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Outcomes of robotic vs laparoscopic hepatectomy: A systematic review and meta-analysis

Montalti R *et al.* Robotic vs laparoscopic hepatectomy: A meta-analysis

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Abstract

BACKGROUND

AIM

To perform a systematic review and meta-analysis on robotic-assisted versus laparoscopic liver resections.

METHODS

A systematic literature search was performed using PubMed, Scopus and the Cochrane Library Central. Participants of any age and sex, who underwent robotic or laparoscopic liver resection were considered following these criteria: (1) studies comparing robotic and laparoscopic liver resection; (2) studies reporting at least one perioperative outcome; and (3) if more than one study was reported by the same institute, only the most recent was included. The primary outcome measures were set for estimated blood loss, operative time, conversion rate, R1 resection rate, morbidity and mortality rates, hospital stay and major hepatectomy rates.

RESULTS

A total of 7 articles, published between 2010 and 2014, fulfilled the selection criteria. The laparoscopic approach was associated with a significant reduction in blood loss and lower operative time (MD = 83.96, 95%CI: 10.51-157.41, $P = 0.03$; MD = 68.43, 95%CI: 39.22-97.65, $P < 0.00001$, respectively). No differences were found with respect to conversion rate, R1 resection rate, morbidity and hospital stay.

CONCLUSION

Laparoscopic liver resection resulted in reduced blood loss and shorter surgical times compared to robotic liver resections. There was no difference in conversion rate, R1 resection rate, morbidity and length of postoperative stay.

Key words: Laparoscopic liver resections; Robotic liver resections; Outcome; Systematic review; Meta-analysis

Core tip: No consensus is available in the literature about which technique between laparoscopic and robotic liver resection is more beneficial to the patient. This is the first systematic review and meta-analysis comparing laparoscopic and robotic liver resection. We investigated these two techniques in terms of estimated blood loss, operative time, conversion rate, R1 resection rate, morbidity and mortality rates, hospital stay and major hepatectomy rates.

INTRODUCTION

Since its introduction by Reich *et al*^[1] in 1991, laparoscopy has been increasingly used for resection of benign and malignant liver lesions, from minor resections to major hepatectomies and living liver donation^[2-7]. Several studies have suggested the safety, feasibility, comparable perioperative and long-term outcomes of laparoscopy compared to the standard open approach^[8-10]. In many centers, laparoscopic liver resection (LLR) is considered the first choice in well-selected patients. Current limitations include a steep learning curve^[11], tumors adjacent to the hilum, the hepatic veins and the inferior vena cava, bulky tumors, difficult access to the posterior segments and the need for biliary and vascular reconstructions^[9]. The reports of LLR on the posterior segments are few and have been limited to centers with a wide experience in both open and laparoscopic liver surgery.

Robotics was introduced two decades ago with the aim of overcoming the intrinsic limitations of laparoscopic instruments and visualization. The da Vinci[®] Robotic Surgical System was introduced in 2000 to improve the surgeon's dexterity by taking advantage of the camera's three-dimensional view and endowristed instruments^[12-15]. Furthermore, robotics has also been described as an effective tool for non-resective and demanding hepatobiliary surgery, such as bilio-digestive reconstructions and choledocal cysts excisions^[16,17].

Radical prostatectomy and various gynecological procedures currently make up the vast majority of robotic surgeries: by 2011, more than 90% of the 360.000 robotic worldwide procedures were urologic and gynecological operations^[18]. Perioperative and oncological outcomes are equivalent to those reported in the literature with the standard approach. Two major drawbacks are the lack of haptic feedback and high costs^[19].

Many believe that robotic-assisted liver resections (RLR) could be an advantageous technique allowing for accurate tissue dissection and easier intracorporeal sewing; furthermore, it is believed that RLR may allow for the better resection of lesions adjacent to major vessels, close to the liver hilum, or in difficult anatomic positions^[20]. However, its evolution to now is not what one would have expected for the LLR. Its use has been relatively unexplored, accounting for few reports with limited patient volume^[21-37].

As is the case of laparoscopic surgery, several reports have documented the clinical outcomes of robotic technique compared to open procedures^[18]. However, due to the limited number of reports comparing both techniques, it is not yet clear which method is more beneficial to the patient or the most useful for lesions located in difficult liver segments.

Considering the lack of consensus, the objective of this study was to perform a systematic review and meta-analysis on robotic-assisted versus laparoscopic liver resections for all type of liver lesions. The primary outcome measures were estimated blood loss, operative time, conversion rate, R1 resection rate, morbidity and mortality rates, hospital stay and major hepatectomy rates. The analysis was limited to humans and to articles reported in English language but no restriction was set for type of publication, date, or publication status.

MATERIALS AND METHODS

Literature search

PRISMA statement guidelines were followed for conducting and reporting meta-analysis data^[38]. PICOS scheme was followed for reporting inclusion criteria. A systematic literature search was performed independently by two of the authors (RM and GB) using PubMed, Scopus and the Cochrane Library Central. The search was limited to humans and to articles reported in English language. No restriction was set for type of publication, date, or publication status. Participants of any age and sex who underwent robotic or laparoscopic liver resection for all type of hepatic lesions were considered; robotic liver resections were considered as the Intervention group while the laparoscopic resections were considered as the comparator group according to the PICOS scheme. The search strategy was based on different combinations of words for each database. For the PubMed database the following combination was used: (Laparoscopic or laparoscopy or laparoscopically or minimally invasive) and (liver resection or liver resections or hepatectomy or hepatectomies or hepatic resection or hepatic resections or liver surgery) and (robotic OR robotically or robot or robot assistance or robot-assisted or robotic-assisted).

For the Scopus database the following combination was used: TITLE-ABS-KEY (Laparoscopic or laparoscopy or laparoscopically or “minimally invasive”) and TITLE-ABS-

KEY (“liver resection” or “liver resections” or hepatectomy OR hepatectomies or “hepatic resection” or “hepatic resections” or “liver surgery”) and TITLE-ABS-KEY (robotic or robotically or robot or “robot assistance” or “robot-assisted” or “robotic-assisted”).

The same key words were inserted in the search manager fields of the Cochrane Library Central. The search was further broadened by extensive cross-checking of reference lists of all retrieved articles fulfilling the inclusion criteria. For all databases, the last search was run on 07 July, 2014.

Study selection

The same two authors independently screened the titles and abstracts of the primary studies that were identified in the electronic search. Duplicate studies were excluded. The following inclusion criteria were set for inclusion in this meta-analysis: (1) Studies comparing robotic and laparoscopic liver resection for all types of hepatic lesions; (2) Studies reporting at least one perioperative outcome including blood loss, operative timing, conversion, mortality, morbidity, R1 resection rates, hospital stay and rate of major hepatectomies; and (3) If more than one study was reported by the same institute, only the most recent or the highest level of study was included.

The following exclusion criteria were set: (1) Original studies assessing the outcome of either laparoscopic or robotic liver resection; (2) Review articles, letters, comments and case reports; and (3) Studies where it was impossible to retrieve or calculate data of interest.

The Cohen kappa statistic was used to quantify agreement between the investigators.

Data extraction

The same two authors extracted the following main data (Table 1 and 2): (1) First author, year of publication and study type; (2) Number and characteristics of patients of both the laparoscopic and robotic resection groups; and (3) Treatment outcomes, including blood loss, operative timing, conversion, mortality, morbidity, R1 resection rates, hospital stay and rate of major hepatectomies. All relevant texts, tables and figures were reviewed for data

extraction; whenever further information was required, the corresponding authors of the papers were contacted by e-mail.

Discrepancies between the two reviewers were resolved by consensus discussion.

Risk of Bias

The Newcastle-Ottawa Scale was used for retrospective studies to assess quality. Funnel plots were constructed to assess the risk of publication bias across series for all outcome measures.

Statistical analysis

The meta-analysis was performed using RevMan software version 5.1. Odds ratios (OR) were used as a summary measure of efficacy for dichotomous data and mean differences (MD) between groups were used for continuous variables. A 95%CI was reported for both measures. If the study provided medians and interquartile ranges instead of means \pm SD, the means \pm SD were imputed, as described by Hozo *et al*[39]. The fixed-effect model was used when no heterogeneity was detected among studies, while the random-effect model was preferred when variance existed. Statistical heterogeneity was evaluated using the I^2 statistic. I^2 values of 0-25%, 25%-50% and $>$ 50% were considered as indicative of homogeneity, moderate heterogeneity and high heterogeneity, respectively. All statistical data were considered with a P -value $<$ 0.05. The statistical methods of this study were reviewed by Filippo Oropallo from National Statistical Institute of Italy.

