



**Universiteit
Leiden**
The Netherlands

Propensity score-matched analysis of oncological outcome between stent as bridge to surgery and emergency resection in patients with malignant left-sided colonic obstruction

Amelung, F.J.; Borstlap, W.A.A.; Consten, E.C.J.; Veld, J.V.; Halsema, E.E. van; Bemelman, W.A.; ... ; Dutch Snapshot Res Grp

Citation

Amelung, F. J., Borstlap, W. A. A., Consten, E. C. J., Veld, J. V., Halsema, E. E. van, Bemelman, W. A., ... Zwols, T. (2019). Propensity score-matched analysis of oncological outcome between stent as bridge to surgery and emergency resection in patients with malignant left-sided colonic obstruction. *British Journal Of Surgery*, 106(8), 1075-1086. doi:10.1002/bjs.11172



Version: Publisher's Version

License: [Licensed under Article 25fa Copyright Act/Law \(Amendment Taverne\)](#)

Downloaded from: <https://hdl.handle.net/1887/122974>

Note: To cite this publication please use the final published version (if applicable).

Propensity score-matched analysis of oncological outcome between stent as bridge to surgery and emergency resection in patients with malignant left-sided colonic obstruction

F. J. Amelung¹ , W. A. A. Borstlap² , E. C. J. Consten¹, J. V. Veld², E. E. van Halsema³, W. A. Bemelman², P. D. Siersema⁴, F. ter Borg⁵, J. E. van Hooft³, P. J. Tanis², on behalf of the Dutch Snapshot Research Group*

¹Department of Surgery, Meander Medical Centre, Amersfoort, Departments of ²Surgery and ³Gastroenterology and Hepatology, Amsterdam University Medical Centres, location AMC, Amsterdam, and Departments of Gastroenterology and Hepatology, ⁴Radboud Academic Medical Centre, Nijmegen, and ⁵Deventer Hospital, Deventer, the Netherlands

Correspondence to: Dr P. J. Tanis, Department of Surgery, Amsterdam University Medical Centres, University of Amsterdam, PO Box 22660, 1100DD Amsterdam, the Netherlands (e-mail: p.j.tanis@amc.nl)

Background: Although self-expandable metal stent (SEMS) placement as bridge to surgery (BTS) in patients with left-sided obstructing colonic cancer has shown promising short-term results, it is used infrequently owing to uncertainty about its oncological safety. This population study compared long-term oncological outcomes between emergency resection and SEMS placement as BTS.

Methods: Through a national collaborative research project, long-term outcome data were collected for all patients who underwent resection for left-sided obstructing colonic cancer between 2009 and 2016 in 75 Dutch hospitals. Patients were identified from the Dutch Colorectal Audit database. SEMS as BTS was compared with emergency resection in the curative setting after 1:2 propensity score matching.

Results: Some 222 patients who had a stent placed were matched to 444 who underwent emergency resection. The overall SEMS-related perforation rate was 7.7 per cent (17 of 222). Three-year locoregional recurrence rates after SEMS insertion and emergency resection were 11.4 and 13.6 per cent ($P = 0.457$), disease-free survival rates were 58.8 and 52.6 per cent ($P = 0.175$), and overall survival rates were 74.0 and 68.3 per cent ($P = 0.231$), respectively. SEMS placement resulted in significantly fewer permanent stomas (23.9 versus 45.3 per cent; $P < 0.001$), especially in elderly patients (29.0 versus 57.9 per cent; $P < 0.001$). For patients in the SEMS group with or without perforation, 3-year locoregional recurrence rates were 18 and 11.0 per cent ($P = 0.432$), disease-free survival rates were 49 and 59.6 per cent ($P = 0.717$), and overall survival rates 61 and 75.1 per cent ($P = 0.529$), respectively.

Conclusion: Overall, SEMS as BTS seems an oncologically safe alternative to emergency resection with fewer permanent stomas. Nevertheless, the risk of SEMS-related perforation, as well as permanent stoma, might influence shared decision-making for individual patients.

