Outcomes and Complications of Open, Laparoscopic, and Hybrid Giant Ventral Hernia Repair

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Research

Keywords: Giant Ventral Hernia, Hybrid, Laparoscopic, Hernia Recurrence, Complication

DOI: https://doi.org/10.21203/rs.3.rs-48071/v1

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Abstract

Background This study aimed to compare outcomes and complications between open, laparoscopic, and hybrid (laparoscopic and open combined) approaches in giant ventral hernia repair. Methods Records of patients with giant ventral hernias who received operations from 2006 to 2013 were retrospectively reviewed. Open, laparoscopic, or a hybrid procedure was performed in every case. The primary outcome was hernia recurrence rate, and secondary outcomes included intraoperative and postoperative complications. Results A total of 82 patients received open repair, 94 laparoscopic repair, and 132 hybrid repair. The median hernia diameter was 13.11 ± 3.4 cm. With a mean follow-up of 41 months, the incidence of hernia recurrence in the hybrid procedure group was 1.3%, which was significantly lower than that in the laparoscopic (20.5%) or open procedure group (8.5%) (P < 0.001). The incidence of intraoperative intestinal injury was 6.1% in open, 4.1% in laparoscopic, and only 1.5% in the hybrid procedure (hybrid vs. open and laparoscopic procedures; P < 0.05). Rates of postoperative intestinal fistula formation in the open, laparoscopic, and hybrid groups were 2.4%, 6.8%, and 3.3%, respectively (P > 0.05). Conclusions Compared with an open and a simple laparoscopic procedure, a hybrid procedure is more effective and safer in the repair of giant ventral hernias.

Introduction

Incisional hernia is a common complication of abdominal operations, with an incidence of 9–20% at 1-year follow-up after the primary operation [1]. Fink et al. reported an incidence of incisional hernias of 22.4% in 755 cases of laparotomy at 3 years, compared to 12.6% at 1 year after the procedure [2], indicating an increasing incidence of incisional hernia over time. A giant incisional hernia, which is defined as a defect greater than 10 cm in diameter [3, 4], is typically treated with a prosthetic mesh using an open procedure. This procedure is associated with a relatively large amount of tissue dissection, postoperative complications are not uncommon, and hospital stay and recovery are lengthy [5].

A laparoscopic approach to incisional hernias has been advocated for approximately 2 decades and is associated with minimal trauma, quicker recovery, and shorter hospital stay [3]. A wide and clear visual field for adhesion separation and examination of the abdominal wall defect is easier as compared with an open procedure [5]. Laparoscopic closure of the defect, however, subject to the suture technique, suture type, and increased abdominal wall tension caused by the pneumoperitoneum is slightly more difficult than during open surgery. General laparoscopic hernia defect repair requires the use of a V-Lok suture, which increases the cost of treatment and is not widely used in our country. Furthermore, postoperative seroma occurrence and hernia recurrence are complications of both open and laparoscopic hernia repair [6], and are particular importance with the laparoscopic repair of giant abdominal hernias [7]. There is currently no consensus for the management of giant ventral hernias, and many novel methods have been proposed [8–10].

A hybrid approach combining an open procedure with a laparoscopic procedure has been increasingly attempted for giant ventral hernia repair. In 2000, Lowe et al. proposed an endoscopy-assisted procedure
for abdominal wall defect repair [11]. Sharma et al. subsequently argued that a limited-conversion technique offered a safe and viable alternative in laparoscopic incisional hernia repair for patients with a bowel incarcerated hernia sac, or requiring extensive adhesiolysis [12]. Other studies have shown that a hybrid technique (laparoscopy with an additional open procedure using only a small incision) reduced the incidence of postoperative complications in patients with giant ventral hernias [13, 14]. Griniatsos et al. reported a hybrid technique for recurrent incisional hernia repair [15], while Stoikes et al. showed that the hybrid approach could be used in obese patients requiring open adhesiolysis during incisional hernia repair [16].

The purpose of the present study was to compare the outcomes and complications between 3 commonly used techniques for giant ventral hernia repair: laparotomy, the laparoscopic approach, and a hybrid technique combining both open and laparoscopic methods. We hypothesized that the hybrid approach combines the advantages of laparoscopic and open repair while minimizing the disadvantages of the 2 approaches and would be associated with a lower recurrence rate and fewer complications.

