ISSN 2308-3840 (online)

World Journal of *Meta-Analysis*

World J Meta-Anal 2019 June 30; 7(6): 259-338

Published by Baishideng Publishing Group Inc

WJMA World Journal of Meta-Analysis

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World Journal of Meta-Analysis

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RESPONSIBLE EDITORS FOR THIS ISSUE

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Proofing Production Department Director: *Yun-Xiaojian Wu*

NAME OF JOURNAL
World Journal of Meta-Analysis

ISSN
ISSN 2308-3840 (online)

LAUNCH DATE
May 26, 2013

FREQUENCY
Irregular

EDITORS-IN-CHIEF
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EDITORIAL BOARD MEMBERS
https://www.wjgnet.com/2308-3840/editorialboard.htm

EDITORIAL OFFICE
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PUBLICATION DATE
June 30, 2019

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World J Meta-Anal 2019 June 30; 7(6): 269-289

DOI: 10.13105/wjma.v7.i6.269

ISSN 2308-3840 (online)

SYSTEMATIC REVIEW

Significance of multivisceral resections in oncologic surgery: A systematic review of the literature

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Author contributions: Nadiradze G and Yurttas C contributed equally to this work. Königsrainer A initiated the study and approved the final version of the manuscript; Nadiradze G and Yurttas C participated in developing the manuscript and approved the final version of the manuscript. Horvath P led the literature research, abstracted and analyzed the data and developed the manuscript.

Conflict-of-interest statement: We declare that we have no conflict of interest.

PRISMA 2009 Checklist statement: The authors have read the PRISMA 2009 Checklist, and the manuscript was prepared according to the PRISMA 2009 checklist.

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Abstract

BACKGROUND

Multivisceral resections (MVR) are often necessary to reach clear resections margins but are associated with relevant morbidity and mortality. Factors associated with favorable oncologic outcomes and elevated morbidity rates are not clearly defined.

AIM

To systematically review the literature on oncologic long-term outcomes and morbidity and mortality in cancer surgery a systematic review of the literature was performed.

METHODS

PubMed was searched for relevant articles (published from 2000 to 2018). Retrieved abstracts were independently screened for relevance and data were extracted from selected studies by two researchers.

RESULTS

Included were 37 studies with 3112 patients receiving MVR for colorectal cancer (1095 for colon cancer, 1357 for rectal cancer, and in 660 patients origin was not specified). The most common resected organs were the small intestine, bladder and reproductive organs. Median postoperative morbidity rate was 37.9% (range: 7% to 76.6%) and median postoperative mortality rate was 1.3% (range: 0% to 10%). The median conversion rate for laparoscopic MVR was 7.9% (range: 4.5% to 33%). The median blood loss was lower after laparoscopic MVR compared to the open approach (60 mL *vs* 638 mL). Lymph-node harvest after laparoscopic MVR was comparable. Report on survival rates was heterogeneous, but the 5-year overall-survival rate ranged from 36.7% to 90%, being worst in recurrent rectal

Manuscript source: Invited manuscript

Received: March 20, 2019
Peer-review started: March 20, 2019
First decision: May 16, 2019
Revised: June 7, 2019
Accepted: June 16, 2019
Article in press: June 17, 2019
Published online: June 30, 2019

P-Reviewer: Kitai C
S-Editor: Dou Y
L-Editor: A
E-Editor: Ma YJ

cancer patients with a median 5-year overall survival of 23%. R0 -resection, primary disease setting and no lymph-node or lymphovascular involvement were the strongest predictors for long-term survival. The presence of true malignant adhesions was not exclusively associated with poorer prognosis. Included were 16 studies with 1.600 patients receiving MVR for gastric cancer. The rate of morbidity ranged from 11.8% to 59.8%, and the main postoperative complications were pancreatic fistulas and pancreatitis, anastomotic leakage, cardiopulmonary events and post-operative bleedings. Total mortality was between 0% and 13.6% with an R0 -resection achieved in 38.4% to 100% of patients. Patients after R0 resection had 5-year overall survival rates of 24.1% to 37.8%.

CONCLUSION
MVR provides, in a selected subset of patients, the possibility for good long-term results with acceptable morbidity rates. Unlikelihood of achieving R0 -status, lymphovascular- and lymph -node involvement, recurrent disease setting and the presence of metastatic disease should be regarded as relative contraindications for MVR.

Key words: Colorectal cancer; Gastric cancer; Primary; Recurrent; Multivisceral resection; Hyperthermic intraperitoneal chemotherapy; Morbidity

Core tip: Multivisceral resections constitute a huge challenge for an interdisciplinary team. Proper patient selection, combined perioperative systemic treatment and en-bloc resection of adherent organs can provide acceptable morbidity-, mortality- and long-term survival rates.

Citation: Nadiradze G, Yurttas C, Königsrainer A, Horvath P. Significance of multivisceral resections in oncologic surgery: A systematic review of the literature. *World J Meta-Anal* 2019; 7(6): 269-289
URL: https://www.wjgnet.com/2308-3840/full/v7/i6/269.htm
DOI: https://dx.doi.org/10.13105/wjma.v7.i6.269

INTRODUCTION

Patients with locally advanced primary and recurrent cancers constitute a challenge for the interdisciplinary treatment team because the only chance for cure and prolonged survival is complete resection of the tumor with clear margins. Invasion of adjacent organs occurs in 10%-20% of patients suffering from colorectal cancer and gastric cancer. The prerequisite for long- and short-term results is completeness of surgical resection. This aggressive surgical concept is accompanied by pre- and postoperative systemic treatment schedules, consisting of chemotherapy, radiotherapy and chemoradiotherapy. Due to the lack of sufficient and reliable preoperative data the decision in favor of multivisceral resections (MVR) is often made intraoperatively. MVR is defined as the *en-bloc* resection of the tumor and the adjacent organs including reproductive organs and organs of the urinary tract. MVR should therefore always be taken into account if macroscopic complete resection is achievable. Adherence of the primary or recurrent tumor to adjacent structures does not necessarily predict true malignant invasion. Winter *et al*[1] stated that up to two-third of cases are postoperatively classified as inflammatory adhesions rather than true malignant invasion. Furthermore, lysis of adhesions or separation of the adjacent organ from the tumor dramatically increases the risk of recurrence and should be avoided. The significance of palliative MVR for patients with obstruction, fistula and pain is not clearly defined but the data presented in this review suggest that non-curative MVR does not improve patient outcome. Leijssen *et al*[2] showed that patients with a T4 -tumor not undergoing MVR had a poorer outcome regarding overall-, disease-free-, and cancer-specific survival. The indication in favor of MVR for patients with metastatic disease is also common in the current literature but the true benefit of MVR for stage IV disease is unclear.

This review aims to systematically evaluate the current literature on outcomes following MVR for colorectal and gastric cancer and for patients undergoing MVR and HIPEC for peritoneal metastasis of gastrointestinal, especially colorectal, origin.