*Members of the Dutch Snapshot Research Group are co-authors of this study and can be found under the heading Collaborators

Presented to a meeting of the European Society of Coloproctology, Nice, France, September 2018

Paper accepted 12 February 2019

Published online 10 May 2019 in Wiley Online Library (www.bjs.co.uk). DOI: 10.1002/bjs.11172

Introduction

Of all patients with colonic cancer, 9–13 per cent present initially with an acute obstruction, which accounts for 85 per cent of colonic emergencies^{1,2}. Traditionally, left-sided obstructing colonic cancer (LSOCC) has been managed with emergency resection³. However, as patients presenting with LSOCC are often elderly and frequently in poor

clinical condition, emergency resection has been associated with substantial morbidity and mortality rates^{1,3–5}. In addition, many patients end up with a permanent stoma, which is known to have a negative impact on quality of life and independence^{6,7}.

In the past decade, self-expandable metal stent (SEMS) placement has been proposed as an alternative to emergency resection for LSOCC. Initial decompression

of the distended colon by SEMs placement can transform the resection into an elective procedure, enabling a laparoscopic approach in a clinically optimized patient. Meta-analyses^{8,9} have confirmed higher proportions of laparoscopic surgery after SEMs placement, with lower postoperative morbidity rates, fewer temporary stomas and higher primary anastomosis rates.

Even though the short-term benefit has been established in recent years, SEMs as bridge to surgery (BTS) for curative treatment of LSOCC is currently not recommended as a standard treatment in international guidelines¹⁰. Concerns include a higher rate of perineural invasion and an increase in tumour cell dissemination after stent insertion^{11–14}. Furthermore, stent- or guidewire-related perforations may increase the risk of recurrence¹⁵. SEMs as BTS has been associated with worse survival¹⁶, although this has not been confirmed by recent meta-analyses^{17–19}.

Treatment of LSOCC in the Netherlands has been influenced strongly by two multicentre Dutch randomized trials, Stent-In 1 and 2^{20,21}. After early termination of both trials because of increased morbidity in the experimental arms, SEMs has been used infrequently, with only a few centres continuing to perform stenting. Although the use of stent placement increased following publication of the European Society of Gastrointestinal Endoscopy (ESGE) guidelines¹⁰ in 2014, where stenting as BTS is recommended in elderly patients with a high operative risk (ASA fitness grade III–IV), emergency resection is still the preferred approach in the vast majority of Dutch hospitals. Allocation of treatment in the Netherlands is therefore mainly hospital-based instead of patient-based. The aim of this propensity score-matched population-based analysis was to provide real-world evidence²² on the long-term oncological outcomes after SEMs as BTS and emergency resection for LSOCC.

Methods

A retrospective national collaborative research project was conducted in the Netherlands. The methodology was described in the first publication of the Dutch Snapshot Research Group (DSRG)²³. Briefly, short-term data from all patients in the Netherlands undergoing resection of primary colorectal cancer are collected prospectively in the Dutch Colorectal Audit (DCRA, formerly known as DSCA). It is mandatory for all Dutch hospitals to register their patients in the DCRA. All patients who underwent resection for LSOCC between 2009 and 2016 were identified from the DCRA database. Short-term DCRA data were extended with additional procedural data,

and long-term surgical and oncological data. For collection of these additional data, a web-based tool was developed and controlled in accordance with privacy regulations by Medical Research Data Management (Deventer, the Netherlands).