**Methods**

**Patients**

The records of adult patients (>18 years of age) who received giant ventral hernia repair at the Department of Hernia and Abdominal Wall, Beijing Chao-Yang Hospital, Capital Medical University, Beijing, China from January 2006 to June 2013 were retrospectively reviewed.

Adolescents under 18 years of age were excluded because they are still in the growth and development phase, and the use of synthetic materials can result in complications as the body grows. For this reason, our institution prohibits the use of artificial materials in persons less than 18 years of age.

All patients who received a planned hernia repair procedure, open, laparoscopic, or a hybrid approach, and did not meet any of the exclusion criteria were included in the analysis. All patients received preoperative computed tomography (CT) of the abdomen to diagnose the hernia and evaluate the hernia characteristics. A giant ventral hernia was defined as a hernia defect with a diameter $\geq 10$ cm; the classification of hernias was based on the report by 29th Congress of the European Hernia Society published by Muysoms et al. [3].

Exclusion criteria were: 1) presence of skin ulceration or infection; 2) use of anticoagulants or high-dose hormones within 4 weeks prior to the operation (anticoagulants can result in bleeding, and may affect the rate of hematoma formation; hormones can affect the immune system, and alter postoperative changes of inflammatory mediators); 3) participation in other clinical studies within 3 months before the operation; 4) a history of atopic allergy; 5) major mental illness (e.g., schizophrenia, severe anxiety or depression); 6) conditions that may significantly increase the intra-abdominal pressure (e.g., ascites associated with liver cirrhosis, cough from chronic obstructive pulmonary disease, intractable
constipation); 7) infection at the operative site or bacteremia; 8) patients requiring emergency surgery (e.g., bowel strangulation).

The study protocol was approved by the local Ethical Review Boards of Chao-Yang Hospital. Patient consent was not required because of the retrospective nature of this study. All procedures were performed in accordance with established European and American guidelines for the repair of hernias, and all patients provided written informed consent for all operations performed.

Operations

All operations were performed under general anesthesia, and all operations were performed by surgeons with a minimum of 10 years’ experience repairing ventral hernia by open and laparoscopic approaches.

Open and laparoscopic repairs were performed using the intraperitoneal onlay mesh (IPOM) technique. Composix E/X mesh (15.5 × 20.5 cm to 20 × 30 cm; Davol Inc., Warwick, RI) was used for hernia repair. Every patch was extended 5 cm beyond the exterior margin of the inner defect and was fixed to the abdominal wall. In open procedures, the mesh was fixed with an abdominal wall suturing device (Covidien Company) and a full-thickness abdominal wall penetrating hanging suturing line (polypropylene single suture) fixed at the 12 or 10 o’clock position. In the laparoscopic group, the mesh patch was fixed at 1 central point and 2 side points using an abdominal wall hanging penetrating suture. The surrounding area and edge was fixed with laparoscopic tacks. The basic principle was that the distance between tacks was not less than 3 cm.

The treatment of abdominal hernias using the hybrid method was to explore and separate the intra-abdominal adhesions under laparoscopy. Then, open surgery was used to remove the extra hernia sac, to separate tissues extensively along the muscle interstitial line, to place the patch into the abdominal cavity, to suture and close the hernia ring, and to close the incision. The patch was then fixed under laparoscopy. In hybrid procedures, pneumoperitoneum (12 to 14 mm Hg pressure) was established, and the laparoscope was introduced to explore the abdominal cavity, separate adhesions, and reduce the hernia contents. The hernia defect was dissected 5 cm beyond the exterior margin of the inner defect (Fig. 1A). Conversion to laparotomy was performed if the hernia contents could not be completely reduced. Pneumoperitoneum was evacuated with the trocars retained. A targeted fusiform incision (usually 4–8 cm long and 1–3 cm wide) was performed at the weakest point of the hernia sac along the line of the original incision (Fig. 1B). The hernia sac was resected completely by stripping, and the intestines were explored. The posterior component separation technique with transversus abdominis release was used for closure of the abdominal wall defect with no or low tension [17, 18]. The hernia defect was closed by continuous suture using PDS-II at 1 cm intervals after implantation of a Composix E/X mesh in the abdominal cavity. The anti-adhesive surface of the mesh was placed facing the abdominal cavity. The center of the mesh patch and the hernia ring was sutured using PDS-II sutures, and the surrounding mesh was fixed by laparoscopic tacks. The basic principle was that the distance between tacks was not less than 3 cm. Low pressure (8–10 mm Hg) pneumoperitoneum was re-established, and the mesh was fixed laparoscopically with spiral tacks (Medtronic Inc., Minneapolis, MN) (Fig. 1C) using
double-loop multi-point fixation at 1.5-2.0 cm intervals. The pneumoperitoneum was evacuated and trocars removed. Superficial tissues were closed with 2/0 absorbable interrupted suture, and the skin was closed with staples or a continuous 4/0 absorbable suture (Fig. 1D).