MATERIALS AND METHODS

A systematic review was conducted with reference to the PRISMA statement and the current methodological literature[3,4]. Electronic medical literature databases were screened for appropriate publications from 2000 to 2018. Databases were searched using the following terms: "multivisceral" AND "colon cancer", "multivisceral" AND "rectal cancer", "multivisceral" AND "gastric cancer", "multivisceral AND "cytoreductive surgery", and "multivisceral" AND "hyperthermic intraperitoneal chemotherapy". Comments and case reports were excluded. Furthermore, publications that did not report performance of MVR, morbidity and mortality rates, oncologic outcome and publications that included unspecified cancer types were also not included in this systematic review.

For the search terms "multivisceral" AND "colon cancer" and "multivisceral" AND "rectal cancer" 211 records were provided. After the abstracts were screened (level 1 screening) independently by two reviewers 165 publications excluded (Figure 1).

For the search terms "multivisceral" AND "gastric cancer" 93 records were provided. After the abstracts were screened (level 1 screening) independently by two reviewers 71 publications excluded.

After level 2 screening, 37 publications for "Multivisceral resection for colon cancer and rectal cancer", 16 publications for "Multivisceral resection for gastric cancer and 3 publications for "Multivisceral resections with hyperthermic intraperitoneal chemotherapy" were included.

MVR were defined as resection of more than two organs.

RESULTS

MVR for colon cancer and rectal cancer (n = 37).

Study design

After full-text screening 37 studies were selected that met the inclusion criteria. Of these 37 included studies, 36 were retrospective.

Demographics

In total 3112 patients underwent MVR for colon and rectal cancer (1095 for colon cancer, 1357 for rectal cancer and in 660 patient's origin of primary tumor was not specified (Table 1). Of the 36 studies ten included patients with recurrent colon and rectal cancer. The remainder dealt only with primary colon and rectal cancer. Included studies were published after 1999 to the present time and all but one was retrospective. In total five publications presented patient- and treatment-related data after minimally-invasive MVR. The decision for or against suspected MVR, according to preoperative imaging modalities like CT, MRI, EUS and PET-CT, was made intraoperatively. Every verified adhesion of the primary tumor to adjacent structures was classified as a cT4b -situation. All but seven publications did not report the true pT4b -rate. There were 17 studies that included patient with Stage IV disease. Another seven studies did not specify whether or not patients with metastatic disease were included.

Pathological features

In the event of adhesion of adjacent structures to the primary tumor, these adhesions should definitely not be separated intraoperatively. For the surgeon it is not possible to distinguish between inflammatory and malignant adhesions. Hunter *et al*[5] showed that patients with adherent colon cancer and lysis of adhesion, had a local recurrence rate of 69% and a 5-year overall survival rate of only 23%. Of the included studies, 30 publications report the histopathologically confirmed malignant invasion rate. The true pT4b -rate varied from 23% to 77%. Three publications performed multivariate analysis in order to determine whether true malignant invasion into adjacent structures is of predictive value for overall- and progression-free survival[6-8]. Rosander *et al*[7] and Lehnert *et al*[8] did not find malignant invasion to be a predictive factor in multivariate analysis. Rosander *et al*[7] found female sex, adjuvant chemotherapy, low tumor stage and R0-resection to be associated with better overall survival. On the other hand, Lehnert *et al*[8] found intraoperative blood loss, age older

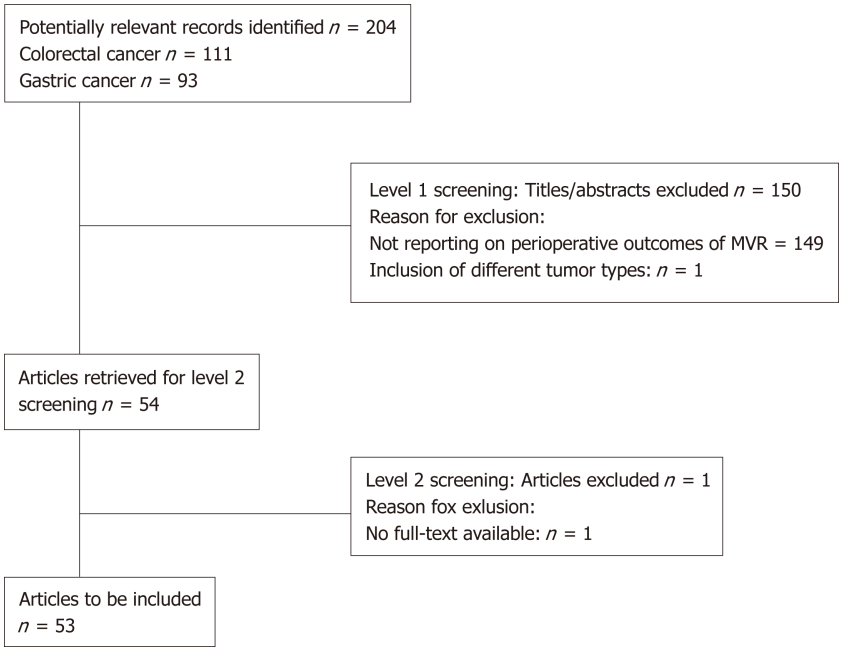

Figure 1 Preferred reporting items for systematic reviews and meta-analyses diagram.

than 64 years and UICC stage to be predictive. Contrary to the aforementioned results Chen *et al*[6] found adhesion pattern (inflammatory *vs* malignant) to be highly significantly associated with reduced overall survival for both, colon and rectal cancer patients.

Concerning resection status, 27 studies report R0 rates, ranging from 65% to 100%. In the vast majority of publications R0 *vs* R1 -status was of significant prognostic impact (Table 2). Data show a trend towards decreased R0 -rates in patients undergoing MVR for recurrent cancers, especially rectal cancer. Nielsen *et al*[9], Rottoli *et al*[10] and Vermaas *et al*[11] reported resection status in primary and recurrent rectal cancers and showed decreased R0 -rates for recurrent rectal cancer without being statistically significant (66% *vs* 38%; 71% *vs* 56% and 82% *vs* 58%).

Morbidity and mortality

There was heterogeneity in reporting total complication rate, degree of complications and specification of different complications, so that the focus was set on complications, which were reported in the vast majority of publications. The postoperative morbidity rates ranged from 7%[12] to 76.6%[13]. Only one study reported that the occurrence of perioperative complications was an independent predictor of shorter overall survival (HR 3.53)[14].

Anastomotic insufficiency: Twelve studies did not report occurrence of anastomotic insufficiency (AI). The remainder reported AI-rates ranging from 0.8%[15] to 19%[16]. There was no structured report on management of AI in the studies included.

Surgical site infection: Surgical site infections (SSI) were one of the most common complications ranging from 2.5%[15] to 53%[13]. The differentiation into superficial and deep SSI was inconsistently used in the studies included. Kumamoto *et al*[15] reported the lowest rate of SSI including 118 patients undergoing minimally-invasive MVR. The other studies, looking at minimal-invasive MVR, reported SSI -rates ranging from 12%-17%. The study by Kim *et al*[17] found no statistically significant difference in the occurrence of SSI between the open and the minimally-invasive group.

Intraabdominal abscess: Intraabdominal abscess (IAA) formation was not reported in 17 studies. The remainder reported IAA rates ranging from 1%[18] to 21%[19]. Documentation of IAA management was again inconsistently reported in the included studies.