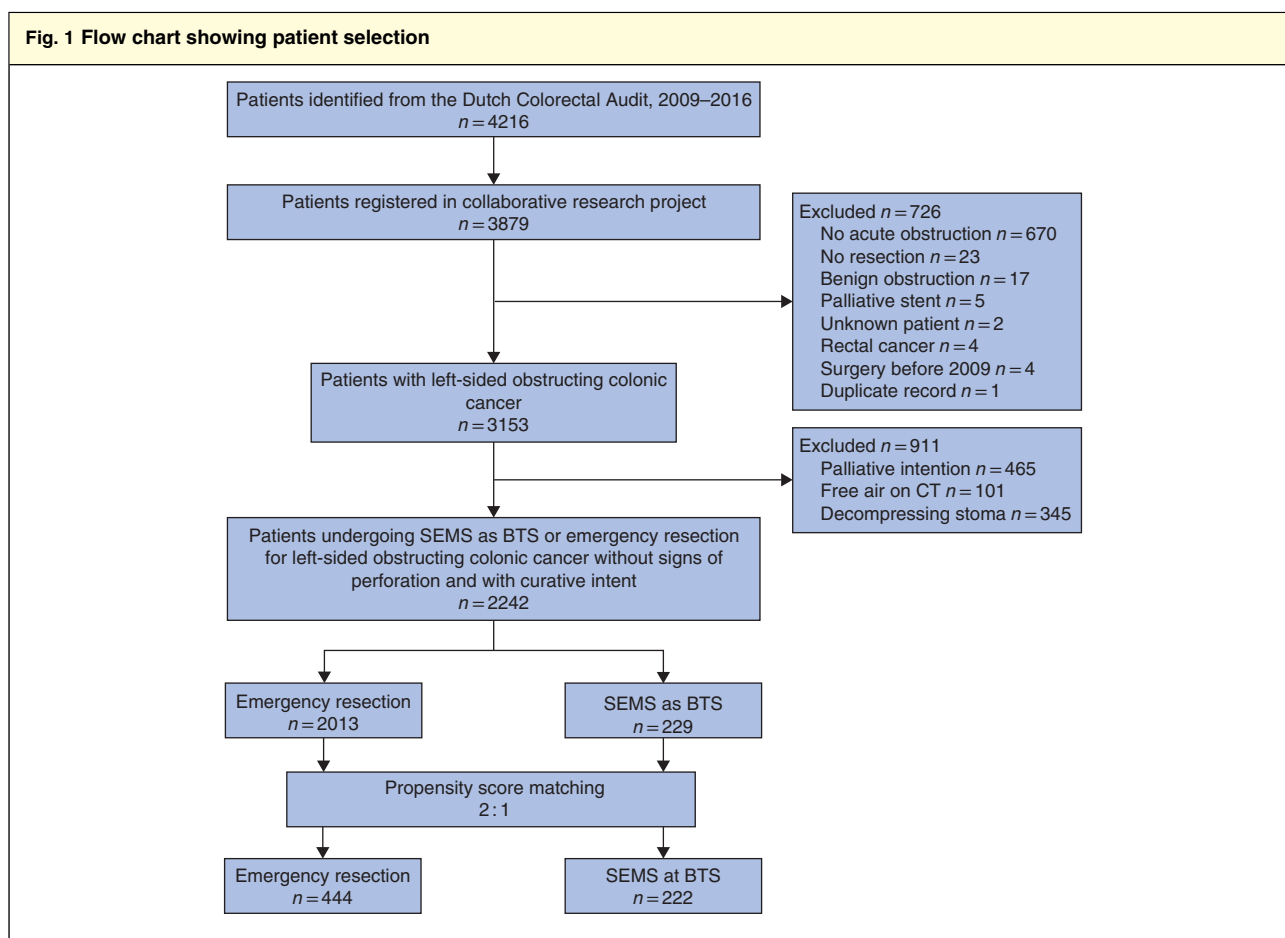
All 77 Dutch hospitals were invited to participate in this project. Collaborators in each participating hospital were asked to provide data on their registered patients. Under the supervision of one or two consultants, surgical residents performed web-based data collection between August 2017 and December 2017. These data were then analysed for discrepancies and missing values. Any discrepancies were communicated back to the participants, who were asked to verify or complete the data. All local investigators had an extra month for data correction. After the period of data verification, the final data extraction was carried out in January 2018. The combined set of DCRA and DSRG data was anonymized and was sent to the central research coordinator. The study was designed and manuscript prepared in accordance with the STROBE statement²⁴. The medical ethics committee of the Academic Medical Centre in Amsterdam reviewed and approved the observational study design, and decided that informed consent did not need to be obtained as there was no additional burden for the patient owing to the observational design of the study.

Patient selection

Patients treated for LSOCC in 2009–2016 were selected from the DCRA database using primary tumour location (splenic flexure, descending colon or sigmoid) and either registration of clinical obstruction and/or an intervention (SEMs placement) preceding primary tumour resection. Patients who presented with perforation and those who had preoperative radiotherapy were excluded.

The DSRG collaborators then reviewed all original patient files individually based on eligibility criteria, with additional variables on signs of clinical obstruction taken into consideration to allow more precise patient selection. Patients were considered to have acute colonic obstruction when they had at least one clinical sign of colonic obstruction (bloated abdomen, nausea and/or vomiting) and radiological signs of colonic obstruction on CT (dilated large and/or small bowel loop).