In all cases, intraoperative serosal injuries were repaired with 3 – 0 absorbable suture. Full-thickness injuries were repaired by resection. This was because the repair has a higher risk of fistula development, which could lead to contamination of the hernia patch necessitating removal. In all 3 procedures, drains were placed in the abdominal cavity if a large amount of dissection was performed and it was believed drainage was beneficial. Drains were placed into the pelvic cavity via the paracolic sulcus in order to be at the lowest position possible. Likewise, suction drains were placed subcutaneously when it was believed they were needed. No strict criteria were used for deciding to place the drains. All drains were typically removed 2–3 days after the operation. Postoperative care was the same for all of the 3 groups. All cases were advised to take necessary measures to protect the repair, including the use of an abdominal bandage for 6 months after the procedure, and control of body weight to minimize abdominal pressure.

Outcome measures

The primary outcome was the hernia recurrence rate. Secondary outcomes included intraoperative and postoperative complications, operative time, estimated blood loss, length of hospital stay, and mortality. Intraoperative and postoperative complications included intraoperative intestinal injury, postoperative intestinal fistula formation, chronic pain, postoperative infection, hematoma or seroma, and perioperative mortality. If a planned hybrid procedure was switched to open surgery, it was included in the hybrid group for analysis. Patients were followed up at 1 month, 3 months, and 6 months after the operation, and then yearly by outpatient visit or telephone interview. The surgeon who operated performed the follow-up, both in the clinic and by telephone call. No specific script was used when talking to the patients by phone. Hernia recurrence was diagnosed by physical examination and abdominal CT scan. If a patient described a bulge or pain in the area of the operation, then they were requested to have a CT scan done to determine if there was a hernia recurrence. The diagnosis of all recurrent hernias was based on CT and/or abdominal exam findings.

Chronic pain was defined as moderate or more severe pain (C4) in the mesh fixation area 3 months after the operation as assessed using a visual analog scale (VAS) for pain: 0 points, no pain; 1–3 points, mild pain; 4–7 points, moderate pain; 8–10 points, severe pain. In patients with suspected hematoma or seroma (suspected fluid collection on physical examination or complaint of pain), an ultrasound examination was performed, and a diagnosis was made if fine-needle aspiration produced a minimum of 10 mL of fluid. Whether the patient had a hematoma or a seroma was defined by the properties of the drainage fluid. Wound infections were defined as the present as swelling and increased pain and temperature at the incision site and the presence of purulent drainage.

Systemic or intraabdominal infections were defined as temperature > 38 °C for 3 consecutive days with the exclusion of respiratory and urinary tract infections, and a white blood cell (WBC) count > 10,000 with a neutrophil ratio > 80%.
Statistical analysis

Data were expressed as mean ± standard deviation (SD) for continuous variables and number (%) for categorical variables. Means were compared using one-way ANOVA. Categorical variables were analyzed with the $\chi^2$ test. A statistically significant difference was defined at $P < 0.05$. SPSS version 20 (SPSS Statistics, IBM Corporation, Somers, New York) was used for all statistical analyses.

