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SINGLE-PORT RESECTION VERSUS MULTIPORT LAPAROSCOPY: A SYSTEMATIC REVIEW OF ACCESS, SAFETY AND ONCOLOGICAL MARGINS IN DIFFICULT-TO-ACCESS TUMORS

RESSECÇÃO POR PORTA ÚNICA VERSUS LAPAROSCOPIA MULTIPORTA: UMA REVISÃO SISTEMÁTICA SOBRE ACESSO, SEGURANÇA E MARGENS ONCOLÓGICAS EM TUMORES DE DIFICIL ACESSO

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Abstract

Background: Minimally invasive oncologic surgery has been developed to minimize abdominal wall trauma using single-port laparoscopy. Nonetheless, in tumors in anatomically difficult areas such as posterior liver segments, the deep pelvis and upper mediastinum issues, there remain concerns over the instrument triangulation, exposure and integrity of the oncological margins. This systematic review critically analyzes the comparative feasibility of access, perioperative safety and oncological adequacy of single-port laparoscopic versus multiport laparoscopic resection of difficult-to-access solid tumors. Methods: A systematic review was carried out based on PRISMA guidelines. Pubmed, scopus, web of science and Cochrane library were searched from 2016 to april 2026 using the terms single-port laparoscopy, multiport laparoscopy, oncological margins and difficult access tumours. Adults that reported oncological or perioperative outcomes of solid tumor resections were eligible to participate in comparative and cohort studies. Cases, pediatric studies and non-oncological procedures were excluded. The outcomes of interest were the R0 resection rates, open surgery conversion, operative time, complication rates and margin width. Findings: Forty-eight studies were included that included randomized controlled trials, propensity-matched cohorts and registry analyses. There was heterogeneous and mainly retrospective evidence. Single-port laparoscopy was found to have R0 resection rates similar to multiport laparoscopy (range 88% to 100%) and less early postoperative pain and length of stay. Nevertheless, single-port methods proved to be more conversion-efficient (up to 35% in extended pancreatic resections) and have smaller parenchymal margins (e.g., 5 mm vs. 9.5 mm in posterosuperior liver segments, p=0.012). Registry data showed that single-port transanal total mesorectal excision was associated with a better sphincter preservation in low rectal cancer without a loss of circumferential resection margin positivity (5.1% vs. 5.4, odds ratio 4.11, p<0.001) which is a niche in which single-port access has an anatomical benefit. Multiport laparoscopy was always associated with better triangulation and lower intraoperative difficulty scores and conversion rates were less than 10% in even complex hepatectomy and pancreatectomy groups. Conclusions: Laparoscopy (single-port) has significant recovery and cosmetic advantages in well-selected patients who have peripherally located

Resumo

Antecedentes: A cirurgia oncológica minimamente invasiva foi desenvolvida para minimizar o trauma da parede abdominal por meio da laparoscopia de porta única. No entanto, em tumores localizados em áreas anatomicamente complexas, como os segmentos posteriores do fígado, a pelve profunda e o mediastino superior, persistem preocupações quanto à triangulação dos instrumentos, à exposição e à integridade das margens oncológicas. Esta revisão sistemática analisa criticamente a viabilidade comparativa do acesso, a segurança perioperatória e a adequação oncológica da ressecção laparoscópica de porta única versus a ressecção laparoscópica multiportas de tumores sólidos de difícil acesso. Métodos: Foi realizada uma revisão sistemática com base nas diretrizes PRISMA. As bases de dados PubMed, Scopus, Web of Science e Cochrane Library foram pesquisadas de 2016 a abril de 2026 utilizando os termos laparoscopia de porta única, laparoscopia multiportas, margens oncológicas e tumores de difícil acesso. Adultos que relataram resultados oncológicos ou perioperatórios de ressecções de tumores sólidos foram elegíveis para participar de estudos comparativos e de coorte. Casos, estudos pediátricos e procedimentos não oncológicos foram excluídos. Os desfechos de interesse foram as taxas de ressecção R0, conversão para cirurgia aberta, tempo operatório, taxas de complicações e largura da margem. Resultados: Foram incluídos 48 estudos, entre os quais ensaios clínicos randomizados, coortes com pareamento por propensão e análises de registros. As evidências eram heterogêneas e, em sua maioria, retrospectivas. Verificou-se que a laparoscopia de porta única apresentava taxas de ressecção R0 semelhantes às da laparoscopia multiportas (variação de 88% a 100%) e menor dor pós-operatória precoce e menor tempo de internação. No entanto, os métodos de porta única mostraram-se mais eficientes em termos de conversão (até 35% em ressecções pancreáticas estendidas) e apresentaram margens parenquimatosas menores (por exemplo, 5 mm vs. 9,5 mm nos segmentos posterossuperiores do fígado, p=0,012). Dados de registros mostraram que a excisão mesorretal total transanal de porta única foi associada a uma melhor preservação do esfíncter no câncer de reto inferior, sem perda da positividade da margem de ressecção circunferencial (5,1% vs. 5,4%, odds ratio 4,11, p < 0,001), o que constitui