For this analysis, only data on patients who underwent either SEMs as BTS or emergency resection with curative intent were extracted. Whether a patient was treated with curative intent was one of the variables acquired in the DSRG data set. Centres performing SEMs placement were categorized for subgroup analysis; high-volume centres were defined as those in which over 70 per cent of



SEMS, self-expandable metal stent; BTS, bridge to surgery.

patients with LSOCC were treated with SEMS and stents were placed by an experienced endoscopist (at least 20 procedures).

Endpoints

The primary endpoints were 3-year disease-free and overall survival. Secondary outcomes were locoregional recurrence and permanent stoma rates. Locoregional recurrence was defined as a recurrence at the level of the anastomosis, in a locoregional lymph node or a peritoneal metastasis.

Adjuvant chemotherapy and follow-up

The Dutch colorectal cancer guidelines²⁵ recommend adjuvant chemotherapy in patients with high-risk stage II (T4, fewer than 10 lymph nodes harvested, presentation with obstruction, vascular invasion, undifferentiated tumour) and stage III disease. Adjuvant chemotherapy until 2016 consisted of either FOLFOX (oxalipatin, leucovorin,

5-fluorouracil) or CAPOX (capecitabine, oxaliplatin) for a total of 6 months.

Follow-up according to the guidelines²⁵ included clinical visits at 6-month intervals for the first 2–3 years and yearly thereafter until 5 years after curative resection, with at least carcinoembryonic antigen (CEA) measurement at each visit. Abdominal (liver) ultrasonography or CT was recommended every 6 months for 1–2 years after resection and yearly thereafter. In addition, surveillance colonoscopy was performed at 1 and 4 years after resection.

Statistical analysis

As patients were not assigned randomly to a treatment approach, a propensity score method was used to balance baseline co-variables between groups. Co-variables were selected *a priori*, and included age, sex, ASA grade, BMI, pathological T, N and M categories, tumour location, year of presentation, tumour length on CT and previous abdominal surgery. Before calculating the propensity

Table 1 Baseline characteristics before and after propensity score matching

	Before PS matching			After PS matching		
	Emergency resection (n = 2013)	SEMS as BTS (n = 229)	MSD (%)	Emergency resection (n = 444)	SEMS as BTS (n = 222)	MSD (%)
Age (years)*	71 (62–79)	72 (64–80)	6.8	73 (63–79)	72 (64–80)	1.7
Sex ratio (M : F)	1071 : 942	128 : 101	5.4	253 : 191	124 : 98	2.3
BMI (kg/m²)†	25.5(4.2)	25.7(4.3)	8.3	24.7(4.2)	24.9(4.4)	2.5
ASA fitness grade						
I	355 (17.7)	49 (21.7)	10.0	94 (21.4)	48 (21.8)	0.5
II	968 (48.2)	120 (53.1)	9.5	227 (51.6)	117 (53.2)	4.5
III	593 (29.5)	53 (23.5)	14.9	110 (25.0)	51 (23.2)	4.8
IV	91 (4.5)	4 (1.8)	21.1	9 (2.0)	4 (1.8)	1.7
Missing	6	3		4	2	
pT category						
pT1–2	78 (3.9)	12 (5.3)	2.1	26 (5.9)	11 (5.0)	3.8
pT3	1399 (69.7)	162 (72.0)	4.6	313 (70.7)	158 (71.8)	2.5
pT4	530 (26.4)	51 (22.7)	9.7	104 (23.5)	51 (23.2)	1.1
Missing	6	4		1	2	
pN category						
pN0	928 (46.4)	111 (49.3)	4.1	220 (49.8)	105 (47.9)	3.8
pN1	699 (34.9)	73 (32.4)	6.5	140 (31.7)	73 (33.3)	2.3
pN2	374 (18.7)	41 (18.2)	0.4	82 (18.6)	41 (18.7)	1.1
Missing	12	4		2	3	
Metastases present at presentation	186 (9.2)	24 (10.5)	4.2	50 (11.3)	22 (10.0)	4.5
Previous abdominal surgery	595 (29.6)	53 (23.1)	14.4	112 (25.2)	53 (23.9)	2.9
Tumour location						
Sigmoid	1364 (67.8)	169 (73.8)	7.2	322 (72.5)	162 (73.0)	1.0
Descending colon	375 (18.6)	45 (19.7)	2.5	91 (20.5)	45 (20.3)	0.5
Splenic flexure	274 (13.6)	15 (6.6)	13.7	31 (7.0)	15 (6.8)	0.8
Median length of stenosis (cm)*	4 (3–6)	4 (3–5)	23.6	4 (3–5)	4 (3–5)	6.5