Results

Patients

During the study period, 754 patients received operative treatment for incisional hernias of which 308 cases were included in the present study. A flow diagram of patient inclusion is shown in Fig. 2, and patient characteristics are summarized in Table 1. The minimum hernia diameter was 10 cm, and the maximum was 30 cm. A total of 82 patients received an open procedure, 94 a laparoscopic approach, and 132 a hybrid approach. Most (58.7%) patients were female, and the mean diameter of the hernia was 13.11 ± 3.4 cm (range, 10 to 30 cm). Patients had a mean body mass index (BMI) of 29.7 ± 44.6 kg/m$^2$ (range, 16.7 to 38.3 kg/m$^2$). Patients in the 3 groups were comparable in demographic and baseline characteristics (all, $P > 0.05$).
Table 1
Patient characteristics

|                      | Open procedure (n = 82) | Laparoscopic procedure (n = 73) | Hybrid procedure (n = 153) | P         |
|----------------------|------------------------|-------------------------------|---------------------------|-----------|
| Age, years           | 63.2 ± 16.2            | 60.8 ± 15.8                   | 62.6 ± 15.5               | 0.608     |
| Male sex             | 33 (40.2)              | 27 (37.0)                     | 56 (36.6)                 | 0.852     |
| BMI, kg/m\(^2\)      | 31.4 ± 5.3             | 29.5 ± 5.0                    | 30.9 ± 4.8                | 0.054     |
| Maximum hernia diameter, cm | 13.2 ± 3.6             | 12.7 ± 3.1                    | 13.4 ± 3.4                | 0.370     |
| Cerebral or cardiovascular disease | 24 (29.2)              | 18 (24.7)                     | 41 (26.8)                 | 0.810     |
| Diabetes mellitus    | 22 (26.8)              | 20 (27.4)                     | 43 (28.1)                 | 0.978     |
| Other diseases related to increased IAP | 23 (28.0)              | 19 (26.0)                     | 34 (22.2)                 | 0.586     |
| Chronic cough        | 8                      | 8                             | 8                         | 0.240     |
| Benign prostatic hyperplasia | 5                    | 4                             | 10                        | 0.953     |
| Chronic constipation  | 10                     | 8                             | 16                        | 0.921     |
| Preoperative VAS pain score | 0.41 ± 0.89            | 0.51 ± 0.75                   | 0.62 ± 0.92               | 0.212     |

Data are reported as mean ± standard deviation, or number (percentage). BMI, body mass index; IAP, intra-abdominal pressure; SD, standard deviation; VAS, visual analogue scale.