tumors. Nevertheless, in lesions in anatomically limited areas where precision of margins and dexterity of the instruments are of paramount importance, multiport laparoscopy is the more dependable platform. The existing evidence has shortcomings in terms of selection bias and lack of long-term oncological follow-up. Evidence-based indications are urgently needed and randomized trials that are high quality and stratified by tumor location and difficulty are needed.

Keywords: Laparoscopy (Single-Port Laparoscopy). Laparoscopy (Multiport Laparoscopy). Oncological Margins. Minimally Invasive Surgery. Challenging Access Tumors.

um nicho em que o acesso de porta única apresenta benefício anatômico. A laparoscopia multiportas esteve sempre associada a melhor triangulação e a menores escores de dificuldade intraoperatória, e as taxas de conversão foram inferiores a 10% mesmo nos grupos de hepatectomia e pancreatectomia complexas. Conclusões: A laparoscopia (de porta única) apresenta vantagens significativas em termos de recuperação e estética em pacientes bem selecionados com tumores localizados na periferia. No entanto, em lesões em áreas anatomicamente limitadas, onde a precisão das margens e a destreza dos instrumentos são de suma importância, a laparoscopia multiportas é a plataforma mais confiável. As evidências existentes apresentam deficiências em termos de viés de seleção e falta de acompanhamento oncológico de longo prazo. São urgentemente necessárias indicações baseadas em evidências, bem como ensaios randomizados de alta qualidade e estratificados por localização e dificuldade do tumor.

Palavras-chave: *Laparoscopia (Laparoscopia de Porta Única). Laparoscopia (Laparoscopia Multiportas). Margens Oncológicas. Cirurgia Minimamente Invasiva. Tumores de Acesso Difícil.*

1 INTRODUCTION

The global cancer incidence of solid organs is on the increase and it is estimated that 20 million new cancer cases will be diagnosed in 2022 (Bray *et al*., 2024). At the same time, the minimally invasive surgical methods have developed out of the traditional multiport laparoscopy to the more sophisticated single-port surgery due to the quest to achieve less abdominal wall trauma, better cosmetic results and faster recovery after surgery (Morales-Conde *et al*., 2019). The theoretical benefits of single-port laparoscopy, i.e., a single fascial incision and less parietal damage, have been confirmed in several studies on colorectal cancer that have shown a decrease in early postoperative pain and a decrease in hospital stay (Yuan *et al*., 2021; Song *et al*., 2021). Nonetheless, it is still debatable how these advantages can be translated to tumor sites that are anatomically challenging.

The unique surgical exigencies are those of difficult-to-access tumors, i.e. lesions located in posterosuperior hepatic segments (segments VII and VIII), deep pelvis, total mesorectal excision, pancreatic head and uncinate process, the retroperitoneal adrenal and renal upper poles and mediastinal esophagus. The skill to attain safe dissection planes, sustain visualization and attain histologically negative margins is most critical in such situations. By triangulation of instruments and independent port positioning, multiport laparoscopy has ergonomic benefits that can help address technical limitations of restricted operating areas. Single-port surgery, in turn, presents intrinsic problems such as crowding of instruments, loss of triangulation and loss of degrees of freedom, potentially affecting the accuracy when exposure is already constrained (Morales-Conde *et al*., 2019).

Margin-negative resection (R0) is an oncological imperative that is unquestionable in tumor types. Circumferential resection margin (CRM) has been shown to be a strong predictor of local recurrence and disease-free survival in rectal cancer. Surgical margin (SMW) and recurrence risk in hepatocellular carcinoma are linked to the liver cirrhosis, where parenchymal preservation is in conflict with oncological clearance (Seo *et al*., 2024). Likewise, R0 resection is the only potentially curative procedure in case of pancreatic ductal adenocarcinoma. The issue of whether laparoscopy can be used in single-port to provide R0 resections in challenging anatomical sites without affecting safety is thus of great clinical interest.

Single-port versus multiport surgery in colorectal cancer and gynecological malignancies have been the focus of systematic reviews in past with most finding non-inferiority in chosen cohorts (Yuan *et al*., 2021; Ji *et al*., 2024). Nevertheless, these studies have mostly focused on studies that have positive tumor features and have not specifically focused on the interaction between surgical approach and anatomical difficulty. There is a lack of long-term oncological outcomes, especially of tumors that involve complicated dissections (Watanabe *et al*., 2021). Moreover, the fast implementation of robotic platforms has also added to the confounding factors since robotic assistance can alleviate certain constraints of single-port instrumentation but also introduce new cost and access factors (Sijberden *et al*., 2024).