RESULTS

Study selection

The literature search yielded 291 articles; after duplicate removal, 207 titles and abstracts were reviewed (Figure 1). Of these, 196 papers were excluded for the following reasons: 110 were not related to liver resections, 81 did not compare techniques, 3 were review articles and 2 were letters. Finally, eleven articles^[21,30,40-48] were selected for full-text review; of these, four more were excluded because of redundant series from the same institute^[40,42,44,48]. There was no disagreement regarding eligibility of full-text articles (Cohen kappa = 1). Finally, a total of

7 articles, dated between 2010 and 2014, fulfilled the selection criteria and were therefore included in this meta-analysis; all the articles finally selected were retrospective studies, of which two case-controls^[30, 46] and five comparative^[21,41,43,45,47]. All of the studies included a total of 694 patients: 479 who underwent laparoscopic liver resection and 215 cases of robotic liver resection. The characteristics of the included studies are summarized in Table 1. According to the NOS scale, the study quality was graded 9 for two publications (both 4+2+3 respectively for Selection, Comparability and Exposure measurements)^[21, 43], 8 for four (three 4+1+3^[41,45,47] and one 3+2+3^[46]) and 7 for one publication (3+1+3)^[30].

Three corresponding authors were contacted by e-mail for obtaining unpublished or unclear data ^[21, 30, 41] and of these, none responded addressing questions. The outcomes of interest of each single study are summarized in Table 2.

Estimated blood loss

Six of the included studies reported results regarding blood loss in both groups. An overall significant reduction in blood loss was observed in the laparoscopic group compared to the robotic one (MD = 83.96, 95%CI: 10.51 - 157.41, $P = 0.03$) (Figure 2).

Operative time

All articles were included to determine the overall effect regarding operative time. According to Figure 3, the laparoscopic approach was associated with a significantly lower operative time compared to the robotic technique (MD = 68.43, 95%CI: 39.22 - 97.65, $P < 0.00001$).

Conversion

Conversion was considered as switching to an open or hand assisted approach during the operation. Six of the seven papers included in the meta-analysis reported data regarding conversion, and no statistically significant overall differences were observed (OR = 1.19, 95%CI: 0.48 - 2.99, $P = 0.71$) (Figure 4).

R1 resection rate

No statistically significant difference was found between the two approaches with respect to the R1 resection rate, including four of the seven studies selected (OR = 1.71, 95%CI: 0.95 – 3.09, $P = 0.07$) (Figure 5).

Mortality and morbidity

Due to the different reporting methods in the single papers, overall results regarding mortality were impossible to calculate. In some articles, 30-day mortality was reported^[41], while in others, 90-day mortality was the measurement used^[43,46]; in some of the papers, no specification was given^[45,47]. Finally, two articles did not report any data on mortality^[21,30]. Regarding overall morbidity, data were reported in all of the included studies and no overall differences were observed (OR = 0.66, 95%CI: 0.40 – 1.09, $P = 0.10$) (Figure 6).

Hospital stay

Four of the seven included studies reported hospital stay outcomes. No overall differences were found between the two approaches (MD = 0.01, 95%CI: -0.15 – 0.17, $P = 0.89$, Figure 7).

Major hepatectomies rate

Due to the different classifications regarding major and minor hepatectomies and to the lack of reported data among studies, no overall effect was calculated. Specifically, two articles described only minor hepatectomies^[21,41], one described only major hepatectomies^[43]; one paper considered a major hepatectomy as the resection of 4 or more segments^[46] while three articles considered a major hepatectomy as the resection of 3 or more segments^[30,45,47].

Publication bias

Funnel plots were constructed for each outcome and showed symmetry, suggesting that publication bias was not large and was unlikely to drive conclusions (Figure 8A). Funnel plots regarding hospital stay showed substantial asymmetry (Figure 8B).

DISCUSSION

Laparoscopic liver resections are considered safe and effective in well-selected patients and have shown better results in terms of blood transfusion, postoperative hospital stay and morbidity compared to open surgery, as described in the thirteen reported meta-analyses^[49-61]. Several variants for the laparoscopic approach have been described, such as the pure laparoscopic, the hand-assisted, the hybrid and single-port techniques. Conversely, it is not yet clear whether robotic assistance demonstrates substantial advantage over the pure laparoscopic technique.

The robotic platform is a tool with which many of the limitations of conventional laparoscopic liver surgery can be overcome: two-dimensional imaging and tremor amplification, fulcrum effect against the port, limited degrees of freedom for manipulation and awkward ergonomics. Furthermore, the augmented dexterity enabled by the endowristed movements, the software filtration of surgeon's movements and the high-definition three-dimensional vision provided by the stereoscopic camera combine to guarantee a steady and careful dissection of the structures^[62]. Nevertheless, RLR has had a slower evolution over the last years; it does not currently provide some useful tools, such as an "endowristed" surgical aspirator or high-energy device that can fully exploit the potential of the movements and vision offered by the robot, especially when operating in a limited resection space (*i.e.*, when approaching P-S segments). Other potential limitations of RLR concern the need of an additional attending surgeon and the high costs of robot purchasing, instrumentation and annual maintenance. There are very few centers in the world that have performed a limited number of robotic liver resections on highly selected patients. The technique has not been standardized and it is questionable whether any of these centers have gone through the learning curve.

Few reports regarding laparoscopic and robotic liver resections have been published that have evaluated different outcomes and results among series; therefore, there has been difficulty not only in interpreting data but also in drawing final conclusions regarding the superiority of one approach over another. A meta-analysis, as a quantitative method for therapeutic evaluation, may be used when controversy persists in order to determine the results.

To our knowledge, this is the first systematic review and meta-analysis comparing robotics to laparoscopy for liver resections. In this analysis, it was possible to include only 7 studies containing 694 patients; all of these articles were retrospective of which 2 case-controls and 5 comparative; to date, this may represent the largest body of information available for the comparison of RLR and LLR. According to the Newcastle-Ottawa scale used for assessing quality of the studies, articles included in this meta-analysis were graded with 9^[21,43], 8^[41,45-47] or 7^[30], reflecting a high quality concerning selection of patients, comparability and exposure measurements.

The first laparoscopic liver resection was described by Gagner *et al*^[63] in 1992, whereas the first robotic liver resection was published in 2003 by Giulianotti *et al*^[64]. While the laparoscopic technique has had a worldwide spread since its introduction, the robotic technique has not had the same evolution, possibly due to the significant upfront costs and the different required learning curve. In 2010, Berber *et al*^[21] described the first study comparing the two methods. Since then, we have observed a progressive increase of publications, suggesting a growing interest in comparing both techniques. Unfortunately, in contrast with laparoscopic surgery, there have been no prospective randomized studies comparing laparoscopic and robotic techniques.

The results of the present meta-analysis shows a significant increase in bleeding in RLR. This may be explained by the different techniques used for liver transection. In fact, the most prevalent technique of hepatic transection used in LLR requires the use of a harmonic scalpel for superficial liver transection; in most of the cases and accordingly to the surgeon's preference, the Cavitron Ultrasonic Surgical Aspirator (CUSA) is used for deeper transection, which is a tool that allow a meticulous and precise dissection of the parenchymal structures. Conversely, robotic liver transection is mainly based on the crush-clamping technique, which requires, in most cases, the use of an intermittent inflow occlusion (Pringles manoeuvre). In this case, an increased ischemia/reperfusion injury should be anticipated when operating on a cirrhotic liver^[65].

Another difference we found was that the surgical time was significantly longer in robotic hepatectomy. The difference could be due to the different technique of hepatic

resection, but may also be because the robotic technique is more recent and requires greater experience and refinement; in addition, there may be a difference among standardization of the procedures and an obvious docking time of the system.

The rate of conversion was comparable between RLR and LLR, which most likely indicates a similar difficulty in approaching liver surgery.