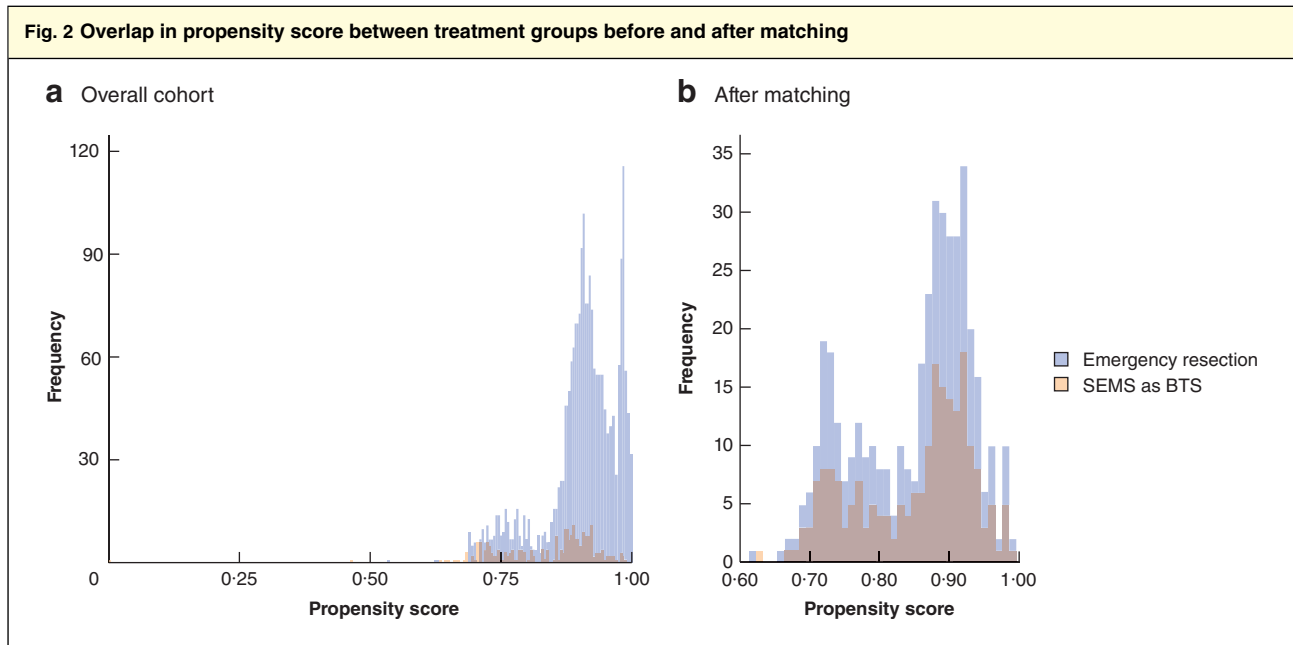
Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.) and †mean(s.d.). PS, propensity score; SEMS, self-expandable metallic stent; BTS, bridge to surgery; MSD, mean standardized difference.

score, missing data were imputed using multiple imputation by chained equations. One-to-two nearest neighbour matching without replacement (optimal matching) was performed within a calliper of 0.2 logit of the standard deviation of the propensity score²⁶. The propensity score was then evaluated using Nagelkerke's R^2 statistic as a measure of fit, with a score close to 0 indicating good overlap in the treatment groups. The co-variable balance of the matched cohort was assessed using mean standardized differences, with differences of less than 10 per cent indicating good balance.