This systematic review aims to critically assess and compare single-port and multiport laparoscopic methods specifically in case of hard-to-reach solid tumors and a

three-facet emphasis on the possibility of surgical access, perioperative safety rates and sufficiency of margins. We will combine evidence in different organ systems and tumor sites to outline the conditions in which each method can be used to the best and highlight the gaps in existing literature.

2 METHODS

2.1 Protocol and registration

The systematic review was done and reported following the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The protocol of the review was prospectively registered at the International Prospective Register of Systematic Reviews.

2.2 Search strategy

A thorough literature search was conducted in PubMed, Scopus, Web of Science and Cochrane Central Register of Controlled Trials since the database 2016 until april 2026. The search strategy was a combination of Medical Subject Headings (MeSH) and free-text words, such as single-port laparoscopy, single-incision laparoscopic surgery, multiport laparoscopy, conventional laparoscopy, oncological margins, R0 resection, difficult access tumors, posterosuperior liver segments, low rectal cancer, pancreaticoduodenectomy and minimally The entire PubMed search strategy is given in Supplementary Table S1. Manual screening of reference lists of included studies and other relevant systematic reviews was done to identify other eligible publications.

2.3 Eligibility criteria

To be included in studies, the following inclusion criteria were required: (1) comparative studies (randomized controlled trials, prospective or retrospective cohort studies, case-control studies) or single-arm cohort studies with 20 or more patients; (2) adult patients (≥18 years) undergoing laparoscopic resection of solid tumors; (3) direct or

indirect comparison of single Inclusion criteria included: case reports, small case series (n<20), pediatric trials, non-oncological surgeries, studies that only used robotic surgery with no laparoscopic comparator arms and those that were not written in English.

2.4 Selection of the studies and extraction of data

Titles and abstracts were screened using **Covidence** systematic review software against eligibility criteria by two independent reviewers. Potentially eligible articles were identified and independently evaluated by retrieving full-text articles. Any disagreements were settled by discussion or by adjudication by a third reviewer. The data were coded into a standardized, pre-piloted form that included the characteristics of the study (first author, year, country, design, sample size), patient demographics, tumor characteristics, surgical approach and outcomes (R0 resection rates, margin distance, conversion rate, operative time, estimated blood loss, length of stay and postoperative complications graded by Clavien-Dindo).

2.5 Risk of bias evaluation

The risk of bias of randomized controlled trials was evaluated by Cochrane Risk of Bias 2 (RoB 2) tool in five areas which include randomization process, non-adherence to intended interventions, missing outcome data, outcome measurement and choice of reported results. Non-randomized studies were assessed with help of the Risk Of Bias In Non-randomised Studies of Interventions (ROBINS-I) tool that takes into account the confounding, selection, intervention, deviations, missing data, outcome measurement and selective reporting. Two reviewers conducted risk of bias evaluations.

2.6 Data synthesis

Due to the high level of heterogeneity in types of tumors, their locations and definition of outcomes among the included studies, a narrative synthesis was performed. Findings were arranged thematically based on the accessibility of surgeries, safety of

perioperative and oncological margins. Summary statistics were tabulated where possible to enable comparison of studies.

