



Comparison between robotic and laparoscopic inguinal hernia repair in Caucasian patients: a systematic review and meta-analysis

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Background: Laparoscopic and robotic techniques allow surgeons to dissect and observe the groin area from the inside out, this study was to evaluate and compare the effects and safety of robotic inguinal hernia repair (R-IHR) and laparoscopic inguinal hernia repair (L-IHR) in Caucasian patients.

Methods: We searched the full texts of studies comparing R-IHR and L-IHR in multiple databases. Meta-, sensitivity, and bias analyses of the included literature were performed with Review Manager 5.2, and forest plots were drawn. The joint estimate of the risk ratio (RR) and the mean difference (MD) of the 95% confidence interval (CI) was used as a measure of the effect size.

Results: This meta-analysis included 8 eligible studies involving 1,379 Caucasian patients with inguinal hernia (IH). No significant difference was found in pain score (MD =1.52, 95% CI, -0.30, 3.35, $P=0.10$; $I^2=97\%$), length of hospital stay (MD =0.14, 95% CI, -0.03, 0.30, P for overall effect =1.63, $I^2=0\%$), or complications (RR =1.24 with 95% CI, 0.94, 1.63, P for overall effect =0.13, $I^2=0\%$) between R-IHR and L-IHR. However, there was significant difference in operative time between R-IHR and L-IHR (MD =17.17, 95% CI, 6.32, 28.03, $P=0.002$; $I^2=84\%$).

Discussion: This meta-analysis revealed only minor differences between R-IHR and L-IHR in terms of clinical effects and safety in Caucasian patients, although R-IHR has a longer operative time than L-IHR. Both R-IHR and L-IHR are suitable to treat Caucasian patients with IH.

Keywords: Robotic inguinal hernia repair (R-IHR); laparoscopic inguinal hernia repair (L-IHR); Caucasian; meta-analysis

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Introduction

The inguinal area is located in the triangular area between the lower abdominal wall and the thigh. Inguinal hernia (IH), commonly known as “hernia”, refers to a mass formed when the abdominal visceral organs protrude through the body’s surface due to a defect in the inguinal area (1,2). In older people, muscle atrophy, a weak abdominal wall, and a weakened inguinal area provides a channel for hernia

formation. Furthermore, the development of cough or asthma in older people increases the abdominal pressure and the risk of developing hernia (3). There is a sex difference in the incidence of hernia, with the female and male incidence reaching about 3% and 27%, respectively. Achieving self-cure of IH is challenging; therefore, IH surgery has become one of the most common abdominal surgical procedures (4,5). With the concept of minimally invasive surgery having

been accepted by the public in recent years, laparoscopic hernia repair has been widely applied.

Laparoscopic IH repair (L-IHR) is a safe and tension-free procedure. The process of laparoscopic preperitoneal patch repair is to enter the abdominal cavity, and firstly open the peritoneum around the hernia defect, then place the patch on the defect, and finally close the peritoneum. The advantages of L-IHR include small incisions, good aesthetics, fast patient recovery, and high patient satisfaction, however, require high cardiopulmonary function to patients due to general anesthesia operation (6,7).

With the increasing application of the Da Vinci robotic surgical system in abdominal surgery in recent years, robotic assistance has also been incorporated into IH repair (IHR). The robotic arm of the system can perform operations that require high flexibility in an extremely small space (8,9). The application of a robotic surgical system in laparoscopic surgery can increase the surgical precision.

Several studies have shown that although robotic IHR (R-IHR) takes longer to perform, postoperative pain is reduced compared to that with traditional laparoscopy, and the postoperative recovery is faster (8-10). The anatomical structure of the groin region is highly complex, with a large number of blood vessels and nerves. The advantages of robotic surgical system can also make the anatomy clearer through its 3-dimensional (3D) high-definition imaging system, which greatly reduces or even avoids the damage sustained by nerves and blood vessels during surgery.

Several randomized trials have compared R-IHR and L-IHR in Caucasian patients. However, previous reviews of IH lacked a consistent comparator. To address these issues, we conducted a meta-analysis of randomized trials and case-control studies to compare the effects and safety of R-IHR and L-IHR in Caucasian patients. We present the following article in accordance with the PRISMA reporting checklist (available at <http://dx.doi.org/10.21037/atm-21-2126>).