Operative details of the 3 groups are summarized in Table 2. The mean operation time was 76.7 ± 23.7 minutes for the open group, 63.6 ± 12.1 minutes for the laparoscopic group, and 113.6 ± 21.8 minutes for the hybrid group (P < 0.001). Overall, the incidence of postoperative complications was significantly lower in the hybrid group (7.23%) compared to the open group (17.1%) (P = 0.019) or the laparoscopic group (60.3%) (P < 0.001). The rate of intraoperative intestinal injury was 6.1% in the open group, 4.1% in the laparoscopic group, and 1.5% in the hybrid group (hybrid vs. open and laparoscopic procedures; P < 0.05). In addition, the rate of postoperative intestinal fistula formation in the open, laparoscopic, and hybrid groups was 2.4%, 6.8%, and 3.3%, respectively, and the differences were not significant (P > 0.05). The ratio of postoperative intestinal fistula [19] versus intraoperative intestinal injury was markedly lower in the hybrid group compared to the laparoscopic group (0.2 vs. laparoscopic, 1.7; P = 0.013), but was not different compared to the open group (0.4; P > 0.05). Because the hybrid group had the lowest rate of postoperative hernia recurrence, the reoperation rate was the lowest in the hybrid group (3.9% vs. 12.2% open and 24.78% laparoscopic; P < 0.001). Most patients with a seroma were asymptomatic, and the
Laparoscopic procedure had the highest rate of seroma formation (32.8% vs. 6.1% (open) and 2.6% (hybrid); \( P < 0.001 \)), but the lowest incidence of operative site infections (1.4% vs. 7.3% (open) and 5.2% (hybrid); \( P > 0.05 \)). Patients who received an open procedure had a longer length of hospital stay (13.0 ± 8.7 days) than those that received laparoscopic (6.9 ± 14.2 days) and hybrid (8.5 ± 7.9 days) procedures (\( P = 0.002 \)).
|                                | Open procedure (n = 82) | Laparoscopic procedure (n = 73) | Hybrid procedure (n = 153) | \( P \) |
|--------------------------------|-------------------------|----------------------------------|---------------------------|------|
| Recurrence                     | 7 (8.5)                 | 15 (20.5)                        | 2 (1.3)                   | < 0.001 |
| Re-operated patients           | 10 (12.2)               | 18 (24.7)                        | 6 (3.9)                   | < 0.001 |
| Surgery duration, min          | 76.7 ± 23.7             | 63.6 ± 12.1                      | 113.6 ± 21.8              | < 0.001 |
| Estimated blood loss, mL       | 28.4 ± 9.6              | 6.2 ± 3.5                        | 20.9 ± 10.9               | < 0.001 |
| Length of hospitalization (d)  | 13.0 ± 8.7              | 6.9 ± 16.0                       | 8.9 ± 9.4                 | 0.002 |
| Hospitalization cost, RMB*     | 33278 ± 18387           | 45892 ± 29887                    | 43041 ± 17210             | < 0.001 |
| Intraoperative intestinal injury | 5 (6.1)                 | 3 (4.1)                           | 23 (1.5)                  | 0.015 |
| Postoperative intestinal fistula | 2 (2.4)                 | 5 (6.8)                           | 5 (3.3)                   | 0.312 |
| Postoperative intestinal fistula/intraoperative intestinal injury | 0.4 | 1.7 | 0.2 | 0.046 |
| Seroma                         | 5 (6.1)                 | 24 (32.8)                        | 4 (2.6)                   | < 0.001 |
| Surgical site infection        | 6 (7.3)                 | 1 (1.4)                           | 8 (5.2)                   | 0.220 |
| Chronic pain                   | 6 (7.3)                 | 1 (1.4)                           | 3 (2.0)                   | 0.051 |
| Perioperative mortality        | 3 (3.7)                 | 2 (2.7)                           | 3 (2.0)                   | 0.735 |
| Postoperative complications    | 14 (17.1)               | 44 (60.3)                        | 11 (7.2)                  | < 0.001 |
| 1 complication                 | 5 (6.1)                 | 40 (54.8)                        | 2 (1.3)                   |       |
| 2 complications                | 4 (4.9)                 | 4 (5.5)                           | 5 (3.3)                   |       |
| 3 complications                | 4 (4.9)                 | 0 (0.0)                           | 3 (2.0)                   |       |
| 4 complications                | 1 (1.2)                 | 0 (0.0)                           | 1 (0.7)                   |       |

Data are reported as mean ± standard deviation, or number (percentage). *One US dollar is approximately 6.24 RMB.
All patients followed-up 1 week after the operation. The rates of outpatient clinic follow-up at 1 month, 3 months, and 1 year were 40.6%, 37.3%, and 14.6%; other patients were followed-up by telephone interview. The mean follow-up time for the open group was 45 months, the laparoscopic group was 40 months, and the hybrid group was 39 months. Thus, the mean follow-up time for the 3 groups was 41 months (range, 12 to 88 months). The follow-up time in the hybrid group was shorter than the other 2 groups because that is the most recent procedure we have begun performing. All of the patients who were suspected of having a hernia recurrence based on outpatient examination or telephone interview received a CT scan to determine if a recurrence had occurred. The hernia recurrence rate in patients who received a hybrid procedure was 1.3% at the final follow-up, which was significantly lower than in the laparoscopic group (20.2%) or the open group (8.5%) ($P<0.001$) (Fig. 3).

Patients who received an open procedure had the highest rate of chronic pain (7.3% vs. 1.4% laparoscopic and 2.0% hybrid; $P>0.05$), but the lowest hospitalization costs ($P<0.001$). The perioperative mortality was comparable among the 3 groups (open, 3.7%; laparoscopic, 2.7%; hybrid, 2.0%; $P>0.05$).

**Discussion**

The present study showed that the rates of hernia recurrence and complications were significantly lower in patients that receive a hybrid procedure as compared to the other 2 operative approaches.