The basic principle behind the oncological resection of malignant diseases is to keep a sufficient tumor-free margin in order to avoid incomplete tumor resection and possibly iatrogenic spread. Considering the fact that most of the indications for minimally invasive liver surgery are actually met in malignancies^[66], margin width is a major indicator in the quality of surgical resection. With the aim of highlighting any differences between the two techniques, the third end-point of our meta-analysis was the margin width. We found that the rate of R1 resection was not statistically different between the two techniques, although there was a trend towards decreased R1 resection margins in the LLR group. These data should be analyzed in more detail in future studies, which may suggest an increased difficulty in the identification of a tumoral lesion by intraoperative ultrasound (IOUS) with the robotic technique. A possible explanation for this is the fact that the surgeon who performs the ultrasound is not the same that performs hepatectomy at the robotic console. Only very recently robotic technology has provided an IOUS guided by the surgeon at the console.

According to our analysis, there was no statistically significant difference in the morbidity rate between the two analyzed techniques, although a trend toward a lower complication rate in the robotic group was observed. One might speculate that RLR offers increased surgical precision leading to meticulous dissection, individuation of small biliary structures, minimizing bile leaks and decreased overall post-operative complications. Unfortunately, we did not evaluate data in terms of the indicators of the degree of difficulty of a minimally invasive procedure performed using both approaches (i.e., resection of P-S segments or living donor hepatectomy). Therefore, we cannot conclude whether laparoscopy was performed for more technically difficult interventions or vice versa. To better characterize this issue, a comparative analysis between RLR and LLR for approaching the P-S segments is warranted.

Finally, the hospital stay showed similar results between the two techniques. These are both minimally invasive procedures; patients seem to have a comparable postoperative course. The two techniques seemed to be different for the surgeon but not for the patient.

The main limitation of this meta-analysis is that it is based on retrospective studies; only two of which are case-control studies. Another limitation of the study is that the included reports are highly heterogeneous in terms of disease indications, types of liver resection (minor or major) and location of liver lesions. One of the included articles was limited to liver resections for hepatocellular carcinoma^[47], one of them was limited to major hepatectomies ^[43], two of them were for minor hepatectomies only^[21,41], while four studies^[40,42,44,48] were excluded from the meta-analysis because a portion of the patients described had already been considered in other series from the same institutions. In this way, a substantial number of patients were excluded from the analysis.

Estimated blood loss and operative time were associated with significant heterogeneity between studies. Although we used the fixed or random-effects model, as appropriate, this bias was impossible to overcome.

In the present meta-analysis, we did not analyze the technical differences between the two methods in terms of trocars positioning, type/version of the robot, instrumentation for the transection of the liver, intraoperative ultrasound methodology, duration of hilar clamping, or other reported data because our outcomes were decided a priori, based on the highest clinically relevant end-points.

Moreover, in the present systematic review we did not find studies, which focused on cost assessment between RLR and LLR. Ji *et al*^[30] described a general hospital cost of \$12,046 per intervention for robotics and \$7,618 for the laparoscopic technique. Furthermore Packiam *et al*^[42], compared only the direct costs of the operating room supplies, resulting in \$5,130 *vs* \$4,408 for RLR and LLR, respectively. Future research should be directed to analyze cost differences between the two procedures.

No prospective randomized trials are reported, therefore, future research should be directed at performing prospective randomized trials comparing RLR to LLR. These prospective trials would have fewer ethical issues than the comparison to the open technique.

In fact, RLR and LLR are both minimally invasive approaches without differences in safety and efficacy.

Future research should aim to extrapolate differences in the learning curves between laparoscopic and robotic liver resection and propose a method to objectively assess the degree of difficulty in minimally invasive liver surgery; this will highlight the value of each technique, leading to better outcomes.

CONCLUSION

In summary, the results of this meta-analysis of retrospective studies, demonstrated that laparoscopic liver resection resulted in less blood loss and shorter surgical times compared to robotic liver resections. There was no difference in the conversion rate, R1 resection rate, morbidity and length of postoperative stay. Future research should be directed in comparing the two techniques, also in terms of cost analysis and learning curve, especially in a prospective randomized controlled fashion.

ARTICLE HIGHLIGHTS

At present, researchers often read a scientific paper in the order of title, abstract, keywords, introduction, materials and methods, results, discussion, conclusions, and references. However, this reading order is associated with many deficiencies, because most researchers are very busy and cannot read the entire paper carefully. In contrast, authors hope that readers will read their papers as carefully as possible at the earliest time after publication, and that this reading will give a meaningful understanding of the paper's topic so that the reader will repeat or cite their work.

In order to help more readers to find what they want to read in the shortest possible time, we have added a section known as 'Article Highlights' to every paper published by BPG journals; this section will appear before the References section. This new section will consist of summarized information on the research background, motivation, objectives, methods, results, conclusions, and perspectives; the subsections will be titled accordingly (*e.g., Research background, Research motivation, etc.*; see below). Each of these subsections should

be a clear and concise but sufficiently detailed summary of the information provided in the guidelines below (1-4 sentences for each subsection should suffice). This section should not be a verbatim (copy-paste) repeat of the full text in the manuscript's main text sections (*i.e.* Methods, Results, or Conclusion).

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Research background

The background, present status, and significance of the study should be described in detail.

Research motivation

The main topics, the key problems to be solved, and the significance of solving these problems for future research in this field should be described in detail.

Research objectives

The main objectives, the objectives that were realized, and the significance of realizing these objectives for future research in this field should be described in detail.

Research methods

The research methods (*e.g.*, experiments, data analysis, surveys, and clinical trials) that were adopted to realize the objectives, as well as the characteristics and novelty of these research methods, should be described in detail.

Research results

The research findings, their contributions to the research in this field, and the problems that remain to be solved should be described in detail.

Research conclusions

The most relevant of the following questions should be briefly answered:

What are the new theories that this study proposes?

What are the new methods that this study proposed?

Research perspectives

The most relevant of the following questions should be briefly answered:

What is the direction of the future research?

ACKNOWLEDGEMENTS

REFERENCES

- 1 **Reich H**, McGlynn F, DeCaprio J, Budin R. Laparoscopic excision of benign liver lesions. *Obstet Gynecol* 1991; **78**: 956-958 [PMID: 1833688]
- 2 **Nguyen KT**, Laurent A, Dagher I, Geller DA, Steel J, Thomas MT, Marvin M, Ravindra KV, Mejia A, Lainas P, Franco D, Cherqui D, Buell JF, Gamblin TC. Minimally invasive liver resection for metastatic colorectal cancer: a multi-institutional, international report of safety, feasibility, and early outcomes. *Ann Surg* 2009; **250**: 842-848 [PMID: 19806058 DOI: 10.1097/SLA.0b013e3181bc789c]
- 3 **Descottes B**, Glineur D, Lachachi F, Valleix D, Paineau J, Hamy A, Morino M, Bismuth H, Castaing D, Savier E, Honore P, Detry O, Legrand M, Azagra JS, Goergen M, Ceuterick M, Marescaux J, Mutter D, de Hemptinne B, Troisi R, Weerts J, Dallemagne B, Jhaes C, Gelin M, Donckier V, Aerts R, Topal B, Bertrand C, Mansvelt B, Van Krunkelsven L, Herman D, Kint M, Totte E, Schockmel R, Gigot JF. Laparoscopic liver resection of benign liver tumors. *Surg Endosc* 2003; **17**: 23-30 [PMID: 12364994 DOI: 10.1007/s00464-002-9047-8]
- 4 **Cherqui D**, Husson E, Hammoud R, Malassagne B, Stéphan F, Bensaid S, Rotman N, Fagniez PL. Laparoscopic liver resections: a feasibility study in 30 patients. *Ann Surg* 2000; **232**: 753-762 [PMID: 11088070]