Re-operation: The rate of necessary surgical re-intervention was again not reported in 17 studies. In the remaining studies the re-operation rate ranged from 0%[14] to 20%[19].

Mortality: In total 15 studies reported mortality rates of 0% and the median mortality rate was 1.3%. The highest reported perioperative mortality rate, namely 10% was

Table 1 Patient demographics

Study/Yr	*n*	Disease	Site
Cukier *et al*[24], 2012	33	Primary	Colon
Hallet *et al*[20], 2014	15	Recurrent	Colon
Kumamoto *et al*[15], 2017	118	Primary	Colon
Leijssen *et al*[2], 2018	103	Primary	Colon
López-Cano *et al*[49], 2010	113	Primary	Colon
Rosander *et al*[7], 2018	121	Primary	Colon
Takahashi *et al*[12], 2017	84	Primary	Colon
Tei *et al*[23], 2018	29	Primary	Colon
Chen *et al*[6], 2011	287; Colon (152); Rectum (135)	Primary recurrent	Colorectal
Eveno *et al*[58], 2014	152; Colon (81); Rectum (71)	Primary	Colorectal
Fujisawa *et al*[29], 2002	35; Colon (19); Rectum (17)	Primary recurrent	Colorectal
Hoffmann *et al*[21], 2012	78; Colon (52); Rectum (26)	Primary	Colorectal
Gezen *et al*[18], 2012	90; Colon (43); Rectum (47)	Primary	Colorectal
Kim *et al*[17], 2012	54; Colon (32); Rectum (22)	Primary	Colorectal
Laurence *et al*[56], 2017	660; Colon/Rectum not specified	Primary	Colorectal
Lehnert *et al*[8], 2002	201; Colon (139); Rectum (62)	Primary	Colorectal
Li *et al*[16], 2011	72; Colon (28); Rectum (44)	Primary	Colorectal
Park *et al*[53], 2011	54; Colon (23); Rectum (31)	Primary	Colorectal
Rizzuto *et al*[57], 2016	22; Colon (16); Rectum (6)	Primary	Colorectal
Winter *et al*[1], 2007	63; Colon (46); Rectum (17)	Primary	Colorectal
Bannura *et al*[55], 2006	30	Primary	Rectal
Crawshaw *et al*[25], 2015	61	Primary recurrent	Rectal
Derici *et al*[48], 2008	57	Primary	Rectal
Dinaux *et al*[50], 2018	29	Primary	Rectal
Dosokey *et al*[30], 2017	34	Primary	Rectal
Gannon *et al*[28], 2007	72	Primary recurrent	Rectal
Harris *et al*[19], 2011	42	Primary	Rectal
Ishiguro *et al*[54], 2009	93	Primary	Rectal
Mañas *et al*[13], 2014	30	Primary	Rectal
Nielsen *et al*[9], 2012	90	Primary recurrent	Rectal
Pellino *et al*[14], 2018	82	Primary	Rectal
Rottoli *et al*[10], 2017	46	Primary recurrent	Rectal
Sanfilippo *et al*[51], 2001	32	Primary	Rectal
Shin *et al*[22], 2016	22	Primary	Rectal
Smith *et al*[47], 2012	124	Primary	Rectal
Vermaas *et al*[11], 2007	35	Primary recurrent	Rectal

reported in the study by Manas *et al*[13].

Long-term outcomes

Table 3 shows overall (OS)- and disease-free survival (DFS) rates and depicts factors associated with decreased OS and DFS after MVR for rectal and colon cancers. 5-year OS rate ranged from 36.7%[13] to 90%[20], but the proportion of included patients with metastatic disease differed between those two studies (20% *vs* 0%).

Local and distant recurrences: The local control rate expressed by the local recurrence rate were reported in 27 publications and ranged from 1.8% to 66.7%[15]. The aforementioned study and Rosander *et al*[7] showed higher rates of local recurrences after R1 -resection. Distant recurrence rates varied from 10.9%[2] to 45.5%[17]. Patients with metastatic disease, receiving MVR, were also included in the vast majority of publications and the rate of patients with Stage-IV disease varied from 0% to 49%[21].

Operative approach

Laparoscopic *vs* open surgery: Five publications focused on the perioperative und long-term results of minimally-invasive (laparoscopic and/or robotic) MVR (Table 4).

Table 2 Patient- and treatment- associated parameters after multivisceral resection for colon and rectal cancers

Study	Resection margin (R0 *vs* R1)	Local and distant recurrence	Most common resected organs	Lymph node involvement	Age	Blood loss(mL)	Pre-operative (Chemo)-radiation	Complica-tions (AI;SSI;IAA) (Re-OP)	Prognostic factors/con-clusions
Cukier *et al*[24]	R0: 100%	LR: 6%; DR: 18%	Small bowel (56%); Bladder/ Ureter (54%)	N0: 79% N1: 21%	64	NR	RCTX:100%	6%; 18%; NR (9%)	No statistical difference in terms of disease-free survival when analyzing subgroups stratified by nodal-status ypN0 *vs* ypN1: (P = 0.29)
Hallet *et al*[20]	R0: 87%	LR: 13%; DR: 13%	Colon (87%) Small bowel (47%) Bladder (40%)	N0: 70% N1: 30%	60.2	1500	RCTX:100%	NR	Neoadjuvant RCTX for recurrent colon cancer is feasible; no addition of toxicity (radiation plus MVR)
Kumamoto *et al*[15]	R0: 95%	LR: R0: 1.8% R1: 66.7%; DR: NR	Small bowel (14%) Bladder (12%) Colorectum (11%)	N0: 62% N1: 28% N2: 10%	64	48	CTX: 4.4%	(0.8%; 2.5%; 0.8%) (0%)	R1-resection and N+ status predictors of poor prognosis Laparoscopic approach: Feasible, low conversion, low R1-rate
Leijssen *et al*[2]	R0: 89%	LR: 14.5%; DR: 10.9%	Small intestine (31%); Reproductive organs (9%); Bladder (7%)	NR	69	NR	NR	(1.8%; 3.6%; NR) (2%)	Patients with T4-cancer not undergoing MVR had a significantly poorer outcome regarding overall-, disease-free and cancer-specific survival
López-Cano *et al*[49]	R0: 85%	LR: 23%; DR: 19%	Small intestine (42%) Oophorec-tomy (28%) Bladder (19%)	N0: 35% N1: 32% N2: 34%	71	NR	0%	(NR; 10%; NR) (8%)	Poorly differentiated tumors and stage IV were associated with a poor survival; significant predictors of disease progression: Venous invasion (RR 2.34) and four or more positive lymph nodes (RR 3.99)