Methods

Literature search strategy

We searched electronic databases for articles comparing the effects and safety of R-IHR and L-IHR among Caucasian patients. The search databases included PubMed, EMBASE, Cochrane Library, and China National Knowledge. Searches were conducted to identify studies published from May 2000 to May 2019, using the following keywords: (I) robotic inguinal hernia repair or R-IHR; (II) laparoscopic

inguinal hernia repair or L-IHR; and (III) inguinal hernia repair or IH. All keyword combinations were connected with “AND”, and no language restrictions were applied. To maximize the number of inquiries, we also checked the retrieved studies’ references to find other relevant studies.

Study selection

First, we conducted primary screening, followed by a review of potentially relevant research texts. To be included, studies needed to meet the following criteria: (I) a comparative study of L-IHR and R-IHR; (II) study participants had IR; (III) study participants were Caucasian; and (IV) the full text was available.

Studies meeting any of the following conditions were excluded: (I) research on other health issues; (II) participants received treatments other than L-IHR or R-IHR; (III) the study participants were not Caucasian; or (IV) lacking available data for research.

Data extraction and quality assessment

Two authors reviewed the full papers of eligible studies. From each article, they extracted data including the first author’s name, publication year, participants’ age and sex, country, sample size, years of onset for each article. The methodological quality of the study was assessed using the Cochrane risk-of-bias tool. We assessed the quality of the included studies based on the Review Manager 5.2 risk-of-bias summary table. The studies were assessed for the following: (I) random sequence generation, (II) allocation concealment, (III) blinding of participants and personnel, (IV) blinding of outcome, (V) incomplete outcome data, (VI) selective reporting (reporting bias) and (VII) other biases (11).

Statistical analysis

We used Review Manager 5.2 software (Cochrane Collaboration, 2011) to evaluate the difference in comparative analysis results between R-IHR and L-IHR.

Continuous data were evaluated using the mean difference (MD). The risk ratio (RR) was used for the evaluation of binary data, and 95% confidence intervals (CIs) were calculated to determine the clinical efficacy and complications of R-IHR and L-IHR. Heterogeneity was assessed using the inconsistency index (I^2) statistical method, with the I^2 statistical value reflecting the level of heterogeneity. When I^2 was greater than 50%,

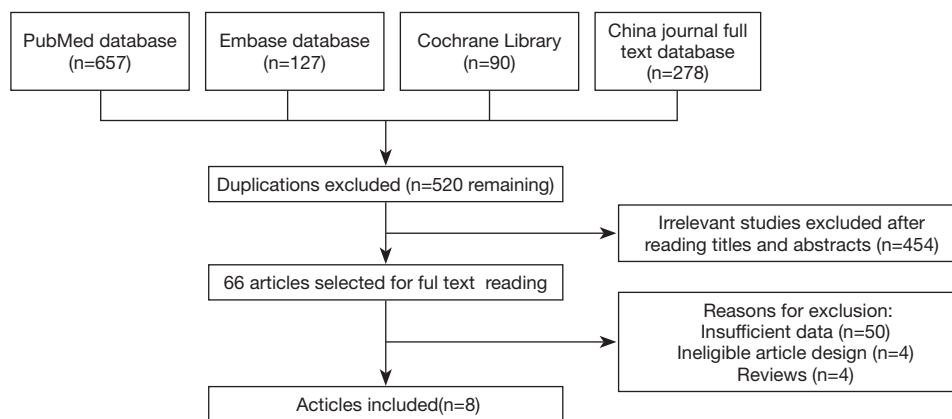


Figure 1 Flow diagram of the study selection process.

heterogeneity was considered to exist, and the random-effects model was adopted; otherwise, the fixed-effects model was adopted. $P < 0.05$ was considered to be statistically significant. Review Manager 5.2 software was also used to conduct a bias analysis of the studies to test their quality. A funnel chart was used to estimate publication bias.

Surgical procedures

The L-IHR procedure was performed as follows. In front of the hernia ring defect, the peritoneum was cut in an arc from the anterior superior iliac crest to the medial umbilical ligament, and then the combined Retzius gap and Bogros gap were separated. After the hernia sac had been visualized and checked for any bleeding, a polypropylene fiber patch was inserted through the operation hole forceps and stretched to fully cover the defect area. Finally, multi-point fixation with bio glue was used to continuously suture the local peritoneum closed using absorbable sutures (7).

The Da Vinci robotic transperitoneal hernia surgical procedure (R-IHR) was performed as follows. Using an open method, a pneumoperitoneum was established by placing a 12-mm cannula approximately 2 cm above the healthy side of the umbilical foramen. The Da Vinci 3D lens was placed with the lens facing up. An 8-mm robot cannula was placed under the camera at the level of the lateral flat umbilicus outside the rectus abdominis and at the level of the lateral margin of the lateral rectus abdominis under the umbilicus. The host was pushed in from the affected foot, and the Da Vinci system 3D laparoscope was connected to the observation hole. The 1st arm was connected to the main operation hole, and the 2nd arm was connected to the

auxiliary operation hole. Bipolar coagulation and grasping forceps were placed respectively. After gaining entry to the abdomen, the surgeon first confirmed the type of hernia, and then the peritoneum was cut from the inner umbilical folds to the anterior superior iliac crest on the upper edge of the hernia (8).