- 5 **Cherqui D**, Soubrane O, Husson E, Barshasz E, Vignaux O, Ghimouz M, Branchereau S, Chardot C, Gauthier F, Fagniez PL, Houssin D. Laparoscopic living donor hepatectomy for liver transplantation in children. *Lancet* 2002; **359**: 392-396 [PMID: 11844509 DOI: 10.1016/S0140-6736(02)07598-0]
- 6 **Scatton O**, Katsanos G, Boillot O, Goumard C, Bernard D, Stenard F, Perdigao F, Soubrane O. Pure laparoscopic left lateral sectionectomy in living donors: from innovation to development in France. *Ann Surg* 2015; **261**: 506-512 [PMID: 24646560 DOI: 10.1097/SLA.0000000000000642]
- 7 **Troisi RI**, Wojcicki M, Tomassini F, Houtmeyers P, Vanlander A, Berrevoet F, Smeets P, Van Vlierberghe H, Rogiers X. Pure laparoscopic full-left living donor hepatectomy for calculated small-for-size LDLT in adults: proof of concept. *Am J Transplant* 2013; **13**: 2472-2478 [PMID: 23914734 DOI: 10.1111/ajt.12362]
- 8 **Hu BS**, Chen K, Tan HM, Ding XM, Tan JW. Comparison of laparoscopic vs open liver lobectomy (segmentectomy) for hepatocellular carcinoma. *World J Gastroenterol* 2011; **17**: 4725-4728 [PMID: 22180716 DOI: 10.3748/wjg.v17.i42.4725]
- 9 **Buell JF**, Cherqui D, Geller DA, O'Rourke N, Iannitti D, Dagher I, Koffron AJ, Thomas M, Gayet B, Han HS, Wakabayashi G, Belli G, Kaneko H, Ker CG, Scatton O, Laurent A, Abdalla EK, Chaudhury P, Dutson E, Gamblin C, D'Angelica M, Nagorney D, Testa G, Labow D, Manas D, Poon RT, Nelson H, Martin R, Clary B, Pinson WC, Martinie J, Vauthey JN, Goldstein R, Roayaie S, Barlet D, Espat J, Abecassis M, Rees M, Fong Y, McMasters KM, Broelsch C, Busuttil R, Belghiti J, Strasberg S, Chari RS. The international position on laparoscopic liver surgery: The Louisville Statement, 2008. *Ann Surg* 2009; **250**: 825-830 [PMID: 19916210]
- 10 **Montalti R**, Berardi G, Laurent S, Sebastiani S, Ferdinande L, Libbrecht LJ, Smeets P, Brescia A, Rogiers X, de Hemptinne B, Geboes K, Troisi RI. Laparoscopic liver resection compared to open approach in patients with colorectal liver metastases improves further resectability: Oncological outcomes of a case-control matched-pairs analysis. *Eur J Surg Oncol* 2014; **40**: 536-544 [PMID: 24555996 DOI: 10.1016/j.ejso.2014.01.005]

- 11 **Vigano L**, Laurent A, Tayar C, Tomatis M, Ponti A, Cherqui D. The learning curve in laparoscopic liver resection: improved feasibility and reproducibility. *Ann Surg* 2009; **250**: 772-782 [PMID: 19801926 DOI: 10.1097/SLA.0b013e3181bd93b2]
- 12 **Heemskerk J**, van Gemert WG, de Vries J, Greve J, Bouvy ND. Learning curves of robot-assisted laparoscopic surgery compared with conventional laparoscopic surgery: an experimental study evaluating skill acquisition of robot-assisted laparoscopic tasks compared with conventional laparoscopic tasks in inexperienced users. *Surg Laparosc Endosc Percutan Tech* 2007; **17**: 171-174 [PMID: 17581459 DOI: 10.1097/SLE.0b013e31805b8346]
- 13 **Maniar HS**, Council ML, Prasad SM, Prasad SM, Chu C, Damiano RJ. Comparison of skill training with robotic systems and traditional endoscopy: implications on training and adoption. *J Surg Res* 2005; **125**: 23-29 [PMID: 15836846 DOI: 10.1016/j.jss.2004.11.010]
- 14 **Moorthy K**, Munz Y, Dosis A, Hernandez J, Martin S, Bello F, Rockall T, Darzi A. Dexterity enhancement with robotic surgery. *Surg Endosc* 2004; **18**: 790-795 [PMID: 15216862 DOI: 10.1007/s00464-003-8922-2]
- 15 **Mucksavage P**, Kerbl DC, Lee JY. The da Vinci(®) Surgical System overcomes innate hand dominance. *J Endourol* 2011; **25**: 1385-1388 [PMID: 21815795 DOI: 10.1089/end.2011.0093]
- 16 **Carpenter SG**, Grimsby G, DeMasters T, Katariya N, Hewitt WR, Moss AA, Reddy KS, Castle EP, Mulligan DC. Robotic resection of choledochocoele in an adult with intracorporeal hepaticojejunostomy and Roux-en-Y anastomosis: Encouraging progress for robotic surgical treatment of biliary disease. *J Rob Surg* 2014; **8**: 77-80
- 17 **Kang CM**, Kim DH, Lee WJ. Ten years of experience with resection of left-sided pancreatic ductal adenocarcinoma: evolution and initial experience to a laparoscopic approach. *Surg Endosc* 2010; **24**: 1533-1541 [PMID: 20054579 DOI: 10.1007/s00464-009-0806-7]
- 18 **Brody F**, Richards NG. Review of robotic versus conventional laparoscopic surgery. *Surg Endosc* 2014; **28**: 1413-1424 [PMID: 24357422 DOI: 10.1007/s00464-013-3342-4]
- 19 **Hyung WJ**. [Robotic surgery in gastrointestinal surgery]. *Korean J Gastroenterol* 2007; **50**: 256-259 [PMID: 18159190]
- 20 **Abood GJ**, Tsung A. Robot-assisted surgery: improved tool for major liver resections? *J Hepatobiliary Pancreat Sci* 2013; **20**: 151-156 [PMID: 23053356 DOI: 10.1007/s00534-012-0560-4]

- 21 **Berber E**, Akyildiz HY, Aucejo F, Gunasekaran G, Chalikonda S, Fung J. Robotic versus laparoscopic resection of liver tumours. *HPB (Oxford)* 2010; **12**: 583-586 [PMID: 20887327 DOI: 10.1111/j.1477-2574.2010.00234.x]
- 22 **Casciola L**, Patrìti A, Ceccarelli G, Bartoli A, Ceribelli C, Spaziani A. Robot-assisted parenchymal-sparing liver surgery including lesions located in the posterosuperior segments. *Surg Endosc* 2011; **25**: 3815-3824 [PMID: 21656067 DOI: 10.1007/s00464-011-1796-9]
- 23 **Choi GH**, Choi SH, Kim SH, Hwang HK, Kang CM, Choi JS, Lee WJ. Robotic liver resection: technique and results of 30 consecutive procedures. *Surg Endosc* 2012; **26**: 2247-2258 [PMID: 22311301 DOI: 10.1007/s00464-012-2168-9]
- 24 **Choi SB**, Park JS, Kim JK, Hyung WJ, Kim KS, Yoon DS, Lee WJ, Kim BR. Early experiences of robotic-assisted laparoscopic liver resection. *Yonsei Med J* 2008; **49**: 632-638 [PMID: 18729307 DOI: 10.3349/ymj.2008.49.4.632]
- 25 **Giulianotti PC**, Coratti A, Sbrana F, Addeo P, Bianco FM, Buchs NC, Annechiarico M, Benedetti E. Robotic liver surgery: results for 70 resections. *Surgery* 2011; **149**: 29-39 [PMID: 20570305 DOI: 10.1016/j.surg.2010.04.002]
- 26 **Giulianotti PC**, Sbrana F, Bianco FM, Addeo P. Robot-assisted laparoscopic extended right hepatectomy with biliary reconstruction. *J Laparoendosc Adv Surg Tech A* 2010; **20**: 159-163 [PMID: 20201685 DOI: 10.1089/lap.2009.0383]
- 27 **Giulianotti PC**, Sbrana F, Coratti A, Bianco FM, Addeo P, Buchs NC, Ayloo SM, Benedetti E. Totally robotic right hepatectomy: surgical technique and outcomes. *Arch Surg* 2011; **146**: 844-850 [PMID: 21768432 DOI: 10.1001/archsurg.2011.145]
- 28 **Giulianotti PC**, Tzvetanov I, Jeon H, Bianco F, Spaggiari M, Oberholzer J, Benedetti E. Robot-assisted right lobe donor hepatectomy. *Transpl Int* 2012; **25**: e5-e9 [PMID: 22029717 DOI: 10.1111/j.1432-2277.2011.01373.x]
- 29 **Holloway RW**, Brudie LA, Rakowski JA, Ahmad S. Robotic-assisted resection of liver and diaphragm recurrent ovarian carcinoma: description of technique. *Gynecol Oncol* 2011; **120**: 419-422 [PMID: 20943259 DOI: 10.1016/j.ygyno.2010.09.007]