Rosander *et al*[7]	R0: 93%	LR: R0: 7% R1: 33% DR: 14%	Bowel (45%) Ovaries (24%) Bladder (partial/total) : 22%/19% Uterus/Vagina (17%)	N0: 71% N1: 19% N2: 10%	67	NR	CTX: 27% RT: 1% RCTX: 5%	(8%; 7%; 7%) (14%)	Female sex, low tumor stage, and adjuvant CTX, and N - but not tumor infiltration per se, were independently associated with better overall survival
Takahashi *et al*[12]	R0: 96%	LR: 2%	Bowel (38%); Uterus/Ovari-es (5%); Bladder (11%)	NR	68.5- 71.5	Lap. completion: 50; Conversion: 366; Lap overall: 57.5; open: 321	CTX: open: 25% lap: 6%	(4%; NR; NR) (NR)	Overall- and disease-free survival (multivariate) was shorter in the males; operative approach did not affect overall- and disease-free survival
Tei *et al*[23]	R0: 93%-100%	LR: NR; DR: 24%	Small intestine (38%); Bladder (17%); Ovaries (14%)	N0: 48% N1: 24% N2: 28%	70	60-220	NR	(3%; 17%; 10%) (3%)	S-MVR and M-MVR do not differ significantly in terms of blood loss, operative time and number of harvested lymph nodes. No difference in occurrence of complications
Chen *et al*[6]	NR	NR	Colon cancer: small bowel (40%); Rectal cancer: Bladder (36%)	NR	NR	NR	NR	NR	Multivariate analysis showed that adhesion pattern was independently associated with overall survival among both colon (P = 0.00001) and rectal (P = 0.0002) cancer patients
Eveno *et al*[58]	R0: 90%	NR	Vagina (25%); Small bowel (23%); Bladder (20%); Ovaries/Uterus (each 19%)	N0: 55% N1: 25% N2: 19%	63	NR	RT: 8%; CT: 2%; RCTX: 27%	(3%, 4%; NR) (9%)	Patients with resection of multiple organs had a better survival rate than patients with single organ resection (P = 0.0469)
Fujisawa *et al*[29]	NR	NR	Bladder (partial/total) : 54%/34%	NR	59	NR	0%	NR	Complication rate was higher in pat; undergoing cystectomy *vs* partial cystectomy (58.3% *vs* 10.5%)

Hoffmann *et al*[21]	R0: 95%	LR: 2%	53%: 1 add. Organ 27%: 2 add; organs	NR	69	NR	RCTX (rectal): 35%	(9%; 9%; NR) (19%)	No significant differences in overall survial: Colon *vs* rectal cancer (P = 0839); lap *vs* open (P = 0.610); emergency *vs* planned (P = 0.674), pN0 *vs* pN1 (P = 0.658)
Gezen *et al*[18]	R0: 91%	NR	Ovaries: 27%; Bladder: 26%; Small bowel: 21%; Uterus: 19%	NR	59	450 (non-MVR: 250)	NR	(2%; 3%; 1%) (2%)	MVR do not alter the rates of sphincter-saving procedures, morbidity and 30-d mortality
Kim *et al*[17]	R0: 71%	LR: 7.7% (lap) and 27.3% (open) P = 0.144) DR: 15.4% (lap) *vs* 45.5% (open) P = 0.091)	Small bowel: 10%; Bladder: 10%; Seminal vesicle: 13%; Prostate: 6%	NR	68	lap: 269; open: 638	RCTX: 50% of rectal cancer patients	(12%; 8%; NR) (NR)	No adverse long-term oncologic outcomes of laparoscopic MVR were observed
Laurence *et al*[56]	NR	NR	NR	NR	64	NR	RT: 62%	NR	Female gender, tumor grade 2, MVR were significant protective factors of mortality
Lehnert *et al*[8]	R0: 65% R1: 9% R2: 26%	LR: 7% DR: 13% Both: 4%	Small bowel: 29%; Bladder: 24%; Uterus: 13%	NR	64	< 1000 mL: 37%; 1000-2000 mL: 13%; > 2000 mL: 10%	RT/CT/RCTX: 40% of R0 resected patients	(5%; 9%; 1%)	Intraoperative blood loss, age older than 64 and UICC stage but not histologic tumor infiltration *vs* inflammation were prognostic factors
Li *et al*[16]	NR	LR at 5 years: 15% DR: 14%	Bladder (partial/total) : 56%/19%	NR	67	Partial cystectomy: 0; Urologic recon-struction: 1700	0%	(19%; 25; 6%) (4%)	Negative prognostic factors: Age older than 70 years; receiving palliative resection and not involvement of the bladder dome
Park *et al*[53]	NR	NR	Small bowel: 24%; Ovary: 17%; Bladder 14%	NR	64	NR	NR	(6%; 11%; 9%) (NR)	MVR was associated with a two times higher complications rate compared to standard resections
Rizzuto *et al*[57]	R0: 91%	NR	Small bowel: 36%; Bladder: 27%; Vagina/Uter-us/Ovaries: Each 22%	N0: 50% N+: 50%	62	NR	RCTX: 28%	(11%; 14%; 5%) (NR)	Patients with rectal cancer and occlusive disease had worse prognosis

Winter *et al*[1]	R0: 89%	LR: 14%	Bladder (partial): 84%	N0: 65% N1: 35%	63	NR	RCTX: 37%	(3%; NR; NR) (NR)	Bladder reconstruction is achievable in most patients; margin- and node-negative patients benefit the most
Banamura *et al*[56]	NR	LR: 13%; DR. 23%: Both: 20%	APR: 30%; PPE: 70%	NR	57	NR	RCTX: 20%	(3%; 27%; NR) (NR)	PPE showed prolonged operative time, higher postoperative complications, a trend towards a poor prognosis in recurrence and survival
Crawshaw *et al*[25]	R0: 87%	LR: 16%	Bladder: 49%; Vagina: 38%; Prostate: 31%; Uterus: 31%; Ovaries: 20%; Small bowel: 10%	NR	62	800	RCTX: 90%	(NR; 7%; 12%) (NR)	Sphincter perseveration did not affect oncologic outcomes
Derici *et al*[48]	R0: 75%	LR: 18%	Adnexa: 47%; Uterus: 32%; Bladder: 30%	NR	60	NR	RCTX: 51%	(7%; 19%; NR) (NR)	Lymph node status pN0 (P = 0.007) and R0 resection (P = 0.005) were independently significant factors in the multivariate analysis for overall survival
Dinaux *et al*[50]	R0: 100%	LR. 3%; DR: 21%	Bladder: 28%; Prostate: 21%; Ovaries: 20%; Uterus: 20%	NR	55	NR	CTX. 100%; RCTX: 97%	(3%; 14%; 3%) (NR)	Chance of overall mortality significantly increased for patients; who underwent MVR, for administration of adjuvant CTX, for Pn+ and ypN+ status
Dosokey *et al*[30]	NR	LR. 3% DR: 11%	Vagina: 50%; Prostate: 30%; Bladder: 33%	NR	66	549	CTX: 97% RT: 92%	(16%; NR; NR) (NR)	Patients with APR only had a longer 5 yr overall survival and a longer disease-free survival compared to patients undergoing MVR

