies showed variable rates of bowel injuries like Rogmark et al12, with 4.6% for laparoscopic group versus 1.4 for open group; Barbaros et al9, with 4.3% for laparoscopic group and no bowel injury in open group; and Itani et al7, with 4.1% for laparoscopic group and no bowel injury in open group.

In the present study, the mean duration of postoperative pain in open group is 5.66 days, while in laparoscopy group is 3.23 days, P <0.05, which is statistically significant.

This goes with the study of Navarra et al13 with significant difference in postoperative pain between laparoscopic and open groups, as mean analgesic requirement was 1.4 for laparoscopic group versus 4.9 for open group. However, in Eker et al15 at the 4-week follow-up, 25% of the laparoscopic group and 24% of the open group reported persisting pain, requiring prolonged analgesia use.

One of the main advantages of laparoscopic repair is the decreased wound related complications. Almost all the RCTs except Asencio et al14 in 2009 reported decreased wound related complications with laparoscopic repair. Amongst all, the most common complications are seroma formation and superficial wound infection. Seroma rates are higher in open group in the studies conducted by Asencio et al14 Misra et al8 and Pring et al17, while Itani et al7 in 2010 reported lower seroma rates in laparoscopy group. Wound infection rates are higher in open group in all the studies. Heniford BT et al18 concluded from his study that wound infection is lower in laparoscopic hernia repair compared to open, as there is decreased extent of tissue dissection in the former. Similar results were seen in to Lomanto D et al19, Itani KM et al7, McGreevy JM et al20 that Laparoscopic repair had fewer postoperative complications than those receiving open mesh repair.

In the present study, the seroma rate is 50.0% in open group when compared to 16.6% in laparoscopy group. Itnai et al7 also reported lower seroma in laparoscopic group. The wound infection rate in open group is 13.4% in open group when compared to 3.3% in laparoscopy group (p <0.05), Heniford et al18 reported that wound infection is lower in laparoscopic hernia compared to open as there is less tissue dissection in lap group. Mesh infection is observed in 1 (3.3%) patients in open group and no patients in laparoscopy group. Mesh infection was controlled by conservative methods.
In the present study, the mean length of hospital stay was 7.20 days in open group compared to 3.46 days in laparoscopy group. The P-value is <0.05, which is statistically significant. In two RCTs conducted by Carbajo et al\(^6\)(lap 2.23 days) & (open 9.06 days) and Moreno egea et al\(^21\)(lap 1 day) & (open 5.2 days) showed significant difference between the two groups and favoured laparoscopy.

In present study return to normal activities in open group was 9.43 days and in laparoscopic group 5.26 days which is statistically significant (<0.05). Return to normal work (in days) was also earlier in laparoscopic repair (10.6) as compared to open mesh repair (14.75) and the difference was statistically significant (p=0.0002). Itani KM et al\(^7\) showed laparoscopic group had shorter postoperative duration for return to normal work (28.5 days) as compared to those who had open mesh repair (23.0 days). But Rosen MJ et al\(^22\) showed that there is no significant difference in return to regular work.

In our study recurrences of hernia was observed in none of our patients. It may be because of less number of patients and less follow up time. Rogmark et al\(^12\) study also does not show any recurrence. In other studies, Lomanto D et al\(^19\) rate of recurrence after laparoscopic repair was 2% as compared to open group (10%). In Itani KM et al\(^7\), overall recurrence at 2 years was 12.5% in lap group and 8.2% in open group. Eker et al\(^15\) shows a recurrence rate of 18.05% in lap group and 14% in open group.

### Comparison with other Studies

| Reference         | Patient(s) | Operating time (Min) | Length of hospital stay (days) | Infection % | Seroma | Follow up months | Recurrence |
|-------------------|------------|----------------------|-------------------------------|-------------|--------|-----------------|------------|
| Hoiziman et al    | Open 16    | Lap 20               | Open 98                      | Lap 128     | Open 6 | Lap 5           | Open 19    |
| Ramshaw et al     | Open 174   | Lap 79               | Open 82                      | Lap 58      | Open 2.8 | Lap 3           | Open 21    |
| Mishra et al      | Open 33    | Lap 33               | Open 75                      | Lap 86      | Open 1.47 | Lap 3.4         | Open 33    |
| Parket al         | Open 49    | Lap 56               | Open 78                      | Lap 95      | Open 6.5 | Lap 2            | Open 24    |
| Caribo et al      | Open 30    | Lap 112              | Open 87                      | Lap 91      | Open 9.1 | Lap 2.2         | Open 24    |
| Itani et al       | Open 73    | Lap 73               | -                            | -           | 4       | 3.9             | 24.6       |
| Present study     | Open 30    | Lap 80.83            | Open 94.2                    | Lap 7.2     | 3.46    | -               | 13.4       |

### Conclusion

Although the duration of surgery is an important issue, it depends on many factors like surgeon expertise, type of adhesions, size of defect. In our study duration of surgery in open repair is less than laparoscopic repair which is statistically significant.

In the present study we found that post perative pain was marginally less in laparoscopic group as compared to open group (mean VAS score on day 1 5.56 and 4.56 respectively).

Most of our patients in lap group were subjectively more comfortable in post op period and were ambulant on POD 1 day while in open group on 2nd POD.

In aspect of postoperative complications like seroma formation, wound infection, mesh postoperative duration for return to normal work (28.5 days) as compared to those who had open mesh repair (23.0 days). But Rosen MJ et al\(^22\) showed that there is no significant difference in return to regular work.

In our study recurrences of hernia was observed in none of our patients. It may be because of less number of patients and less follow up time. Rogmark et al\(^12\) study also does not show any recurrence. In other studies, Lomanto D et al\(^19\) rate of recurrence after laparoscopic repair was 2% as compared to open group (10%). In Itani KM et al\(^7\), overall recurrence at 2 years was 12.5% in lap group and 8.2% in open group. Eker et al\(^15\) shows a recurrence rate of 18.05% in lap group and 14% in open group.