- 30 **Ji WB**, Wang HG, Zhao ZM, Duan WD, Lu F, Dong JH. Robotic-assisted laparoscopic anatomic hepatectomy in China: initial experience. *Ann Surg* 2011; **253**: 342-348 [PMID: 21135692 DOI: 10.1097/SLA.0b013e3181ff4601]
- 31 **Lai EC**, Tang CN, Li MK. Robot-assisted laparoscopic hemi-hepatectomy: technique and surgical outcomes. *Int J Surg* 2012; **10**: 11-15 [PMID: 22079835 DOI: 10.1016/j.ijssu.2011.10.005]
- 32 **Machado MA**, Makdissi FF, Surjan RC, Abdalla RZ. [First robotic-assisted laparoscopic liver resection in Latin America]. *Arq Gastroenterol* 2009; **46**: 78-80 [PMID: 19466315]
- 33 **Panaro F**, Piardi T, Cag M, Cinqualbre J, Wolf P, Audet M. Robotic liver resection as a bridge to liver transplantation. *JSLs* 2011; **15**: 86-89 [PMID: 21902950 DOI: 10.4293/108680811X13022985131417]
- 34 **Patriti A**, Ceccarelli G, Bartoli A, Spaziani A, Lapalorcia LM, Casciola L. Laparoscopic and robot-assisted one-stage resection of colorectal cancer with synchronous liver metastases: a pilot study. *J Hepatobiliary Pancreat Surg* 2009; **16**: 450-457 [PMID: 19322510 DOI: 10.1007/s00534-009-0073-y]
- 35 **Ryska M**, Fronck J, Rudis J, Jurenka B, Langer D, Pudil J. [Manual and robotic laparoscopic liver resection. Two case-reviews]. *Rozhl Chir* 2006; **85**: 511-516 [PMID: 17233179]
- 36 **Vasile S**, Sgarbură O, Tomulescu V, Popescu I. The robotic-assisted left lateral hepatic segmentectomy: the next step. *Chirurgia (Bucur)* 2008; **103**: 401-405 [PMID: 18780612]
- 37 **Wakabayashi G**, Sasaki A, Nishizuka S, Furukawa T, Kitajima M. Our initial experience with robotic hepato-biliary-pancreatic surgery. *J Hepatobiliary Pancreat Sci* 2011; **18**: 481-487 [PMID: 21487755 DOI: 10.1007/s00534-011-0388-3]
- 38 **Liberati A**, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med* 2009; **6**: e1000100 [PMID: 19621070 DOI: 10.1371/journal.pmed.1000100]
- 39 **Hozo SP**, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. *BMC Med Res Methodol* 2005; **5**: 13 [PMID: 15840177 DOI: 10.1186/1471-2288-5-13]

- 40 **Lai ECH**, Tang CN, Li MKW. Conventional laparoscopic and robot-assisted laparoscopic liver resection for benign and malignant pathologies: A cohort study. *J Rob Surg* 2012; **6**: 295-300
- 41 **Lai ECH**, Yang GPC, Tang CN. Robot-assisted laparoscopic liver resection for hepatocellular carcinoma: Short-term outcome. *Am J Surg* 2013; **205**: 697-702 [PMID: 23561638 DOI: 10.1016/j.amjsurg.2012.08.015]
- 42 **Packiam V**, Bartlett DL, Tohme S, Reddy S, Marsh JW, Geller DA, Tsung A. Minimally invasive liver resection: robotic versus laparoscopic left lateral sectionectomy. *J Gastrointest Surg* 2012; **16**: 2233-2238 [PMID: 23054901 DOI: 10.1007/s11605-012-2040-1]
- 43 **Spampinato MG**, Coratti A, Bianco L, Caniglia F, Laurenzi A, Puleo F, Ettorre GM, Boggi U. Perioperative outcomes of laparoscopic and robot-assisted major hepatectomies: an Italian multi-institutional comparative study. *Surg Endosc* 2014; **28**: 2973-2979 [PMID: 24853851 DOI: 10.1007/s00464-014-3560-4]
- 44 **Tranchart H**, Ceribelli C, Ferretti S, Dagher I, Patrity A. Traditional versus robot-assisted full laparoscopic liver resection: a matched-pair comparative study. *World J Surg* 2014; **38**: 2904-2909 [PMID: 24984879 DOI: 10.1007/s00268-014-2679-8]
- 45 **Troisi RI**, Patrity A, Montalti R, Casciola L. Robot assistance in liver surgery: a real advantage over a fully laparoscopic approach? Results of a comparative bi-institutional analysis. *Int J Med Robot* 2013; **9**: 160-166 [PMID: 23526589 DOI: 10.1002/rcs.1495]
- 46 **Tsung A**, Geller DA, Sukato DC, Sabbaghian S, Tohme S, Steel J, Marsh W, Reddy SK, Bartlett DL. Robotic versus laparoscopic hepatectomy: a matched comparison. *Ann Surg* 2014; **259**: 549-555 [PMID: 24045442 DOI: 10.1097/sla.0000000000000250]
- 47 **Wu YM**, Hu RH, Lai HS, Lee PH. Robotic-assisted minimally invasive liver resection. *Asian J Surg* 2014; **37**: 53-57 [PMID: 24642128 DOI: 10.1016/j.asjsur.2014.01.015]
- 48 **Lai ECH**, Tang CN, Yang GPC, Li MKW. Multimodality laparoscopic liver resection for hepatic malignancy - From conventional total laparoscopic approach to robot-assisted laparoscopic approach. *Int J Surg* 2011; **9**: 324-328 [PMID: 21334468 DOI: 10.1016/j.ijsu.2011.02.004]

- 49 **Croome KP**, Yamashita MH. Laparoscopic vs open hepatic resection for benign and malignant tumors: An updated meta-analysis. *Arch Surg* 2010; **145**: 1109-1118 [PMID: 21079101 DOI: 10.1001/archsurg.2010.227]
- 50 **Beal SM**, Finch CF. An overview of retrospective case-control studies investigating the relationship between prone sleeping position and SIDS. *J Paediatr Child Health* 1991; **27**: 334-339 [PMID: 1836736]
- 51 **Mirnezami R**, Mirnezami AH, Chandrakumaran K, Abu Hilal M, Pearce NW, Primrose JN, Sutcliffe RP. Short- and long-term outcomes after laparoscopic and open hepatic resection: systematic review and meta-analysis. *HPB (Oxford)* 2011; **13**: 295-308 [PMID: 21492329 DOI: 10.1111/j.1477-2574.2011.00295.x]
- 52 **Mizuguchi T**, Kawamoto M, Meguro M, Shibata T, Nakamura Y, Kimura Y, Furuhata T, Sonoda T, Hirata K. Laparoscopic hepatectomy: a systematic review, meta-analysis, and power analysis. *Surg Today* 2011; **41**: 39-47 [PMID: 21191689 DOI: 10.1007/s00595-010-4337-6]
- 53 **Rao A**, Rao G, Ahmed I. Laparoscopic or open liver resection? Let systematic review decide it. *Am J Surg* 2012; **204**: 222-231 [PMID: 22245507 DOI: 10.1016/j.amjsurg.2011.08.013]
- 54 **Li N**, Wu YR, Wu B, Lu MQ. Surgical and oncologic outcomes following laparoscopic versus open liver resection for hepatocellular carcinoma: A meta-analysis. *Hepatol Res* 2012; **42**: 51-59 [PMID: 21988222 DOI: 10.1111/j.1872-034X.2011.00890.x]
- 55 **Zhou YM**, Shao WY, Zhao YF, Xu DH, Li B. Meta-analysis of laparoscopic versus open resection for hepatocellular carcinoma. *Dig Dis Sci* 2011; **56**: 1937-1943 [PMID: 21259071 DOI: 10.1007/s10620-011-1572-7]
- 56 **Xiong JJ**, Altaf K, Javed MA, Huang W, Mukherjee R, Mai G, Sutton R, Liu XB, Hu WM. Meta-analysis of laparoscopic vs open liver resection for hepatocellular carcinoma. *World J Gastroenterol* 2012; **18**: 6657-6668 [PMID: 23236242 DOI: 10.3748/wjg.v18.i45.6657]
- 57 **Yin Z**, Fan X, Ye H, Yin D, Wang J. Short- and long-term outcomes after laparoscopic and open hepatectomy for hepatocellular carcinoma: a global systematic review and meta-analysis. *Ann Surg Oncol* 2013; **20**: 1203-1215 [PMID: 23099728 DOI: 10.1245/s10434-012-2705-8]