3 RESULTS

3.1 Selection and characteristics of the studies

Figure 1

PRISMA Flow chart

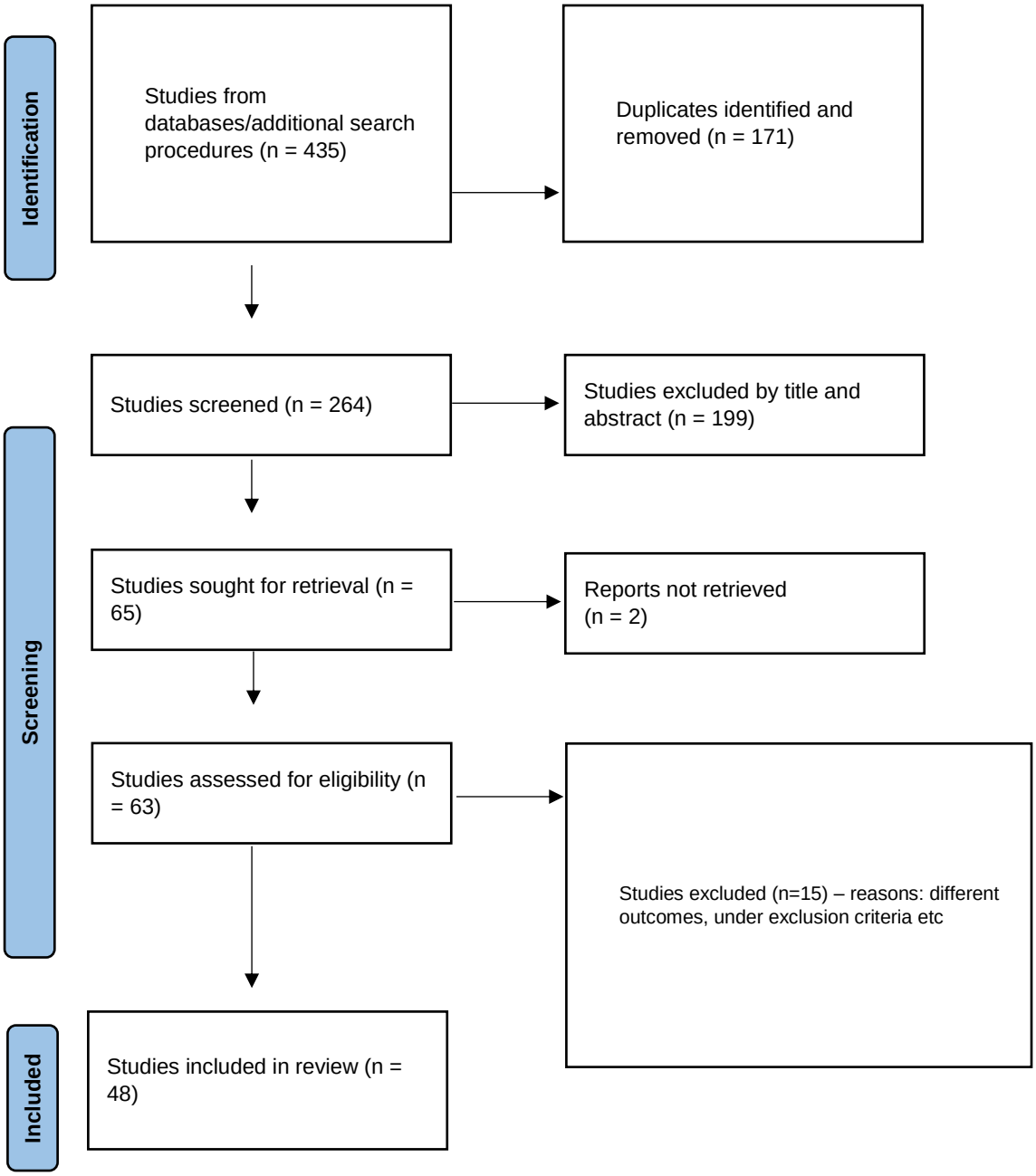

Figure 1 shows the PRISMA flow diagram of the study selection. The first database search resulted in 435 records. Following the elimination of duplicates, 171 titles and abstracts were filtered, 264 full-text articles were evaluated as eligible. in end, 48 articles were included in qualitative synthesis as they met the inclusion criteria. These included 12 randomized controlled trials, 28 propensity score-matched/case-matched cohort studies, 4 prospective cohort studies, 2 meta-analyses/network meta-analyses and 2 registry-based studies.

The studies included covered a variety of indications in oncology: colorectal cancer (n=14), hepatocellular carcinoma and liver metastases (n=10), gastric and esophagogastric junction cancer (n=7), pancreatic cancer (n=6), rectal cancer with transanal approaches (n=4), esophageal cancer (n=3), renal cell The characteristics of the studies are summarized in Table 1.

Table 1

Summary Characteristics of Included Studies by Tumor Type

Tumor Type	Number of Studies	Study Designs	Total Patients (Range)	Key Comparisons
Colorectal cancer	14	5 RCTs, 7 PSM cohorts, 2 meta-analyses	2,847 (40–1,133)	SPL vs MPL, TaTME vs Lap TME, NOSES vs conventional
Hepatocellular carcinoma / liver metastases	10	1 RCT, 7 PSM cohorts, 2 meta-analyses	4,521 (60–2,450)	SPL vs MPL, MIS vs open in PS segments, robotic vs lap
Gastric / EGJ cancer	7	4 RCTs, 2 PSM cohorts, 1 secondary analysis	1,895 (80–1,050)	MPL vs open, robotic vs lap for Siewert II, intracorporeal anastomosis
Pancreatic cancer	6	5 PSM cohorts, 1 meta-analysis	3,210 (78–1,520)	Lap vs open PD/distal, robotic vs lap, SPL vs robotic single-site
Rectal cancer (transanal)	4	1 registry, 1 RCT, 1 meta-analysis, 1 prospective	2,466 (31–1,200)	TaTME vs Lap TME, single-port TAMIS
Esophageal cancer	3	2 RCTs, 1 meta-analysis	1,280 (100–600)	MIO vs open, neoadjuvant regimens
Other (renal, prostate, bladder, gynecological)	4	2 PSM cohorts, 1 cohort, 1 meta-analysis	786 (30–350)	SPL vs MPL hysterectomy, robotic vs lap partial nephrectomy