Results

Search process

After our initial screening, there were 520 articles, among which 66 papers met the preliminary criteria. Of these 66 articles, 58 were excluded due to the study design, having insufficient data, or the article type. Eventually, 8 papers involving 1,120 patients were selected for the meta-analysis. The flowchart in *Figure 1* shows the identification, inclusion, and exclusion processes.

Information of included studies

Table 1 summarizes the study information including the first author, publication year, country, and participant age range. The 8 articles (7,12–18) in this meta-analysis were all published between 2011 and 2019. The sample size of the included studies ranged from 38 to 275 participants. Of the 1,120 patients in the 8 included studies, 459 cases were in the R-IHR group and 661 cases were in the L-IHR group.

Results of quality assessment

The Cochrane bias risk tool was used to assess the possible bias of the included 8 studies (*Figure 2* and *Figure S1*).

Table 1 Characteristics of studies included in the meta-analysis

Study	Year	Language	Country	Age range (mean)	Groups	n	Years of onset
Bittner <i>et al.</i> (12)	2018	English	USA	55.9±11.7	R-IHR	83	2015–2016
					L-IHR	83	
Huerta <i>et al.</i> (13)	2019	English	USA	59.1±12.5	R-IHR	71	2005–2017
					L-IHR	128	
Khoraki <i>et al.</i> (14)	2020	English	USA	49.8±13.5	R-IHR	45	2015–2017
					L-IHR	138	
Kudsi <i>et al.</i> (15)	2017	English	USA	56.9±15.1	R-IHR	118	2012–2015
					L-IHR	157	
Muysoms <i>et al.</i> (16)	2018	English	USA	59.7±14.2	R-IHR	49	2013–2017
					L-IHR	64	
Sheldon <i>et al.</i> (17)	2019	English	USA	39.5±11.5	R-IHR	49	2016–2018
					L-IHR	34	
Spernat <i>et al.</i> (7)	2014	English	USA	59.2±10.2	R-IHR	5	2004–2010
					L-IHR	33	
Waite <i>et al.</i> (18)	2016	English	USA	57.8±11.5	R-IHR	39	2012–2014
					L-IHR	24	

R-IHR, robotic inguinal hernia repair; L-IHR, laparoscopic inguinal hernia repair.

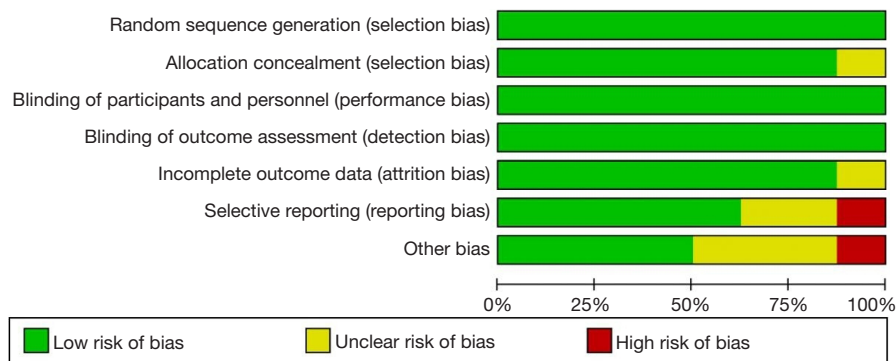


Figure 2 Assessment of the quality of the included studies. Green represents as low risk of bias, yellow represents as unclear risk of bias, and red represents as high risk of bias.

The results of the bias risk analysis revealed that 1 study had reporting bias and 1 study had other biases. Overall, no issues were found with selection bias, attrition bias, performance bias, or detection bias. Therefore, 2 studies had a risk of bias and 6 studies had no risk of bias.

Results of heterogeneity test

Comparison of the pain score between R-IHR and L-IHR

Four of the included studies compared pain scores between Caucasian patients treated with R-IHR and L-IHR.