- 58 **Wei M**, He Y, Wang J, Chen N, Zhou Z, Wang Z. Laparoscopic versus open hepatectomy with or without synchronous colectomy for colorectal liver metastasis: a meta-analysis. *PLoS One* 2014; **9**: e87461 [PMID: 24489916 DOI: 10.1371/journal.pone.0087461]
- 59 **Zhou Y**, Xiao Y, Wu L, Li B, Li H. Laparoscopic liver resection as a safe and efficacious alternative to open resection for colorectal liver metastasis: a meta-analysis. *BMC Surg* 2013; **13**: 44 [PMID: 24083369 DOI: 10.1186/1471-2482-13-44]
- 60 **Rao A**, Rao G, Ahmed I. Laparoscopic left lateral liver resection should be a standard operation. *Surg Endosc* 2011; **25**: 1603-1610 [PMID: 21136115 DOI: 10.1007/s00464-010-1459-2]
- 61 **Rao AM**, Ahmed I. Laparoscopic versus open liver resection for benign and malignant hepatic lesions in adults. *Cochrane Database Syst Rev* 2013; **5**: CD010162 [PMID: 23728700 DOI: 10.1002/14651858.CD010162.pub2]
- 62 **Kitisin K**, Packiam V, Bartlett DL, Tsung A. A current update on the evolution of robotic liver surgery. *Minerva Chir* 2011; **66**: 281-293 [PMID: 21873962]
- 63 **Gagner M**, Rheault M, Dubuc J. Laparoscopic partial hepatectomy for liver tumor. *Surg Endosc* 1992; **6**: 99
- 64 **Giulianotti PC**, Coratti A, Angelini M, Sbrana F, Cecconi S, Balestracci T, Caravaglios G. Robotics in general surgery: personal experience in a large community hospital. *Arch Surg* 2003; **138**: 777-784 [PMID: 12860761 DOI: 10.1001/archsurg.138.7.777]
- 65 **Sugiyama Y**, Ishizaki Y, Imamura H, Sugo H, Yoshimoto J, Kawasaki S. Effects of intermittent Pringle's manoeuvre on cirrhotic compared with normal liver. *Br J Surg* 2010; **97**: 1062-1069 [PMID: 20632273 DOI: 10.1002/bjs.7039]
- 66 **Nguyen KT**, Gamblin TC, Geller DA. World review of laparoscopic liver resection-2,804 patients. *Ann Surg* 2009; **250**: 831-841 [PMID: 19801936 DOI: 10.1097/SLA.0b013e3181b0c4df]

Footnotes

Conflict-of-interest statement: The authors deny any conflict of interest.

PRISMA 2009 Checklist statement:

Figure Legends

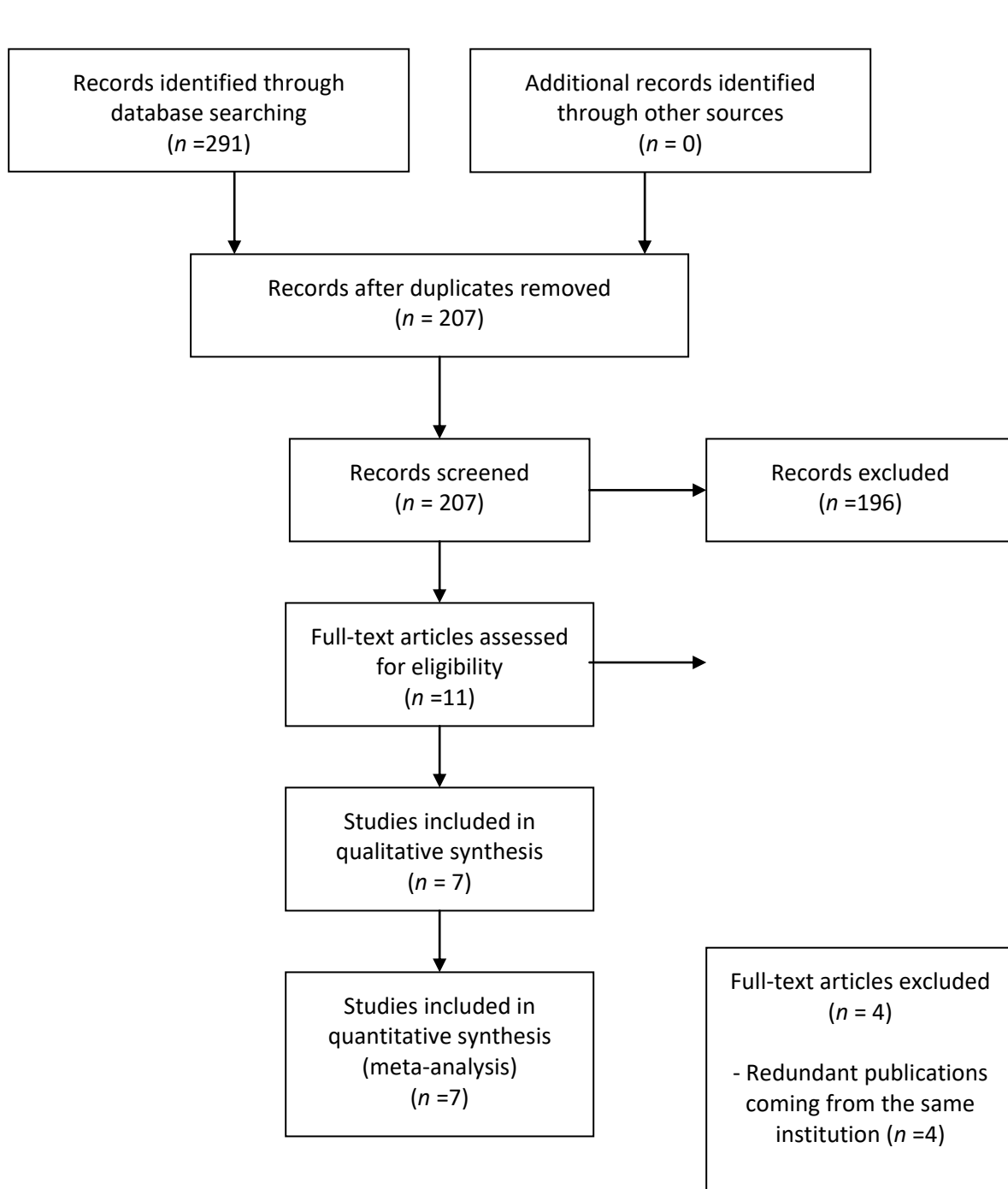


Figure 1 Study selection.

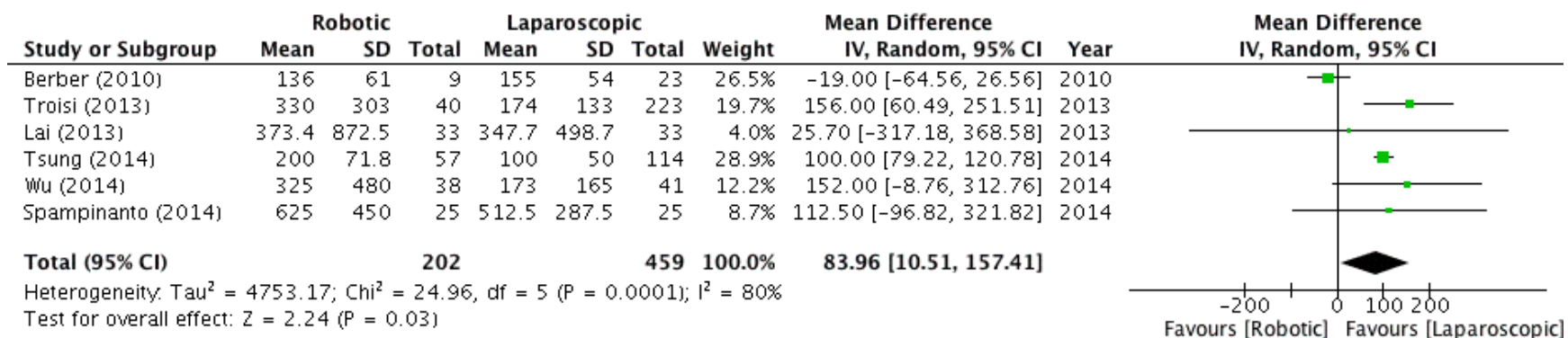


Figure 2 Meta-analysis Forest plot concerning estimated blood loss.