Categorical or dichotomous variables are presented as absolute numbers with percentages, and were compared before matching using the χ^2 test. After matching, in order to account for the matched nature of data, outcome variables were assessed by means of conditional logistic regression^{27,28}. Continuous variables are shown

as mean(s.d.) or median (i.q.r.) according to their distribution. Depending on the distribution, treatment groups were compared using independent Student's t test or Mann–Whitney U test before matching; paired t test was used after matching. All analyses were conducted based on the intention-to-treat principle (emergency resection for SEMS perforation was analysed in the SEMS group).

Comparison of survival probabilities in the matched cohort was performed using a Cox proportional hazards model with shared frailty. To verify the results in the matched groups, survival analyses were also carried out for the entire patient cohort before matching, with propensity score as a correcting factor. Subgroup analyses were undertaken to compare outcome parameters in the SEMS group for patients with SEMS-related perforation *versus* no perforation, and treatment at high- *versus* low-volume centres. Survival curves in the SEMS group were plotted according to the Kaplan–Meier method and tested for significant



a Overall cohort and **b** after matching. SEMS, self-expandable metal stent; BTS, bridge to surgery. Nagelkerke $R^2 = 0.095$ in overall cohort.

Table 2 Treatment characteristics in the matched cohort				
	Emergency resection (n = 444)	SEMS as BTS (n = 222)	Hazard ratio:‡#	P**
Surgical approach				< 0.001
Open	410 (93.0)	126 (57.5)		
Laparoscopic	31 (7.0)	93 (42.5)	9.27 (5.58, 15.39)	
Missing	3	3		
Resection type			0.94 (0.83, 1.08)	0.391
Sigmoid resection	279 (62.8)	132 (59.5)		
Left hemicolectomy	99 (22.3)	68 (30.6)		
Subtotal colectomy	28 (6.3)	6 (2.7)		
Anterior resection	11 (2.5)	7 (3.2)		
Other	27 (6.1)	9 (4.1)		
Primary anastomosis	177 (39.9)	165 (74.3)	4.18 (2.87, 6.08)	< 0.001
Temporary stoma	290 (65.3)	63 (28.4)	0.20 (0.14, 0.30)	< 0.001
Age < 70 years	116 of 183 (63.4)	21 of 91 (23)	0.14 (0.06, 0.36)	< 0.001
Age ≥ 70 years	174 of 261 (66.7)	42 of 131 (32.1)	0.18 (0.09, 0.34)	< 0.001
No. of lymph nodes resected*	14 (10–19)	16 (13–23)	1.03 (1.01, 1.05)	< 0.001
No. of patients with a complication				
During the entire treatment approach§	186 (41.9)	95 (42.8)	0.96 (0.68, 1.37)	0.831
Anastomotic leakage¶	25 of 177 (14.1)	18 of 165 (10.9)	0.65 (0.30, 1.42)	0.279
Complications requiring reintervention	35 (7.9)	24 (10.8)	1.43 (0.81, 2.54)	0.223
Following tumour resection	186 (41.9)	78 (35.1)	0.77 (0.55, 1.08)	0.095
90-day or in-hospital mortality	28 (6.3)	12 (5.4)	0.85 (0.43, 1.70)	0.647
Adjuvant chemotherapy	165 (37.2)	84 (37.8)	0.97 (0.70, 1.35)	0.868
Time to start of adjuvant chemotherapy after resection (weeks)*	6 (5–9)	9 (7–12)	1.04 (0.99, 1.08)	0.113

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.) and ‡values in parentheses are 95 per cent confidence intervals. §Complications after self-expandable metal stent (SEMS) placement and/or tumour resection combined. ¶For patients who had a primary anastomosis. #Emergency surgery is the reference group. **Conditional logistic regression analysis.