Cost factor need to be addressed with respect to LVHR main contributor to cost of lap repair is use of dual mesh and use of disposable tacker to fix mesh in place. The minimal hospital stay and better post op satisfactory level in LVHR with respect to OVHR compensates the cost of tacker and dual mesh.

Nowadays, laparoscopic repair of ventral hernia is being accepted by most of surgeons and patients.
Almost all ventral hernia can be repaired by laparoscopy regardless of morbid obesity and age group.

Laparoscopic hernia repair is a complex but very efficient method in experienced hands. To achieve the best possible result it requires an acceptance of a learning curve. Laparoscopic ventral hernia repair has shown promising results and a clear advantage over open repair in regard with reduced postoperative pain, decreased postoperative complications, reduced length of hospital stay, and less time for return to normal activity. Hence, laparoscopic ventral hernia repair is a safe and feasible alternative to open repair.

**Declarations**

**Funding:** None

**Conflicts of interest:** None declared.

**Ethical approval:** The work has been approved by the institutional ethics committee, GSVM Medical college, Kanpur UP, India.

**Acknowledgements**

Author would like to thanks gsvm medical college Kanpur, UP, India

**References**

1. Mark A. Malangoni, Michael J. Rosen. Sabiston textbook of surgery, 19th edition. United States, Saunders;2012:1128-9.

2. Cassar K, Munro A. Surgical treatment of incisional hernia. Br J Surg. 2002;89:534-45.

3. Anthony T, Bergen PC, Kim LT, Henderson M, Fahey T, Rege RV, et al. Factors affecting recurrence following incisional herniorrhaphy. World J Surg. 2000;24:95–100.

4. Luijendijk R, Hop W, Van den Tol MP, de Lange DC, Braaksmia MM, IJzermans JN, et al. A comparison of suture repair with mesh repair for incisional hernia. N Eng J Med. 2000;343:392–8.

5. Leblanc KA, Booth WV. Laparoscopic repair of incisional abdominal hernias using polytetrafluoroethylene: preliminary findings. Surg Laparosc Endosc. 1993;3:39–41.

6. Carbajo MA, Martin del Olmo JC, Blanco JI et al (1999) Laparoscopic treatments open surgery in the solution of major incisionaland abdominal wall hernias with mesh. SurgEndosc13:250–252.

7. Itani KM, Hur K, Kim LT et al (2010) Comparison of laparoscopicand open repair with mesh for the treatment of ventralincisional hernia: a randomized trial. Arch Surg 145:322–328.

8. Misra MC, Bansal VK, Kulkarni MP et al (2006) Comparison oflaparoscopic and open repair of incisional and primary ventralhernia: results of a prospective randomized study. SurgEndosc20:1839–1845.

9. Barbaros U, Asoglu O, Seven R et al (2007) The comparison of laparoscopic and open ventral hernia repairs: a prospective randomized study. Hernia 11:51–56.

10. Goel TC, Dubey PC. Abdominal incisional hernia- anatomical technique of repair. Ind J Surg. 1981;43:324-7.

11. Shukla VK, Gupta A. Cardiff repair of incisional hernia : a university hospital experience. Eur J Surg. 1998;164:271-4.

12. Rogmark P, Petersson U, Bringman S et al (2013) Short-term outcomes for open and laparoscopic midline incisional herniarepair: a randomized multicenter controlled trial: the ProLOVE(prospective randomized trial on open versus laparoscopic operation of ventral events) trial. Ann Surg 258:37–45

13. Navarra G, Musolino C, De Marco ML et al (2007) Retromuscular sutured incisional hernia repair: a randomized controlled trial to compare open and laparoscopic approach. Surg Laparosc Endosc Percutan Tech 17:86–90.
14. Asencio F, Aguilo J, Peiro S et al (2009) Open randomized clinical trial of laparoscopic versus open incisional hernia repair. Surg Endosc 23:1441–1448

15. Eker HH, Hansson BM, Buunen M et al (2013) Laparoscopic vs. open incisional hernia repair: a randomized clinical trial. JAMA Surg 148:259–263

16. Olmi S, Scaini A, Cesana GC et al (2007) Laparoscopic versus open incisional hernia repair: an open randomized controlled study. Surg Endosc 21:555–559.

17. Pring CM, Tran V, O’Rourke N et al (2008) Laparoscopic versus open ventral hernia repair: a randomized controlled trial. ANZ J Surg 78:903–906.

18. Heniford BT, Park A, Ramshaw BJ, Voeller G. Laparoscopic ventral and incisional hernia repair in 407 patients. J Am Coll Surg. 2000;190:645-50.

19. Lomanto D, Iyer SG, Shabbir A, Cheah WK. Laproscopic versus open ventral hernia mesh repair. SurgEndsc. 2006;20(7):1030-5.

20. McGreevy JM, Goodney PP, Birkmeyer CM, Finalayson SRG, Laycock WS, Birkmayer JD. A prospective study comparing complications rates between laparoscopic and open ventral hernia repairs. Surg Endosc. 2003;17(11):1778-80.

21. Moreno-Egea A, Carrasco L, Girela E et al(2002)Open vs laparoscopic repair of spigelian hernia: a prospective randomized trial. Arch Surg 137:1266–1268.

22. Rosen MJ, Duperier T, Onders R, Hardacre J, Ponsky J, Ermlich B, Laughinghouse M. Prospective randomized double bind placebo controlled trial of post-operative pain pump devices used after laparoscopic hernia repair. Surg Endosc. 2009;23(12):2637-43.