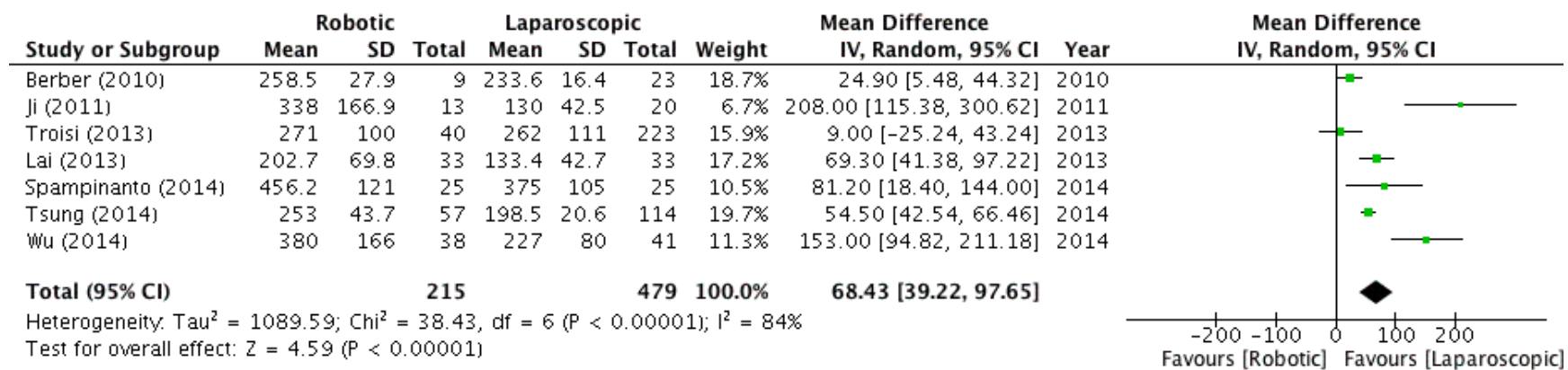


Figure 3 Meta analysis Forest plot concerning operative time.

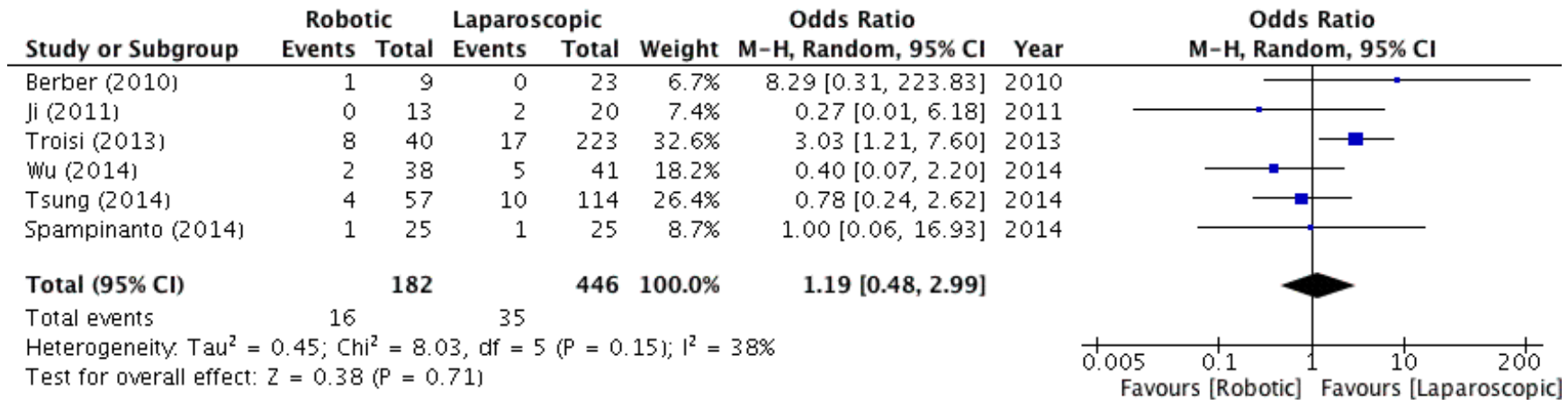


Figure 4 Meta-analysis Forest plot concerning conversion.

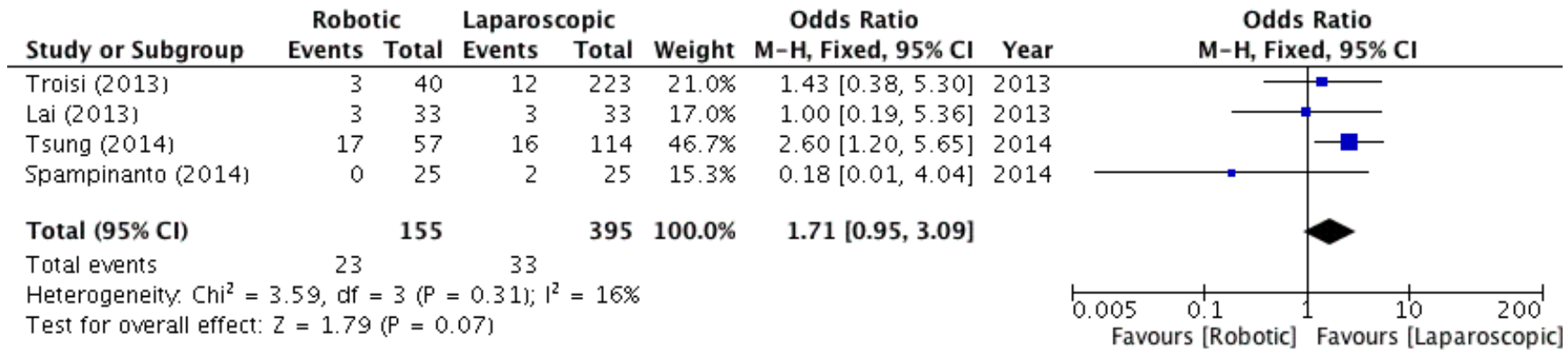


Figure 5 Meta-analysis Forest plot concerning R1 resection rate.

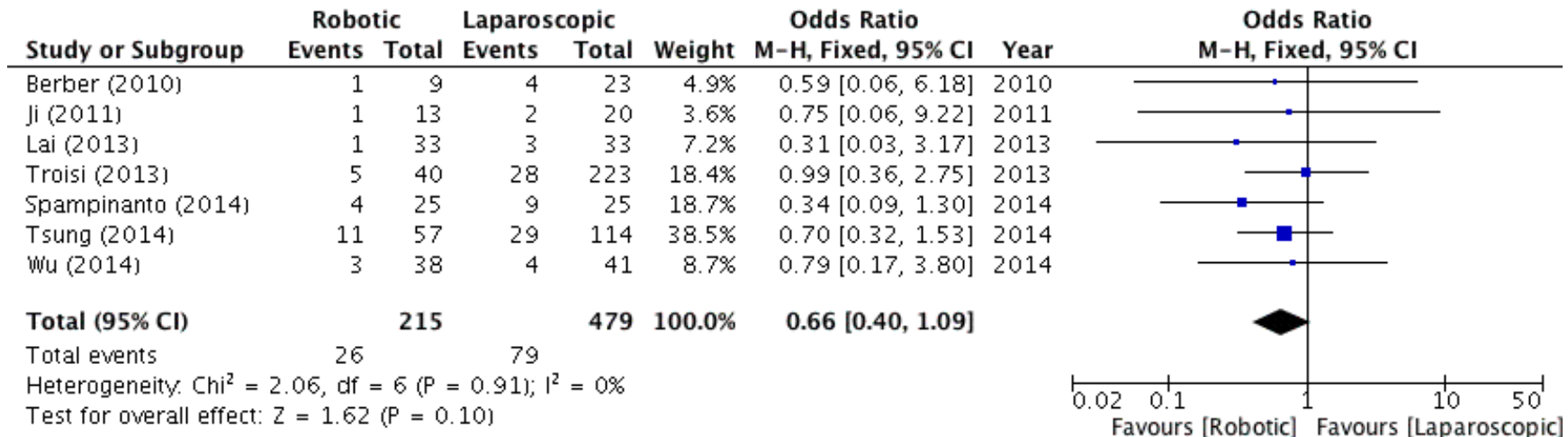


Figure 6 Meta-analysis Forest plot concerning morbidity.