	Emergency resection (n = 444)	SEMS as BTS (n = 222)	Hazard ratio‡§	P¶
Median follow-up (months)*	34 (15–58)	42 (17–65)	1.01 (1.00, 1.02)	0.002
Permanent stoma at end of follow-up	201 (45.3)	53 (23.9)	0.39 (0.28, 0.57)	<0.001
Age < 70 years	50 of 183 (27.3)	15 of 91 (16)	0.53 (0.23, 1.24)	0.014
Age ≥ 70 years	151 of 261 (57.9)	38 of 131 (29.0)	0.36 (0.21, 0.62)	<0.001
Any recurrence during follow-up	225 (50.7)	105 (47.3)	0.90 (0.64, 1.26)	0.541
Locoregional recurrence	53 (11.9)	22 (9.9)	0.88 (0.50, 1.54)	0.655
Anastomotic recurrence	15 (28)	7 (32)		
Loco-regional lymph node metastasis	1 (2)	2 (9)		
Peritoneal metastasis	37 (70)	13 (59)		
Distant metastases	118 (26.6)	48 (21.6)	0.75 (0.50, 1.14)	0.125
Para-aortic lymph node metastasis	3 (2.5)	2 (4.1)		
Liver	73 (61.9)	32 (67)		
Lung	59 (50.0)	19 (40)		
Bone	5 (4.2)	4 (8)		
Brain	6 (5.1)	3 (6)		
Actuarial 3-year rates (%)#				
Locoregional recurrence	13.6	11.4	0.84 (0.72, 1.96)	0.457
Disease-free survival	52.6	58.8	0.83 (0.92, 1.57)	0.175
Overall survival	68.3	74.0	0.85 (0.90, 1.53)	0.231

Values in parentheses are percentages unless indicated otherwise; *values are median (i.q.r.) and ‡values in parentheses are 95 per cent confidence intervals. §Emergency resection is reference group. SEMS, self-expandable metal stent; BTS, bridge to surgery. ¶Conditional logistic regression analysis, except #determined by Kaplan–Meier analysis and tested using Cox proportional hazards model with shared frailty.

differences using the log rank test. Two-sided $P < 0.050$ was considered significant. All analyses were performed with SPSS® version 25.0 (IBM, Armonk, New York, USA) and R version R3.3.2 (Matching and Frailtypack package, MICE package; R Foundation for Statistical Computing, Vienna, Austria).

Results

Seventy-five of 77 Dutch hospitals participated in this collaborative research project. A total of 3879 patients were registered of the 4216 patients identified (92.0 per cent) (Fig. 1). After retrospective evaluation of original patient files, 726 patients were excluded, of whom 670 appeared to be registered incorrectly in the DCRA as having an obstruction (stricturing tumour, unable to pass with the endoscope, but without clinical signs of obstruction). This resulted in an overall cohort of 3153 patients with LSOCC. Applying eligibility criteria for the present analysis resulted in 2242 patients, of whom 229 underwent SEMS as BTS and 2013 emergency resection. Using 1 : 2 propensity score matching, 222 patients in the SEMS group were matched to 444 in the emergency resection group. Seven patients in the SEMS group were excluded as no matches could be found in the emergency resection group.

Before matching, baseline characteristics were biased for ASA grade, previous abdominal surgery, tumour location and tumour length on CT (mean standardized difference over 10 per cent) (Table 1). After propensity score matching, none of these differences remained. Histograms of the estimated propensity scores before and after matching are shown in Fig. 2. The Nagelkerke's R^2 value of 0.095 indicates a good overlap in propensity scores between treatment groups. The degree of overlay in propensity score (Fig. 2b), and standardized mean differences between baseline variables below 10 per cent for all variables, indicated that matching was successful in obtaining two well balanced groups.

There were no missing data in the unmatched data set for age, sex, primary tumour location, year of presentation, anastomotic leakage, 90-day mortality and overall survival. Data for all other baseline and outcome variables in the matched data set were missing for less than 3 per cent of patients, except for local recurrence during follow-up, which was missing for 34 of 666 patients (5.1 per cent), and metastasis during follow-up, which was missing for 26 of 666 patients (3.9 per cent). Missing values for variables used to calculate the propensity score were completed by multiple imputation (ASA grade, previous abdominal surgery, TNM categories, BMI and tumour length on CT).

Treatment characteristics

The overall technical success rate of SEMS was 87.4 per cent (194 of 222 patients). The two main reasons for technical failure were not being able to pass the guidewire (14) or SEMS (4) past the obstruction. Owing to technical SEMS failure, 22 patients had to undergo emergency resection within 24 h, three patients had a decompressing stoma constructed, and a second attempt at SEMS placement was successful in the remaining three patients.

Two guidewire perforations and six clinically overt SEMS-related perforations occurred, and all these patients underwent emergency resection. During the elective resection, two silent SEMS perforations were noted. In addition, the pathologist reported microperforation by a SEMS in seven other patients. The overall perforation rate was 7.7 per cent (17 of 222).