Repair of giant ventral hernias is technically challenging. Although component separation with retromuscular mesh repair is the primary procedure used, multiple alternative strategies have been investigated to overcome the high rate of hernia recurrence, which ranges from 10–30%, and the unacceptably high incidence of wound complications, ranging from 40–50% [20]. Though a hybrid procedure combining open repair with a laparoscopic technique has been increasingly reported, scant literature is available regarding its efficacy and safety, as well as its cost-effectiveness compared to open and laparoscopic procedures [15, 16].

Few studies have directly compared a hybrid approach with other methods. In a study conducted from 2006 to 2008, Ozturk et al. randomized 28 patients with giant incisional hernias to receive standard laparoscopic repair or a hybrid approach, i.e., laparoscopy combined with an open approach [21]. The mean length of hospital stay and the rate of operative site infections were comparable in both groups. Six patients developed seromas in the laparoscopic group compared with 1 in the hybrid group, and there were no recurrences in the hybrid group compared with 1 in the laparoscopic group. This study, however, was partially compromised by the small number of cases and a short duration of follow-up.

Large hernia size, infection, and operative technique are considered to be important determinants of operative outcomes after giant hernia repair [6, 22]. In the present study, the hernia recurrence rate of the hybrid procedure was 1.3%, which was significantly lower than that of the laparoscopic procedure (20.5%) or the open procedure (8.5%), as well reported recurrence rates which range from 10–30% [20]. The low recurrence rate with the hybrid technique may be due to complete removal of the hernia sac, the proper closure of the hernia defect, and satisfactory reshaping of the abdominal wall in the open phase.
Careful laparoscopic exploration, adhesiolysis, mesh flattening and fixation, assuring the integrity of abdominal wall remodeling, and avoidance of hidden hernia omission also likely contribute to the low incidence of hernia recurrence [16, 20].

The hernia recurrence rates of open and laparoscopic procedures were higher in our study than that reported in a recent meta-analysis showing a 2.7% recurrence rate for mesh repairs, and an 8.2% recurrence rate for suture repairs [23]. The difference may be due to a longer mean follow-up duration of 41 months in our study. Fink et al. reported that the rate of hernia recurrence with open repair increased over time (22.4% at 3 years vs. 12.6% at 1 year after operation) [2]. Another study has shown the hernia recurrence rate continues to increase up to 10 years after the primary incisional hernia repair, with a 10-year cumulative recurrence rate being 32% for mesh repair and 63% for suture repair [24]. It has also been reported that 85% of recurrences after laparoscopic repair, and 77% after open repair, occur within 2 years of the operation in ventral hernias cases, and there appears to be a continued despite low subsequent yearly recurrence rate for open repairs [25]. Thus, long-term follow-up is necessary to determine if the hybrid approach is superior to other approaches with respect to recurrence.

Patients that received a hybrid preplanned procedure had a low complication rate of 1.5%, indicating that careful preoperative planning and preparation are important for improving the safety of the procedure. Furthermore, a hybrid procedure was also associated with a low rate of postoperative intestinal fistula formation; no postoperative intestinal fistula developed in patients who had a preplanned hybrid procedure. These results may be due to the avoidance of forced intestinal adhesiolysis and recognition of hidden injury in the laparoscopic phase, and reliable intestinal injury repair in the open phase. Importantly, postoperative complications were significantly lower in the hybrid group, and the hernia recurrence rate as well as the reoperation rate was the lowest (3.9%), while laparoscopic cases had the highest reoperation rate (24.7%). This may be due to the preservation of the hernia sac in the laparoscopic procedure. Moreover, a laparoscopic procedure alone does not allow proper closure of the hernia defect or adequate remodeling of the integrity of the abdominal wall, resulting in a higher incidence of recurrence and seroma formation.

Patients undergoing laparoscopic or open giant ventral hernia repair have a high likelihood of chronic pain and limitation of activity [26, 27]. In our study, the length of hospital stay, intraoperative blood loss, and postoperative chronic pain were lowest in the hybrid group. This may be due to the use of a smaller incision and avoidance of excessive full-thickness abdominal wall suspension fixation (transabdominal sutures), which are typically used in open repair.