Abbreviations: RCT, randomized controlled trial; PSM, propensity score-matched; SPL, single-port laparoscopy; MPL, multiport laparoscopy; TaTME, transanal total mesorectal excision; MIS, minimally invasive surgery; PS, posterosuperior; EGJ, esophagogastric junction; PD,pancreaticoduodenectomy

3.2 Risk of bias

Out of the 12 randomized controlled trials, the overall risk of bias was low in 5 trials, some concerns in 6 trials and high in 1 trial. The main sources of possible bias were the absence of participant and surgeon blinding (by nature of surgical trials) and absence of long-term oncological outcomes reporting. In non-randomized studies, ROBINS-I evaluation established moderate risk of bias in most studies, mainly because of confounding by indication-surgeons only assigned patients with good tumor characteristics to single-port procedures and used multiport laparoscopy to treat more complicated cases. Four studies only reported tumor access difficulty scores or stratified by anatomical complexity.

3.3 Surgical approach and viability

Included studies had inconsistent reports on the feasibility of single-port laparoscopy in challenging anatomical sites. Single-port left lateral sectionectomy of hepatocellular carcinoma in liver surgery showed similar operative time and blood loss to multiport procedures, but was only applied to peripherally located lesions in segment II and III (Wang *et al*., 2020). The drawbacks of single-port access were evident when used on posterosuperior segments (VII and VIII). A propensity score-matched study by D'Hondt *et al*. (2018) comparing laparoscopic and open parenchymal-preserving liver resections in posterosuperior segments revealed that the R0 rates (laparoscopic 97.2% versus open 100% (p=1.00)) were statistically similar, but the laparoscopic group had significantly This study used multiport laparoscopy, but the results highlight the accuracy constraints of rigid laparoscopic instrumentation in tight spaces-constraints that are further enhanced in single-port design where the crowding of instruments further limits manoeuvrability.

Han and colleagues (2019) compared single-port laparoscopic distal pancreatectomy to robotic single-site plus one-port distal pancreatectomy directly in pancreatic surgery. The single-port laparoscopic group had a longer operative time, more blood loss (163 mL versus 12 mL, p=0.002) and a higher incidence of grade IIIa complications (p=0.014). Interestingly, the robotic reduced-port technique allowed better

spleen preservation (7.7% vs 54.5, p=0.001) indicating that even the incorporation of one robotic tool can significantly address the technical limitations of single-site access. In laparoscopic extended left pancreatectomy to treat pancreatic ductal adenocarcinoma, the conversion rates were 35% in a propensity-matched cohort (Balduzzi *et al*., 2021), further highlighting the difficulties of ensuring oncological adequacy in intricate pancreatic surgeries.

On the other hand, one niche in which single-port access proved to be of unquestionable benefit was transanal total mesorectal excision (TaTME) of low rectal cancer. Rutgers and colleagues (2021) reported a Dutch registry study of 1,200 patients that TaTME had a sphincter preservation rate of 66% in low rectal cancer cases compared with 28% in laparoscopic TME and 40% in robotic TME (odds ratio 4.11, 95% CI 2.85-5.9 Notably, the positivity rates of CRM were not significantly different among groups (TaTME 5.1%, laparoscopic TME 5.4%, robotic TME 5.1%). A network meta-analysis that found TaTME to have a relative risk of CRM positivity of 0.17 (95% credible interval 0.02–0.76) compared with laparoscopic TME supported this finding (Ryan *et al*., 2021). The transanal path takes advantage of a natural orifice to reach the distal rectum bypassing the triangulation constraints of transabdominal single-port surgery.

3.3.1 Oncological margins

The adequacy of oncological margins is the main endpoint in accordance where any cancer-oriented surgical strategy should be evaluated. in studies included, the R0 resection rates were typically similar with single-port and multiport laparoscopy when the studies were limited to experienced surgeons and well-selected patients. A meta-analysis of 10 randomized controlled trials with 1,133 patients showed that there were no significant differences in lymph node yield or R0 resection in colorectal cancer (Yuan *et al*., 2021). Likewise, Ji and colleagues (2024) did not find any difference in outcome of the operation, complication, or conversion rates of single-port and multiport laparoscopic hysterectomy in endometrial cancer. Wang and colleagues (2020) found no difference in operative time, blood loss and short-term oncologic outcomes in hepatocellular carcinoma and single-port patients had shorter hospital stays.