Gannon *et al*[28]	R0: 90%	Primary: LR: 9%, LR + DR: 13%, DR: 22%; Recurrent: LR: 4%, LR + DR: 48%, DR:15%	TPE: 47% SLE: 47% PPE: 33%	NR	52	NR	RCTX: 85%	(NR; 4%; 11%) (4%)	A significant difference in 5-yr disease-free survival was found between primary and recurrent tumors (52% *vs* 13%, $P < 0.01$)
Harris *et al*[19]	R0: 93%	LR: 7%	Bladder+ Prostate: 55% Uterus: 24%	N0: 52% N1: 29% N2: 17% N3: 2%	62	NR	RCTX: 74%	(5%; 5%; 21%) (20%)	Association with worse overall survival in multivariate analysis: Metastatic disease, pT4N1 stage, vascular invasion
Ishiguro *et al*[54]	R0: 98%	LR: 9% DR: 25%	Uterus+ Bladder+ Rectum: 89%	N0: 57% N+: 43%	55	NR	RCTX: 14%	(4%; 23%; 8%) (9%)	Patients with positive lateral pelvic lymph node had a higher probability to recur and a decreased 5-yr over all survival
Mañas *et al*[13]	R0: 73%	LR: 37% DR: 35%	Uterus/Ovari-es (each): 53%; Vagina; 27%; Seminal vesicle: 23%	N0: 40% N1: 27% N2: 34%	68	NR	RCTX: 20%	(13%; 53%; 10%) (NR)	Multivariate analysis showed that nodal involvement was independent predictor of poor survival (> 4 pos; nodes RR: 9.06 (P = 0.006)
Nielsen *et al*[9]	Primary:R0: 66% Recurrent: R0: 38%	NR	TPE with sacrectomy: 22%	NR	63	NR	RT: 65%	(4%; 20%; 7%) (NR)	There was no statistically significant difference in overall survival between primary and recurrent disease when comparing R0 resections
Pellino *et al*[14]	R0: 77%	LR: 16% DR: 22%	Not clearly specified	N0: 13% N1: 29% N2: 43%	62	NR	RT: 54%	(NR; 37%; 10%) (10%)	Perioperative complications were independent predictors of shorter survival (HR 3.53)

Rottoli *et al*[10]	Primary: R0 71%, Recurrent: R0: 56%	Primary: LR: 18% DR: 29% Both: 7%; Recurrent: LR: 22% DR: 33% Both: 17%	Sacrectomy: Primary: 18% Recurrent: 22%)	N0: 41% N1: 15% N2: 37%	57	Primary: 600 Recurrent: 750	65% (not specified)	NR	The long-term disease-free survival of patients undergoing pelvic exenteration is significantly worse when the procedure is performed for recurrent rectal cancer, regardless of the tumor involvement of the resection margins
Sanfilippo *et al*[51]	NR	LR: 20% DR: 44%	Vagina: 66%; Bladder/Pros -tate: 14%; Bladder/Vagi -na: 6%; Vagi-na/Uterus/O -varies: 6%	N0: 72% N1: 9% N2: 9%	55	NR	RCTX: 100%	(NR; 19%; 6%) (9%)	No significant association with pelvic control rate and age, sex, cN-stage, tumor distance from the anal verge, clinical tumor length, tumor circumference , tumor mobility, obstruction, grade, neoadjuvant CTX, and MVR
Shin *et al*[22]	R0: 100%	LR: 4%	Prostate: 36%; Vagina: 23%; Small bowel: 14%; Bladder wall: 14%	N0: 41% N1: 46% N2: 14%	54	225	RCTX: 82%	(NR; 17%; 17%) (13%)	Robotic MVR including resection of lateral pelvic lymph nodes is feasible with acceptable morbidity and no conversion
Smith *et al*[47]	R0: 85%	LR: 19%	Vagina: 52%; Uterus: 23%; Bladder: 11%	N0: 60% N+: 40%	63	NR	RCTX: 73% RT: 2%	(6%; 19%; 6%) (at least 1%)	5-yr overall survival in stage I-III: Tumor category (T3-4 *vs* T0-2: HR 2.80), Node category (N1-2 *vs* N0: HR 1.75), Involved resection margin: HR = 2.19), lymphovascu-lar invasion (L0 *vs* L1: HR 1.56)

Vermaas *et al*[11]	Primary:R0: 82%; Recurrent: R0: 58%	LR at 5-yr: Primary: 12%; Recurrent: 40%	TPE: 83% TPE an sacral bone: 11%; TPE with coccygeal bone: 6%	N0: 37% N1: 6% N2: 6%	58	NR	RT: 97%	(NR; 26%; NR) (9%)	Patients with recurrent rectal cancers have a higher rate of complications, a high distant metastasis rate and a poor overall survival

CTX: Chemotherapy; MVR: Multivisceral resection; S-MVR: Single-port MVR; M-MVR: Multi-port MVR; HR: Hazard ratio; RR: Relative risk; APR: Abdominoperioneal resection; PPE: Posterior pelvic exenteration; RCTX: Chemoradiotherapy; TPE: Total pelvic exenteration; LR: Local recurrence; DR: Distant recurrence; AI: Anastomotic insufficiency; SSI: Surgical site infections; IAA: Intraabdominal abscess; RT: Radiotherapy; NR: Not reported.

Completeness of surgical resection was not impaired by minimally-invasive MVR and the included studies showed no reduction in lymph -node harvest as compared to open surgery. The conversion rate to open surgery varied from 4.5%[22] to 33%[23]. The most common reasons for conversion were involvement of the small intestine, intraperitoneal adhesions and the need for urologic reconstructive procedures. The minimally-invasive approach offered a reduced length of stay, significantly reduced blood loss but prolonged operative time.

Chemoradiotherapy

The number of patients receiving any kind of preoperative therapy, including chemotherapy, radiotherapy and combined chemoradiotherapy, was mentioned in 31 studies. Preoperative chemotherapy was received by 129 (4%) patients, 591 (19%) patients underwent preoperative radiotherapy and 423 (14%) patients were given preoperative combined chemoradiotherapy. Two studies reported on applications of chemoradiotherapy in primary and recurrent colon cancers[20,24]. Cukier *et al*[24] reported that perioperative complication rates were not negatively impacted by chemoradiotherapy. The same results were obtained by Hallet *et al*[20] who stated that the addition of neoadjuvant chemoradiotherapy prior to MVR for recurrent adherent colon cancer did not elevate toxicity-or complication rates.

Six studies reported on patients receiving intraoperative radiotherapy (IORT)[11,22,24-27]. All studies exclusively included patients with primary and or recurrent rectal cancer. Indications for application of IORT were a minimal circumferential free resection margin equal to or less than 2 mm in the study from Vermaas *et al*[11] and the concern for close and/or involved radial margins in the study by Gannon *et al*[28] Only 12 patients in the study by Vermaas *et al*[11] received IORT but no improvement in overall survival was seen.

Primary vs recurrent rectal cancer

In total seven publications included primary as well as recurrent rectal cancers[6,9-11,26,28,29]. The studies by Gannon *et al*[28] Nielsen *et al*[9] and Vermaas *et al*[11] included 197 patients and only Gannon *et al*[28] reported that the disease setting was the only significant prognostic factor in favor of primary rectal cancers. This is in line with the results published by Rottoli *et al*[10] who also found the recurrent disease setting to be a negative prognostic factor.