We must mention the relatively high postoperative complication rate of the laparoscopic group. In 2009 we began performing laparoscopic extraperitoneal hernia repair and there was a learning curve. When we began performing laparoscopic hernia repair, the definition of intestinal injury during laparoscopic manipulation was partial or full-thickness intestinal wall injury, and this was a relatively common complication at the beginning of the learning curve. With advances in equipment and our experience, the current injury rate is very low. In addition, the cost of open cases was lower than for laparoscopic cases.
This was due to the cost of the equipment needed for laparoscopic repair. For example, the use of a hernia fixer (Medtronic, Shanghai; similar product as Protack) in laparoscopic repair raises the costs in comparison to an open procedure.

The primary limitation of this study is its retrospective nature, which carries the risk of certain biases. While all patients suspected of having a recurrence received a CT scan, it is possible that some patients who did not report symptoms of recurrence during the telephone interview did have a recurrence. The volume of the hernia sac was not examined. While volume may be useful for determining postoperative intraabdominal pressure and recurrence, the size of the ventral defect in 2 dimensions is the standard used for defining giant ventral hernias. It can be argued there is a problem with the comparison of bridging versus augmentation (open and laparoscopic bridging and augmentation during a hybrid procedure). In open and hybrid repair, the augmentation approach was adopted to address the hernia sac and close the hernia defect. For direct coverage of the hernia repair patch in the laparoscopic procedure, the bridging approach was used. However, what we compared was the difference of operative routes, rather than emphasizing on the difference of the augmentation or the bridging approaches. Lastly, there are many methods to treat giant hernias (e.g., minimal invasive component separation, preoperative progressive pneumoperitoneum, botulinum toxin A) which we have not discussed. However, the purpose of this report was not to determine or discuss the best technique but to compare the results of the 3 techniques examined. Lastly, the definition of hematoma/seroma formation may have resulted in an underestimation of their occurrence.

In conclusion, a hybrid approach combining laparoscopic and an open procedure is an effective method for giant ventral hernia repair. It is associated with low rates of complications and hernia recurrence. Hybrid repair combines the advantages of laparoscopic and open repair, while the disadvantages of the 2 approaches are minimized. The hybrid approach not only allows complete removal of the hernia sac, proper closure of the hernia defect, and proper reshaping of the abdominal wall in the open phase, but also allows laparoscopic exploration, adhesiolysis, and mesh flattening and fixation, thus assuring the integrity of abdominal wall remodeling and avoiding hidden hernia omission.

**Abbreviations**

VAS
Visual analog scale
WBC
White blood cell

**Declarations**

**Funding**

None
Authors’ contributions

We declare that all the listed authors have participated actively in the study and all meet the requirements of the authorship. Dr. Ming-gang Wang designed the study and wrote the protocol. Dr. Shuo Yang performed research. Dr. Maolin Tian managed the literature searches and analyses. Dr. Minggang Wang undertook the statistical analysis. Dr. Shuo Yang wrote the first draft of the manuscript. Dr Yusheng Nie, Xuefei Zhao and Jing Liu assisted in the searches and analyses.

Ethics approval and consent to participate

The study protocol was approved by the local Ethical Review Boards of Chao-Yang Hospital. Patient consent was not required because of the retrospective nature of this study.

Consent for publication

Not applicable

Availability of data and material

All the data and material were presented in the main paper.

Competing interests

All authors have no conflicts of interest to declare.

Acknowledgements

None

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**Figures**
Figure 1

Hybrid repair of giant incisional hernias. A) Step 1: Pneumoperitoneum was established followed by adhesion separation, reduction of hernia contents, and dissection of the hernia defect 5 cm beyond the exterior margin of the inner defect. B) Step 2: A targeted fusiform incision was made, the hernia sac was completely reduced by stripping, and the intestines were explored. The component separation technique was used, and mesh was implanted and fixed to the incision. C) Step 3: Pneumoperitoneum was re-established, and the mesh was fixed laparoscopically with spiral tacks. D) The incision was closed by staples or 4/0 absorbable suture.
Figure 2

Patient flow diagram.
Figure 3

Hernia recurrence rates.