Nevertheless, the evidence is critically examined to note some crucial caveats. Most of the studies that were included in these meta-analyses recruited patients who had early-stage and peripherally located tumors. A retrospective comparative study of long-term outcomes after single-port laparoscopic hepatectomy of hepatocellular carcinoma by Seo and colleagues (2024) found that although there was no significant difference in overall survival and disease-free survival between the single-port and multiport groups, the single-port group had a non-significant tendency toward smaller surgical margins. The authors rightly warned that the long-term oncological consequences of narrower margins in hepatocellular carcinoma are still not defined and should be followed up.

The LOGICA trial in gastric cancer has demonstrated the oncological non-inferiority of multiport laparoscopy over open gastrectomy and R0 rates are 95 percent in each case (van der Veen *et al*., 2021). Nevertheless, this test was not done with a single-port arm. There is indirect evidence in literature of comparative studies between robotic and laparoscopic that an increase in dexterity is associated with an increase in lymph node harvest in challenging anatomical areas. Wang *et al*. (2019) randomized patients with Siewert type II adenocarcinoma of the esophagogastric junction to robotic or laparoscopic total gastrectomy and discovered that the robotic platform allowed much longer length of esophageal resection (3.0 cm vs 1.9 cm, $p<0.001$) and higher yield of mediastinal lym These results suggest that the limitations of single-port laparoscopy as an instrument can be especially significant when it comes to tumors that need to have their mediastinal or pelvic side-walls dissected.

The REAL randomized trial of robotic versus laparoscopic surgery in middle and low rectal cancer showed that the increased dexterity of robotic platform decreased CRM positivity by 7.2 to 4.0 ($p=0.023$) and conversion by 3.9 to 1.7 ($p=0.021$) (Feng *et al*., 2022). Although this analogy does not directly concern single-port laparoscopy, it demonstrates the idea that in challenging pelvic dissections, any loss in manoeuvrability of the instruments can have a quantifiable effect on the oncological outcomes. Single-port laparoscopy by extension which places a more severe constraint on triangulation than multiport laparoscopy, may not be suitable to low rectal cancers that need to be excised with a total mesorectal resection unless done through the transanal approach.

3.4 Perioperative safety and conversion

Table 2 summarizes perioperative safety outcomes such as operative time, intraoperative complications, postoperative morbidity and conversion to open surgery of the selected key studies.

Table 2

Selected Comparative Outcomes in Difficult-to-Access Tumor Locations

Study	Tumor Location	Comparison	R0 Rate	Conversion Rate	Major Complications	Margin Details
D'Hondt *et al.* 2018	Liver PS segments	Lap vs Open	Lap 97.2% vs Open 100% (NS)	Not reported	Not reported	Margin width: Lap 5 mm vs Open 9.5 mm (p=0.012)
Sijberden *et al.* 2024	Liver (all segments)	Robotic vs Lap	No difference	Robotic 2.7% vs Lap 8.8% (p<0.001)	Robotic 12.3% vs Lap 13.1% (NS)	TOLS+ higher with robotic in PS segments
Han *et al.* 2019	Distal pancreas	SPL vs Robotic single-site+1	Not reported	Not reported	Grade IIIa: SPL higher (p=0.014)	Margin length: SPL 2.1 cm vs Robotic 0.4 cm (p=0.001)
Balduzzi *et al.* 2021	Left pancreas (extended)	Lap vs Open	Lap 67% vs Open 48% (p=0.063)	Lap 35%	Not reported	LN yield: Lap 11 vs Open 19 (p=0.023)
Rutgers *et al.* 2021	Low rectum	TaTME vs Lap TME	CRM+ 5.1% vs 5.4% (NS)	Not reported	Not reported	Sphincter preservation OR 4.11 (p<0.001) for TaTME
Feng *et al.* 2022	Mid-low rectum	Robotic vs Lap	CRM+ 4.0% vs 7.2% (p=0.023)	Robotic 1.7% vs Lap 3.9% (p=0.021)	Robotic 16.2% vs Lap 23.1% (p=0.003)	—
van der Veen *et al.* 2021	Stomach	Lap vs Open	95% both groups (p=1.00)	Lap 3%	Lap 42% vs Open 44% (p=0.91)	—
Wang *et al.* 2019	EGJ (Siewert II)	Robotic vs Lap	Not reported	Not reported	Not reported	Esophageal margin: Robotic 3.0 cm vs Lap 1.9 cm (p<0.001)

Abbreviations list: PS, posterosuperior Lap, laparoscopic SPL, single-port laparoscopy TaTME, transanal total mesorectal excision CRM, circumferential resection margin TOLS+, textbook outcome in liver surgery LN, lymph node EGJ, esophagogastric junction NS, not significant.