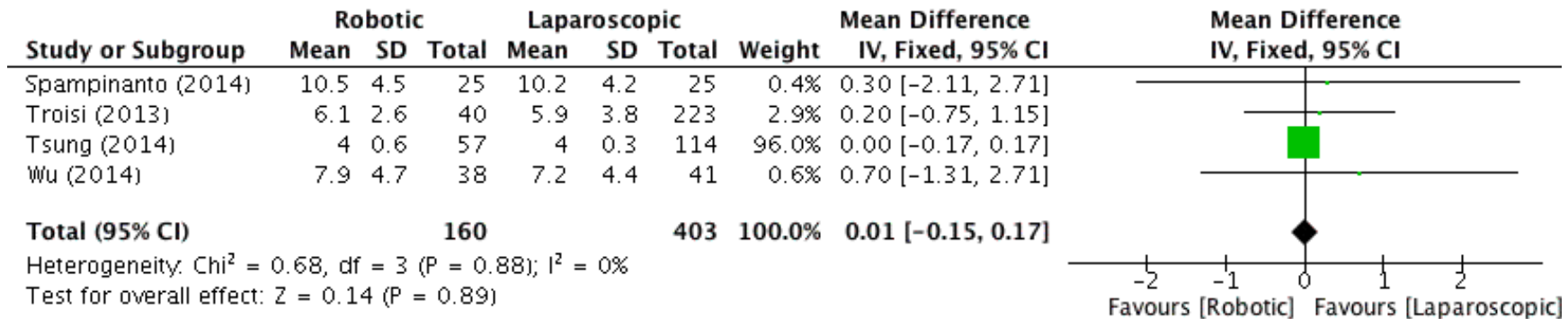


Figure 7 Meta-analysis Forest plot concerning hospital stay.

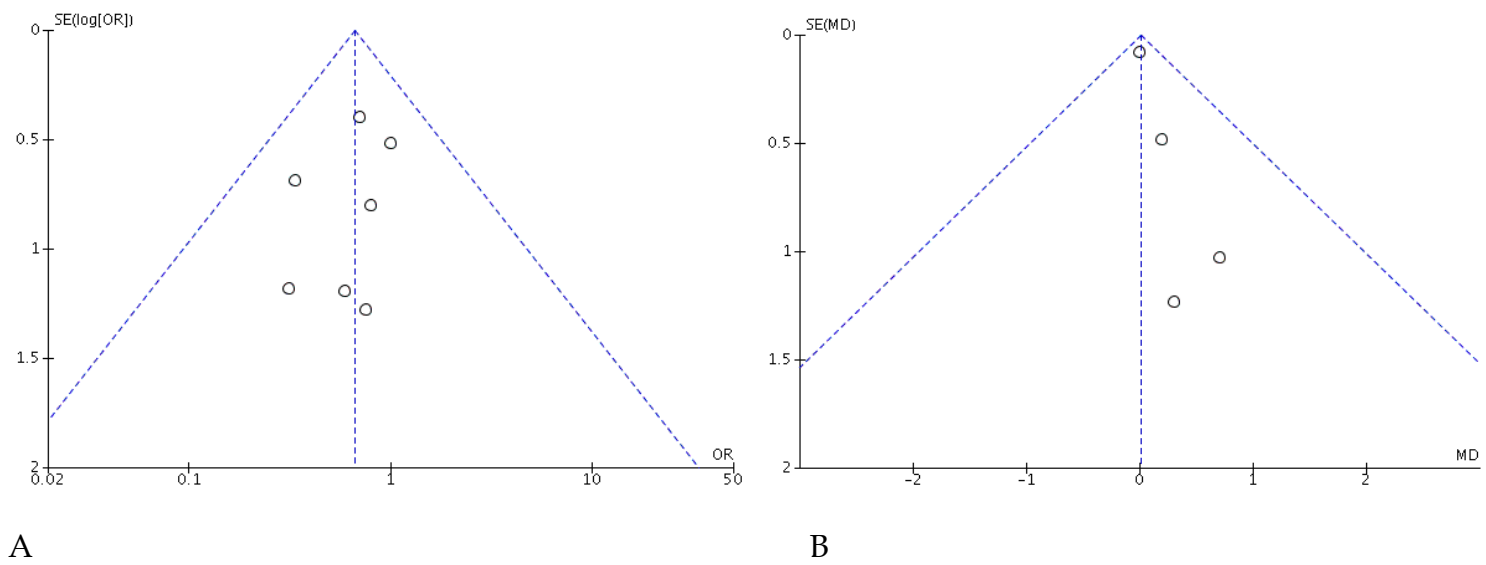


Figure 8 Funnel plot of morbidity (A) and hospital stay (B) in all included studies.

Table 1 Characteristics of included studies

Ref.	Country	Type of study	Total n. of patients	Laparoscopic liver resection			Robotic liver resection			Score of study quality ³
				No. of patients	Age	M/F	No. of patients	Age	M/F	
Berber <i>et al</i> ^[21]	United States	Retro/Comparative	32	23	66.7 ± 9.6 ¹	12/11	9	66.6±6.4	7/2	4+2+3
Ji <i>et al</i> ^[30]	China	Retro/Case-control	33	20	NR	NR	13	53 (39-79) ²	9/4	3+1+3
Troisi <i>et al</i> ^[45]	Belgium-Italy	Retro/Comparative	263	223	55.3 ± 15.7	98/125	40	64.6 ± 12.1	± 27/13	4+1+3
Lai <i>et al</i> ^[41]	China	Retro/Comparative	66	33	NR	NR	33	NR	NR	4+1+3
Wu <i>et al</i> ^[47]	Taiwan	Retro/Comparative	79	41	54.1 ± 14	28/13	38	60.9 ± 14.9	± 32/6	4+1+3
Tsung <i>et al</i> ^[46]	United States	Retro/Case-control	171	114	58.7 ± 15.8	47/67	57	58.3 ± 14.6	± 24/33	3+2+3
Spampinato <i>et al</i> ^[43]	Italy	Retro/Comparative	50	25	62 (33-80) ²	10/15	25	63 (32-80)	13/12	4+2+3

¹Data expressed as mean \pm SD; ²Data expressed as Median (Range); ³According to the NOS (Newcastle-Ottawa Scale) classification.

Retro: retrospective; NR: not reported.

Table 2 Raw data of each included study

First author		Blood loss (mL)	Operative time (min)	Conversion	Morbidity	R1 rate	Hospital stay (d)
Berber <i>et al</i> ^[21]							
Laparoscopic resection	liver	155 ± 54	233.6 ± 16.4	0%	17%	NR	NR
Robotic liver resection		136 ± 61	258.5 ± 27.9	11.10%	11%	NR	NR
Ji <i>et al</i> ^[30]							
Laparoscopic resection	liver	NA	130 ± 42.5	10%	10%	NR	NA
Robotic liver resection		NA	338 ± 166.9	0%	7.80%	NR	NA
Troisi <i>et al</i> ^[45]							
Laparoscopic resection	liver	174 ± 133	262 ± 111	7.60%	12.60%	5.40%	5.9 ± 3.8
Robotic liver resection		330 ± 303	271 ± 100	20%	12.50%	7.50%	6.1 ± 2.6
Lai <i>et al</i> ^[41]							
Laparoscopic resection	liver	347.7 ± 498.7	133.4 ± 42.7	NR	9%	9.10%	NR

Robotic liver resection	373.4 ± 872	202.7 ± 69.8	NR	3%	9.10%	NR
<i>Wu et al</i> ^[47]						
Laparoscopic liver resection	173 ± 165	227 ± 80	12.20%	10%	NR	7.2 ± 4.4
Robotic liver resection	325 ± 480	380 ± 166	5%	8%	NR	7.9 ± 4.7
<i>Tsung et al</i> ^[46]						
Laparoscopic liver resection	100 ± 50	198.5 ± 20.6	8.80%	26%	8%	4 ± 0.3
Robotic liver resection	200 ± 71.8	253 ± 43.7	7%	19.30%	5%	4 ± 0.6
<i>Spampinato et al</i> ^[43]						
Laparoscopic liver resection	512.5 ± 287.5	375 ± 105	4%	36%	9%	10.2 ± 4.2
Robotic liver resection	625 ± 450	456.2 ± 121	4%	16%	0%	10.5 ± 4.5

NR: Not reported; NA: Not assessable.