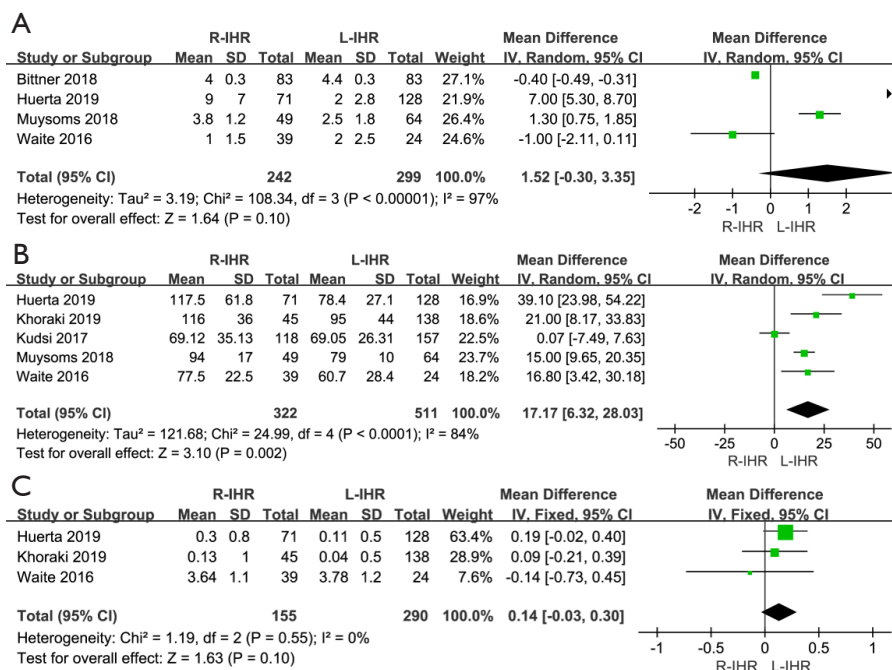


Figure 3 Meta-analysis results of pain score. (A) Forest plots of pain score in the R-IHR and L-IHR groups; (B) forest plots of operative time in the R-IHR and L-IHR groups; and (C) forest plots of length of hospital stay in the R-IHR and L-IHR groups. R-IHR, robotic inguinal hernia repair; L-IHR, laparoscopic inguinal hernia repair.

Figure 3A shows a forest plot of the pain score in the R-IHR and L-IHR groups. The combined result suggested that there was no significant difference between the 2 groups (MD =1.52, 95% CI, -0.30, 3.35, P=0.10; P for heterogeneity <0.00001, I²=97%).

Comparison of operative time between R-IHR and L-IHR

Five of the included studies compared the operative time between Caucasian patients treated with R-IHR and L-IHR. Figure 3B shows a forest plot of the operative time in the R-IHR and L-IHR groups. The meta-analysis results showed that the operative time differed significantly between the 2 procedures, with the time in the R-IHR group being longer than that in L-IHR group (MD =17.17, 95% CI, 6.32, 28.03, P=0.002; P for heterogeneity <0.0.0001, I²=84%).

Comparison of length of hospital stay

Three of the included articles compared the length of hospital stay between Caucasian patients treated with R-IHR and L-IHR. The heterogeneity test results showed

that the overall effect of length of stay between the R-IHR and L-IHR groups was insignificant (MD =0.14, 95% CI, -0.03, 0.30, P for overall effect =1.63, P for heterogeneity =0.55 and I²=0%) (Figure 3C).

Comparison of complications

Five studies compared the complications between Caucasian patients treated with R-IHR and L-IHR, the heterogeneity test results revealed no difference between the 2 groups (RR =1.24 with 95% CI, 0.94, 1.63, P for overall effect =0.13, I²=0% and P of heterogeneity =0.57) (Figure 4A).

Sensitivity analysis and publication bias

According to the results of the 1st part of the meta-analysis, the heterogeneity for pain scores was high (I²=97%). This heterogeneity may have been attributable to differences in the results of the studies. As shown in Figure 4B, when Huerta 2019 study (13) was excluded, the I² changed from 97% to 95%, which evidenced the reliability of that article's results. We also performed a funnel plot analysis. The funnel plot, which is shown in Figure S2, includes