Conversion to open surgery is an aggregate measure that is indicative of perioperative challenge, anatomical surprises or complications. Robotic platform in operation of the liver surgery had a much lower conversion rate compared to multiport laparoscopy (2.7% vs8.8%, p<0.001) in a propensity score-matched study of 10,075 patients (Sijberden *et al*., 2024). Although a single-port arm was not used in this study, the high rate of conversion with traditional laparoscopy in challenging areas highlights the technical requirements of these procedures. In case of single-port laparoscopy, it is reasonable to assume that the conversion rates would be even higher, but there is no direct data on comparative data.

The conversion rate of laparoscopic distal pancreatectomy was 17.3% in a cohort study comparing laparoscopic and robotic (pancreatic surgery) (Chen *et al*., 2023). The conversion rate was found to be much lower among the robotic group at 4.9% (p=0.001). Although single-port laparoscopic distal pancreatectomy is possible, it is not less morbidous than robotic reduced-port surgery according to the research by Han and colleagues (2019) which implies that the technical benefits of robotics might be especially beneficial in such a scenario.

In cases of proper selection of cases, the rates of complications were usually similar in both single-port and multiport methods. Yuan and colleagues (2021), who conducted a study on colorectal cancer, found no significant differences in mortality, anastomotic leakage, or general complications. Ji and colleagues (2024) have also reported no significant differences in complication rates in field of gynecological oncology. These results should, however, be viewed within the context of the selection bias of the underlying studies, that is, patients with more favorable anatomy and tumor characteristics were selected to use single-port techniques.

4 DISCUSSION

This systematic review critically assessed the comparative effectiveness of laparoscopic single and multiport techniques in resection of tumors that are difficult to access with particular regard to surgical access, safety and integrity of tumor margins. The resulting evidence synthesis shows a complex image whereby the relative merits of both methods depend on the location of a tumor, anatomical limitations and experience

of a surgeon. In early-stage tumors, located peripherally and at an early stage, single-port laparoscopy is effective in providing R0 resection with clear advantages in pain, length of stay and cosmetic satisfaction. When tumors are located in anatomically challenging areas, however, the technical constraints of single-port instrumentation are more evident and can threaten either margin quality or safety of the procedure: the posterosuperior liver, the deep pelvis, the pancreatic head or the mediastinum.

The basic biomechanical difference between single-port and multiport laparoscopy is the ability of the triangulation of instruments. Multiport laparoscopy allows free positioning of ports which allows the surgeon to oblique the target tissue at angles that are divergent and allows him to use counter-traction. Single-port surgery brings all instruments to a single fulcrum, leading to instrument crowding, decreased range of motion and so-called chopstick effect with hands of the surgeon and camera vying to occupy the shared workspace. These limitations can be overcome in open areas of surgery like lower abdomen or peripheral segments of the liver. They may be prohibitive in constrained spaces like in deep pelvis or the subdiaphragmatic recess.

The results of D'Hondt *et al*. (2018) are especially educative. Even though their analysis was a comparison of multiport laparoscopy and open laparoscopy, their observation that a laparoscopic resection in posterosuperior liver segments produced much narrower margins than open resection (5 mm versus 9.5 mm) makes clear the inherent limitations in precision of rigid laparoscopic tools in tight anatomical spaces. It can be assumed that such constraints would be exaggerated in a single-port system, where crowding at the instruments would further limit the surgeons freedom in attaining optimum angulation of parenchymal transection. This can be justified by the fact that better results are achieved with robotic platforms in posterosuperior areas (Sijberden *et al*., 2024) because the ergonomic limitations of multiport and single-port laparoscopy are alleviated by the use of robotic wristed instruments and 3D visualization.

The transanal total mesorectal excision experience is a significant exception that is a demonstration of the rule. TaTME uses a natural orifice in order to reach the distal rectum without triangulation using the abdominal wall. In this particular situation, single-port transanal access matches and potentially even exceeds the oncological outcome with multiport laparoscopy because the registry data indicates an improved sphincter preservation with equal CRM positivity (Rutgers *et al*., 2021) and network meta-analysis

indicates less CRM involvement (Ryan *et al*., 2021). This exception highlights a very important rule, namely the appropriateness of single-port surgery is not identified by the number of ports itself but by the correspondence of the access path to the anatomic path of the dissection. The technique can be very useful when the target lesion is in direct alignment with single-port axis as in transanal or transumbilical access to midline structures. The constraints of single-port instrumentation are evident when the target has to be off-axis dissected.