MVR for gastric cancer (n = 16).

Study design

A total of 93 articles were identified using the aforementioned search algorithm (Figure 1). After full-text screening 16 studies were selected that met the inclusion criteria.

Demographics

We identified 16 studies published between 1998 and 2019 describing MVR for a total of 1600 patients with locally advanced gastric cancer (Table 5). One publication reported patient- and treatment-related data after minimally-invasive MVR, whereas the other authors either performed open surgery or did not mention whether an open or laparoscopic approach was chosen[31]. The decision for or against suspected MVR, according to preoperative imaging modalities like CT, MRI, EUS and PET-CT, was made intraoperatively. Every verified adhesion of the primary tumor to adjacent structures was classified as a cT4b -situation. Together with a gastrectomy, mainly surrounding organs like spleen, pancreas or colon were resected. More rarely, the gallbladder or parts of the small bowel or the liver had to be removed.

Table 3 Morbidity, mortality and survival rates after multivisceral resection for colon and rectal cancer

Study	Follow-up (mo)	Morbidity (%)	Mortality (%)	Survival[1]	Stage IV disease (%)	True pT4b (%)
Cukier *et al*[24]	36	36	0	3-yr OS: 85.9%; 3-yr DFS: 73.7%	0	67
Hallet *et al*[20]	54	33.3	0	90%; 5-yr DFS: 63.5%	0	50
Kumamoto *et al*[15]	32	17.8	0.8	87%	12	45
Leijssen *et al*[2]	48.5	25	0	5-yr OS (pT3): 63%; 5-yr OS (pT4): 70%	0	24
López-Cano *et al*[49]	74.9	47.8	7.1	48%; 5-yr DFS: 46.3 mo	20	65
Rosander *et al*[7]	28	37% (≥ Grade III)	5	60.8% for the infiltration group; 86.9% for the inflammation group	0	63
Takahashi *et al*[12]	48.4	LAP: 7 OPEN: 36	0	3-ys OS (open): 79.8%; (lap): 92.8%	25	50
Tei *et al*[23]	34	37.9	0	3-yr OS Stage II-III (S-MVR/M-MVR): 81.8%/80.0% 3-yr DFS Stage II-III (S-MVR/M-MVR: 58.3%/70.0%	28	34
Chen *et al*[6]	NR	11.5	NR	59% (Colon/inflammation) 39% (Colon/invasion) 63% (Rectum/inflammation); 42% (Rectum/invasion)	54	55
Eveno *et al*[58]	48	12	1.3	77%; 3-yr OS (without stage IV disease): 89%; 5-yr DFS: 58%	13	65
Fujisawa *et al*[29]	42 (mean)	NR	NR	3-yr OS (colon/bladder sparing): 90%; (colon/nonsparing): 67%; 3 yr OS (rectal/bladder sparing): 50%; (rectal/nonsparing): 67%	NR	NR
Hoffmann *et al*[21]	NR	34.6	7.7	55% (if curative)	49	63
Gezen *et al*[18]	25 (mean)	24.4	4.4	69.4%	12	34
Kim *et al*[17]	35/40 (mean)	LAP: 21 OPEN: 44	0	LAP: 60.5%; OPEN 48%	33	44
Laurence *et al*[56]	NR	NR	NR	52.7%	3	NR
Lehnert *et al*[8]	71	33	7.5	51%	5	50
Li *et al*[16]	64.3	61	5.6	50%; 59%: if curative	21	47
Park *et al*[53]	NR	35.2	3.1	58%	0	44
Rizzuto *et al*[57]	NR	55	0	3-yr OS (non-occlusive): 58.4%; (occlusive): 33.3%	0	77
Winter *et al*[1]	84	18	1.5	57%; 61% (R0); 17% (R1) 77% (R0, N0); 28% (R0, N+)	NR	54
Banmura *et al*[56]	32	50	0	Local recurrence rate: 30%	33	63
Crawshaw *et al*[25]	27.8	57.4	0	49.2%; 5-yr DFS: 45.3%	0	39
Derici *et al*[48]	40.4 (mean)	38.6	3.5	49%; 3-yr OS: 81.6%	0	58
Dinaux *et al*[50]	38.2	72.4	0	OS: 45 mo	0	24
Dosokey *et al*[30]	32 (mean)	39	0	67%; 5-yr DFS: 79%	0	NR

Gannon *et al*[28]	40	43	0	48%; Primary: 65% Recurrent: 22%; 5-yr DFS. 38%; Primary: 52% Recurrent: 13%	NR	NR
Harris *et al*[19]	30	50	0	5-yr OS (R0): 48%; R1/R2: 33%	14	52
Ishiguro *et al*[54]	40	39.8	2.2	52%; 5-yr DFS: 46%	NR	49
Mañas *et al*[13]	28.8	76.6	10	36.7%	20	67
Nielsen *et al*[9]	12	51	2.2	5-yr OS (primary): 46%; (recurrent):17%	0	NR
Pellino *et al*[14]	NR	54.9	2.4	67%	NR	70
Rottoli *et al*[10]	32.5/56.6	33 Primary: 32% Recurrent: 33%	4	5-yr DFS (primary): 46% (recurrent): 24%	NR	NR
Sanfilippo *et al*[51]	NR	25	NR	4-yr OS: 69%	0	44
Shin *et al*[22]	30	41.7	0	80%	27	23
Smith *et al*[47]	NR	47.6	0.8	53.3%; M0: 59%	20	44
Vermaas *et al*[11]	28 (mean)	69; Primary: 61; Recurrent: 83	3	52% (primary); 3-yr OS (recurrent): 32%	NR	43

[1]if not specified 5-yr OS is reported. S-MVR: Single-port laparoscopic multivisceral resection; M-MVR: Multi-port laparoscopic multivisceral resection; NR: Not reported.

Pathological features

Prior clinically suspected T4-tumor was confirmed in 14%[32]-89.0%[33] of histopathological samples. Involvement of lymph nodes was described in 38.8%[33]-89.3%[34]) of patients.

Morbidity and mortality

The rate of morbidity ranged from 11.8%[35] to 59.8%[31] of patients who underwent gastrectomy and MVR (Table 6). Main postoperative complications were pancreatic fistulas and pancreatitis, anastomotic leakage, cardiopulmonary events and postoperative bleedings. Total mortality lay between 0%[35] and 13.6%[33]. R0-resections were achieved in 38.4%[34]-100%[36] of patients.

Anastomotic insufficiency: Ten studies did not report the occurrence of anastomotic insufficiency (AI). The remainder reported AI -rates ranging from 0%[37,38] to 19.4%[31]. There was no structured report on management of AI in the studies included.

Re-operation: The rate of re-operation was only mentioned in 4 publications and ranged from 0%[37,38] to 13.8%[31].

Long-term outcomes

Patients after R0 resection had 5 year overall survival rates of 24.1%[38] to 37.8%[35]. In the multivariate analysis, mostly incomplete resection status[34,39-42] as well as lymph node involvement[31,34,36,39,40,42-45] were found to be negative prognostic factors for survival. Further negative prognostic factors were metastasized stage[35,39], advanced age[44] the number of resected organs[31,42,44,46], no adjuvant chemotherapy[31] and white race[31].