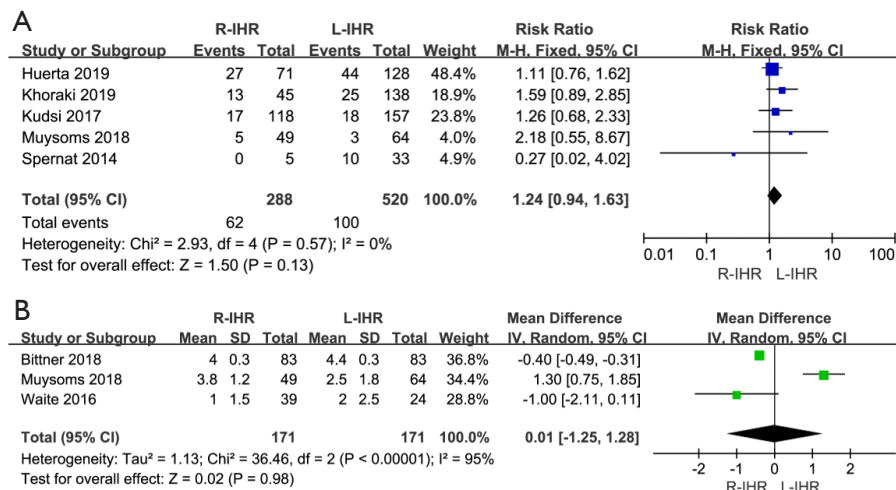


Figure 4 Meta-analysis results of complications. (A) Forest plots of complications in the R-IHR and L-IHR groups, and (B) sensitivity analysis of forest plots of pain score in the R-IHR and L-IHR groups. R-IHR, robotic inguinal hernia repair; L-IHR, laparoscopic inguinal hernia repair.

4 studies and has good symmetry, reflecting a limited publication bias.

Discussion

There are 100–300 new cases of IH per 100,000 people each year all over the world (19). Among the various types of extra-abdominal hernias, IHs are the most common. A decrease in abdominal wall muscle strength and an increase in intra-abdominal pressure are the main causes of IH (20,21). The most typical symptom of an IH is a prominent, reducible mass in the groin area. At first, the mass is small, with the patient experiencing only a slight sense of bloating. However, as the mass becomes larger, pain symptoms develop. Many surgical methods for IH exist at present, and the most suitable surgical scheme should be selected according to the specific situation of each patient.

Laparoscopic surgery is performed by first puncturing the cannula under the umbilicus and puncturing the trocar. After all trocars have been implanted, they are connected to a pneumoperitoneum and observed in the abdominal cavity (22,23). Patients undergoing Da Vinci robotic transperitoneal hernia surgery also require endotracheal intubation and general anesthesia (24).

In their study (7), Spernat *et al.* compared R-IHR (n=118) and L-IHR (n=157), and showed that although the treatment received by patients in the R-IHR group was more complex, the short-term effects of the 2 procedures

were comparable. At 4 weeks after surgery, there was no significant difference in the EuroHS quality of life score between the R-IHR and L-IHR groups. Our study also failed to find a significant difference between the 2 groups, which is consistent with Spernat *et al.*'s observations. Horovitz *et al.* (24) reported that there was no significant difference between the 2 groups with respect to hospital service levels. In our study of Caucasian patients, the hospital stay between the R-IHR and L-IHR groups was not significantly different. This study found that the rates of adverse events, readmission, and death were similar between the 2 groups. Furthermore, there were no differences in terms of 30-day postoperative complications after R-IHR and L-IHR, and the difference in the complications rate between the R-IHR and L-IHR groups was also insignificant.

Horovitz *et al.* (24) found that although the robot can provide excellent visualization and dissection of the preperitoneal space, it was associated with a longer operative time. Suture closure of the peritoneal flap appears to account for this difference. Our meta-analysis also showed that the operative time in the R-IHR group was longer than that in the L-IHR group.

One of the biggest concerns regarding robotic repair of IHs is the cost. However, most institutions with robotic systems have purchased robotic systems for different programs in many professional fields; in this respect, they are no different to laparoscopic operating towers or

operating tables. The cost of capital is amortized over time and across all patients treated at the facility, rather than only those who receive robotic surgery. Khoraki *et al.* (14) reported that the average direct cost per case in the L-IHR group was \$3,216, compared with \$3,479 in the R-IHR group. The cost of surgery does not seem to be a major consideration in choosing between the 2 procedures.

Robotic technology has gradually entered the surgical thinking, and changed the surgical procedures. With the increasing application of robotic platforms in general surgery, surgeons with minimally invasive surgery experience should be familiar with robot inguinal repair technology. In addition, the selection of robotic methods may provide the selected patients with better acute pain perception and the benefits of reducing activity disruption (12).

In conclusion, considering the results of pain score, surgical complexity, and safety, R-IHR and L-IHR have similar clinical effects and safety for Caucasian patients. However, more analyses of indications for R-IHR and L-IHR in Caucasian patients should be performed in the future. Also, further research should consider additional updated articles from other countries.

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Footnote

Reporting Checklist: The authors have completed the PRISMA reporting checklist. Available at <http://dx.doi.org/10.21037/atm-21-2126>

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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