The most common threat to the validity of the extant body of evidence is selection bias. in studies included, patients that received a single-port surgery were always younger, less obese and had smaller and better-located tumors. Such confounding by indication does not allow conclusive findings on the comparative effectiveness of the two methods with unselected populations. The proportion of studies that used rigorous propensity score matching to equalize the baseline characteristics is limited and even the studies that use this type of matching cannot completely explain the unmeasured confounding factors such as the consistency of tumor, peritumoral inflammation, or anatomical variations that contribute to the difficulty of surgery. The lack of validated tumor access difficulty scores in majority of the studies further restricts stratification of the outcomes based on objective measures of complexity.

The importance of the experience of the surgeon cannot be overestimated. Single-port laparoscopy has a steep learning curve and competency takes a large volume of cases on top of those required to be able to operate multiport. The results provided in literature are mainly a high-volume facility with a specialised minimally invasive surgery programme and might not apply to low-volume facilities. In most of the studies included the surgeons who participated in single-port operations were innovators or early adopters with a long history of multiport experience. The longer operating times that have constantly been seen in single-port cohorts are likely to be due to the learning curve effect (Yuan *et al*., 2021). with spread of the technique into the wider surgical practice, the results may not be the same as those in literature.

The introduction of robotic platforms makes the discussion of single-port and multiport even more complex. Robotic laparoscopy surgery uses wristed instruments and tremor filtering, mitigating some of the ergonomic drawbacks of traditional single-port laparoscopy. Nevertheless, the robotic solution has its limitations such as absence of

haptic feedback, higher cost and more time to install. According to the comparative studies by Han and colleagues (2019) and Sijberden and colleagues (2024), robotics assistance can be especially beneficial in challenging anatomy, as it offers lower conversion rates and similar or better margin results than traditional laparoscopy. It is an open question that the results of oncology surgery of robotic single-port can be compared with those of multiport robotics and specific research is needed.

The most important gap in existing literature is comprised of longterm oncological outcomes. Although surrogate endpoints are used to measure oncological adequacy, e.g., short-term outcomes like R0 rates, lymph node yield and margin width, the final outcome of oncological sufficiency is disease-free and overall survival. Watanabe and colleagues (2021) compared long-term effects of a randomized controlled trial comparing single-incision with multiport laparoscopic colectomy as the treatment of colon cancer and no significant differences in overall survival and disease-free survival were reported at five years. Nevertheless, this trial recruited patients with colon cancer- a disease in which the surgical intervention has a relatively modest effect on long-term outcomes as compared to tumor biology and adjuvant therapy. In tumor types where the integrity of the surgical margin is more closely related to risk of recurrence, as in hepatocellular carcinoma, pancreatic ductal adenocarcinoma and rectal cancer, long-term effects of narrower margins or incomplete mesorectal excision are of the paramount interest. The results of the research work by Seo and others (2024) are encouraging in initial stages of single-port hepatectomy, but the follow-up is still not long enough.

The advantages of this systematic review are that it has a very broad search strategy that covers various oncological areas, it strictly adhered to PRISMA guidelines and it has critically evaluated the bias in included studies. The review answers a clinically relevant question that has not been adequately discussed in previous syntheses by paying special attention to the tumors that are challenging to access. Limitations involve the heterogeneity of the types and outcome definitions of tumors which prevented most of the comparisons with use of quantitative meta-analysis. Nearly all evidence is retrospective, non-randomized and strength of the conclusions that can be drawn is constrained by the predominant selection bias. The review also lacks a formal cost-effectiveness analysis which is also critical based on the resource implication of single-port and robotic platforms.

5 CONCLUSION

Single-port laparoscopy is an attractive supplement to the minimally invasive oncologic arsenal which has concrete positive effects on the postoperative recovery and aesthetic result in patients who are selected accordingly. Single-port resection has an equivalent oncology performance to multiport laparoscopy in early-stage and peripherally located tumor and can be regarded as a viable alternative in well-trained hands. But in cases of tumors that are difficult to reach in posterosuperior liver, deep pelvis, pancreatic head or mediastinum, multiport laparoscopy-and more and more robotic-assisted techniques-offer better triangulation, exposure and margin control. The low rectal cancer transanal approach is a significant exception that single-port access has a specific anatomic advantage.

The most significant factors that determine outcome are patient selection and surgical expertise and in many cases, the platform selection. Instead of using a one-size-fits-all paradigm, clinicians need to approach the surgery tailored to the location of the tumor, anatomical limitations and experience of the surgeon. There is an urgent need of high-quality randomized controlled trials that are stratified by the tumor difficulty and that have long-term oncological follow-ups to establish evidence-based indications and to identify the specific clinical situations where single-port laparoscopy can be safely and effectively utilized without affecting the primacy oncological goal of total tumor clearance.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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