DISCUSSION

MVR for locally advanced and adherent colorectal and gastric cancers seems to be a feasible approach that is associated with an acceptable morbidity - and mortality -rate and in a subset of patients good oncologic long-term results can be obtained[15,20,25,42,44,47]. Due to the reduced sensitivity and specificity of preoperative imaging for prediction of true malignant adhesion, the decision in favor of performing MVR is made intraoperatively in the vast majority of cases[1]. It is virtually impossible for the surgeon to differentiate between inflammatory and true malignant adhesions, so that every adherence to the tumor must be considered malignant and the appropriate operative strategy has to be applied. Data on intraoperative lysis of adhesions to the primary tumor, which were proven malignant by histopathological examination, revealed devastating overall survival rates and high local recurrence rates (Hunter *et al*[5]). In this review the true pT4b -rate varied from 23% to 77% and data on the impact of malignant invasion are heterogeneous with two studies[7,8] reporting no impact on overall-survival if malignant adhesions were detected and one

Table 4 Patient- and treatment- associated parameters of minimal-invasive multivisceral resection for colon and rectal cancer

Study	Resection margin (R0 *vs* R1)	Lymph-node harvest (*n*)	Conversion rate	Reason for conversion	Blood loss (mL)	Operative time (min)	LOS (d)
Kumamoto *et al*[15]	R0: 95%	26	6.8%	Excessive tumor fixation (n = 4); Suspicion of invasion to the duodenum (n = 2); Intraperitoneal adhesion (n = 2)	49	254	11
Takahashi *et al*[12]	R0: 96%	34 Open: 33	12%	The conversion rate was highest in cases involving the urinary tract (40%)	50; Open: 321	279; Open: 255	14; Open: 22.5
Tei *et al*[23]	R0: S-MVR: 100%; M-MVR: 93%	S-MVR: 30; M-MVR: 25	S-MVR M-MVR: 14%; M-MVR Open: 33%	Small intestine involvement	S-MVR: 60; M-MVR: 220	S-MVR: 222; M-MVR: 255	S-MVR: 11; M-MVR: 18
Kim *et al*[17]	R0: 71%	34; Open: 40	7.9%	NR	268; Open: 637	330; Open: 257	21.9; Open: 21
Shin *et al*[22]	R0: 100%	20	4.5%	Unable to tolerate Trendelenburg position and intraperitoneal adhesions	225	421	4.5

LOS: Length of hospital stay; S-MVR: Single-port multivisceral resection; M-MVR: Multi-port MVR.

study reporting the opposite[6]. It seems it is not the presence of proven malignant infiltration into adherent adjacent organs but the presence other tumor- and treatment-associated factors that are of prognostic importance. This review emphasized the importance of microscopic complete surgical resection, as one of the most predictive factors for overall- and recurrence-free survival[15,48]. These results are further highlighted by the results presented by Nielsen *et al*[9] comparing primary and recurrent rectal cancers. The authors stated that no statistically significant difference in overall survival was seen regarding the disease setting when comparing R0-resections. The remaining studies dealing with primary versus recurrent rectal cancer found the disease setting to be of significant prognostic impact[10,28]. Patient selection for MVR in the recurrent disease setting should be made on a case-by-case basis, because achievement of R0 -resection in these patients can also produce acceptable long-term results. The intraoperative assessment of truly preventing an R1 -resection is virtually not possible, but nevertheless palliative MVR should not be performed as shown by the data from Leijssen *et al*[2]. Authors reported for patients with proven T4 -cancers not undergoing MVR the highest local recurrence rate, namely 21.5% (compared to patients undergoing MVR: 14.5%) and the worst 5-year OS-and DFS rates (46.3% *vs* 52.7% *vs* 70% and 74.1%, respectively).

Apart from the completeness of surgical resection factors like lymph -node and lymphovascular involvement seem to be predictive for survival. López-Cano *et al*[49], Smith *et al*[47] and Harris *et al*[19] showed that lymphatic spread was associated with worse prognosis. Cukier *et al*[24] and Dinaux *et al*[50] discussed the significance of the ypN -stage. Cukier *et al*[24] reported no statistical difference in terms of DFS when comparing ypN0 and ypN1 patients. Contrarily, Dinaux *et al*[50] showed that ypN+ status was significantly associated with overall mortality. Hoffmann *et al*[21] found no difference in terms of OS for pN0 versus pN1 patients after MVR for primary co-lorectal cancers.

The role of neoadjuvant and adjuvant chemo- (radio-) therapy in short- and long-term results was hardly assessable due to the heterogeneity of data provided. The study by Sanfilippo *et al*[26] showed no significant association between application of neoadjuvant chemotherapy and local pelvic control rate. Dinaux *et al*[50] even found the performance of adjuvant chemotherapy to be significantly associated with overall mortality.

The significance of minimally-invasive MVR was highlighted in a couple of studies (Table 4). The laparoscopic approach for standard -resections for colon - and gastric cancer has already become accepted with low morbidity rates and comparable oncologic long-term results. The acceptance of laparoscopic or robotic MVR is low but the minimally-invasive approach seems to harbor some advantages over the open

Table 5 Patient- and treatment- associated parameters after multivisceral resection for gastric cancer

Study	Resection margin (R0 *vs* R1)	Most common resected organs	Lymph node involvement	Age	Blood transfusion	Complications (AI) (Re-OP)	Other prognostic factors
Carboni *et al*[39], 2005	R0 61.5%; R1 27.7%; R2 10.8%	Spleen: 48%; Pancreas: 43%; Colon: 25%	86.2%	61	NR	(1.5%) (1.5%)	Lymph-node involvement and metastatic disease
Colen *et al*[37], 2004	NR	Spleen: 62%; Pancreas 57%; Colon: 24%	NR	67.5	NR	0% (NR)	NR
D'Amato *et al*[38], 2004	R0: 69%	Pancreas: 62%; Colon: 12%	NR	NR	NR	(0%) (NR)	NR
Jeong *et al*[43], 2009	R0: 78.3%; R+: 21.7%	Spleen: 47%; Pancreas: 61%; Colon: 24%	N+: 90.1%	59	NR	(6.7%) (11%)	Lymph-node and lymphovascular involvement
Kim *et al*[35], 2009	R0: 43%; R1: 15%; R2: 74%	Spleen: 38%; Pancreas: 29%; Colon: 56%	NR	NR	NR	(2.9%) (0%)	histologic type, M stage, peritoneal metastasis, curability and treatment groups
Martin *et al*[36], 2002	R0: 100%	Spleen: 67%; Pancreas: 19%; Colon: 6%; Liver: 4% Gallbladder: 7%	N0: 35% N+: 65%	66	NR	(NR) (NR)	Lymph-node involvement and > pT3
Oñate-Ocaña *et al*[32], 2008	R0: 58.1%; R1: 18.9%; R2: 23%	Spleen: 68%; Pancreas: 26%; Colon: 12%; Liver: 9%	NR	NR	NR	(NR) (NR)	NR
Ozer *et al*[44], 2009	NR	Pancreas: 54%; Colon: 32%; Liver: 18%	NR	58	NR	(8.9%) (NR)	Advanced age, lymph node involvement, and resection of more than 1 additional organ were significant prognostic factors for survival.
Persiani *et al*[46], 2008	R0: 320; R1: 39; R2: 29%	Spleen: 84%; Pancreas: 25%; Colon: 10%	NR	63.4	NR	(NR) (NR)	Splenectomy, D2 lymphadenectomy, and age greater than 64 yr were the only factors predictive of overall morbidity
Shchepotin *et al*[33], 1998	NR	Spleen: 43%; Pancreas: 69%; Colon: 45% Liver: 29%	N+: 38.8%	NR	NR	(3.7%) (NR)	NR
Isozaki *et al*[45], 2000	NR	Pancreas + Spleen: 36%; Pancreatoduodenectomy: 7%	N0 = 13%; N1 = 36%; N2 = 25%; N3 = 12%	NR	NR	(NR) (NR)	Location of the tumor, lymph node metastasis, histological depth of invasion, and extent of lymph node dissection
Molina *et al*[40], 2019	R0: 94%	Pancreas (49%); Spleen (34%) Liver (29%).	N+: 80%	64,5	NR	(NR) (NR)	Lymph-node involvement and R1-status
Mita *et al*[42], 2017	R0: 82.5%; R1: 17.5%	Spleen 29.1%; Pancreas: 46.6%; Colon: 13.6%; Liver: 11.7%	N+: 84.5%	70	NR	(NR) (NR)	Resection status
Vladov *et al*[38], 2015	R0: 75%	Spleen: 76.7%; Pancreas:40%; Colon: 18.3%; Liver 15%	NR	NR	NR	(NR) (NR)	NR

Tran *et al*[31], 2015	R1: 15.5	Spleen: 48%; Pancreas:27% Liver 14% Colon: 13%	N0: 34.5%	64	NR	(11.5%) (13.8%)	MVR with pancreatectomy, was significantly associated with decreased survival, along with T-stage, N stage, perineural invasion, and
Pacelli *et al*[34], 2013	R0: 38.4%	Pancreas 46; Colon 43	N+: 89.3%	NR	NR	(7%) (NR)	Lymph-node involvement and incomplete resection

MVR: Multivisceral resection; NR: Not reported; AI: Anastomotic insufficiency.

approach. Table 4 sums up the most important studies, highlighting the fact that minimally-invasive MVR is associated with a reduced operative time, reduced blood loss and transfusion requirement. The conversion rates were low by a comparable lymph-node harvest. Prior to scheduling patients for minimal-invasive MVR, relative contraindications like excessive small bowel- and urologic tract involvement should receive attention.

Our analysis of the so far published results of MVR for patients with locally advanced gastric cancer shows 5-year survival rates of 24.1%-37.8% for patients with an R0-resection, while the rate of morbidity was 11.8% to 59.8% and the rate of mortality 0-15%. The authors of these studies therefore consider MVR for locally advanced gastric cancer to be a potentially beneficial procedure, especially if there is a possibility of curative resection.

Comparable results can also be found for MVR of other abdominal tumor entities such as neuroendocrine tumors or gastrointestinal stroma tumors[51]. Similar approaches were also investigated for locally advanced pancreatic adenocarcinoma and colorectal cancer. With the acceptance of higher rates of morbidity and longer operating times MVR for locally advanced pancreatic adenocarcinoma may lead to a long -term survival comparable to that for standard resections of the pancreas[52].

In conclusion, the main limitation of this review is the mainly retrospective studies included and the heterogeneity in reporting short- and long-term outcomes. Nevertheless, MVR for primary cancers are of significant importance in oncologic surgery providing acceptable morbidity- and mortality rates with good long-term survival for selected patients. Negative selection criteria are incomplete surgical resection, recurrent rectal cancer, and lymph-node and lymphovascular involvement. Stage-IV disease should be regarded as a relative contraindication for MVR.

Table 6 Morbidity, mortality and survival rates after multivisceral resection for gastric cancer

Study	*n*	Follow-up (mo)	Morbidity (%)	Mortality (%)	Survival	Stage IV (%)	True pT4b (%)
Carboni *et al*[39], 2005	65	13	27.7	12.3	OS: 21.8 mo	46	80
Colen *et al*[37], 2004	21	NR	39	10	OS: 30 mo	NR	38
D'Amato *et al*[38], 2004	52	NR	34.6	1.9	OS: 31 mo	NR	NR
Jeong *et al*[43], 2009	71	17.6	26.8	NR	3-yr OS: 36.4%	76	63
Kim *et al*[35], 2009	34	NR	11.8	0	OS: 37.8 mo	38	NR
Martin *et al*[36], 2002	268	NR	39.2	NR	OS: 63 mo	NR	21
Oñate-Ocaña *et al*[32], 2008	74	NR	26.9	NR	OS: 30.5 mo	NR	14-38
Ozer *et al*[44], 2009	56	10.8	37.5	12.5	3-yr OS: 53.3%	62	66
Persiani *et al*[46], 2008	51	NR	16.2	2.3	NR	79	19.6
Shchepotin *et al*[33], 1998	353	NR	31.2	13.6	5-yr OS: 25%	NR	89.0
Isozaki *et al*[45], 2000	86	NR	NR	NR	5-yr OS: 35%	NR	53
Molina *et al*[40], 2019	35	31	46	3	5-yr OS. 34%	NR	40
Mita *et al*[42], 2017	103	23.0	37.9	1.0	3-yr OS: 42.1%	0	57
Vladov *et al*[38], 2015	60	NR	28.3	6.7	5-yr OS: 24.1%	NR	70
Tran *et al*[31], 2015	159	NR	59.8	4.3	5-yr OS: MVR with pancreatectomy: 20%; MVR without: 36%	0	67
Pacelli *et al*[34], 2013	112	18.7	33.9	3,6	5-yr OS: 27.2%	NR	88

OS: Overall survival; NR: Not reported; MVR: Multivisceral resection.

ARTICLE HIGHLIGHTS

Research background

Multivisceral resections (MVR) still constitute a challenge for the interdisciplinary team. The indications to perform MVR are not clearly defined.

Research motivation

Motivation was generated by the fact that there are no recommendations regarding MVR.

Research objectives

In order to define indications and factors associated with beneficial oncologic outcomes and reduced perioperative morbidity and mortality this systematic review was conducted.

Research methods

We performed a PubMed-search from 2000 to 2018 including articles reporting on MVR in patients with colon-, rectal- and gastric cancer.

Research results

Available data shows that MVR from locally advanced colorectal and gastric cancer is a feasible option which is associated with acceptable morbidity- and mortality-rates. Oncologic outcome is favorable when clear resection margins can be obtained.

Research conclusions

Patients who are clinically fit and preoperative imaging does not reveal obvious contraindication for radical surgery, the option of MVR should not be abandoned. Clear resection margins are the main goal of aggressive surgical approach.

Research perspectives

Perspectives are to evaluate more patient- and treatmenspecific parameters in order to define more clearly patients who are likely to benefit from this approach.

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