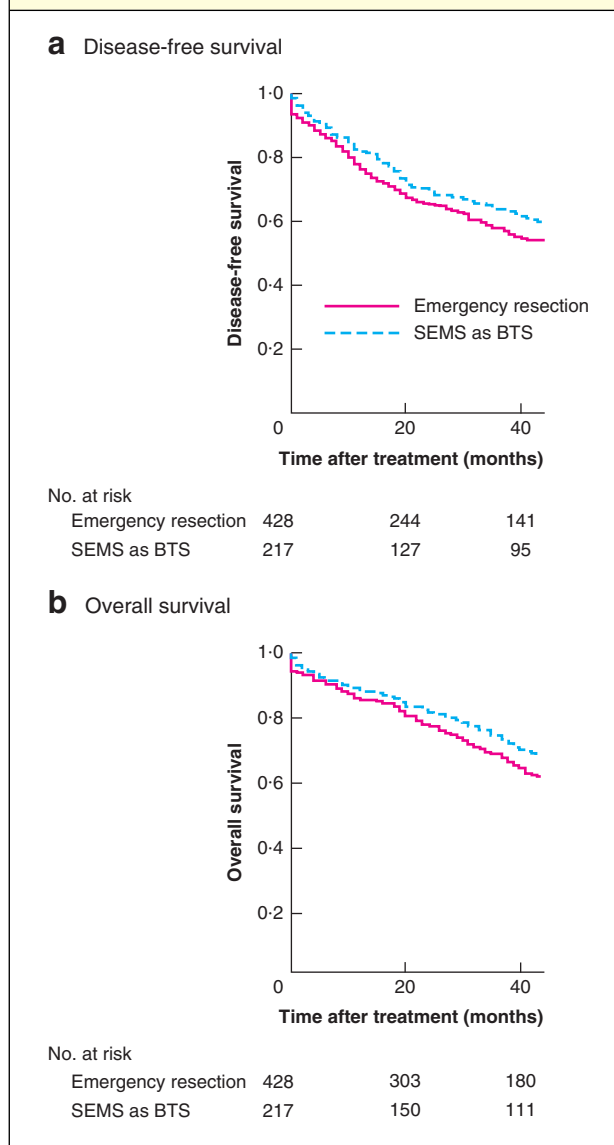
Of all SEMS procedures, 129 (58.1 per cent) were performed in five of 75 participating hospitals. Two hospitals were considered high volume and 85 of the 222 SEMS were carried out in these two institutions. Technical success rates in high- and low-volume SEMS centres were 78 of 85 (92 per cent) and 116 of 137 (84.7 per cent) respectively ($P = 0.207$). Corresponding clinical success rates were 71 of 85 (84 per cent) and 106 of 137 (77.4 per cent) ($P = 0.483$). The rate of SEMS-related complications (6 of 85 (7 per cent) *versus* 18 of 137 (13.1 per cent); $P = 0.184$) and SEMS-related perforations (4 of 85 (5 per cent) *versus* 13 of 137 (9.5 per cent); $P = 0.299$) was lower in high-volume centres, but the differences were not significant.

Table 2 summarizes treatment characteristics of the emergency resection and SEMS groups. Patients in the SEMS group more often underwent laparoscopic resection (42.5 *versus* 7.0 per cent; hazard ratio (HR) 9.27, 95 per cent c.i. 5.58 to 15.39; $P < 0.001$), more often had a primary anastomosis (74.3 *versus* 39.9 per cent; HR 4.18, 2.87 to 6.08; $P < 0.001$) and were less likely to have a temporary stoma (28.4 *versus* 65.3 per cent; HR 0.20, 0.14 to 0.30; $P < 0.001$). Thirty- and 90-day mortality rates, morbidity rate and the proportion of patients who underwent adjuvant chemotherapy did not differ between treatment groups.

Long-term outcomes

Median follow-up in the emergency resection and SEMS groups was 34 (i.q.r. 15–58) and 42 (17–65) months respectively. Overall long-term outcomes are summarized in Table 3. Three-year disease-free survival rates were 52.6 and 58.8 per cent for emergency resection and SEMS groups respectively (HR 0.83, 95 per cent c.i. 0.92 to

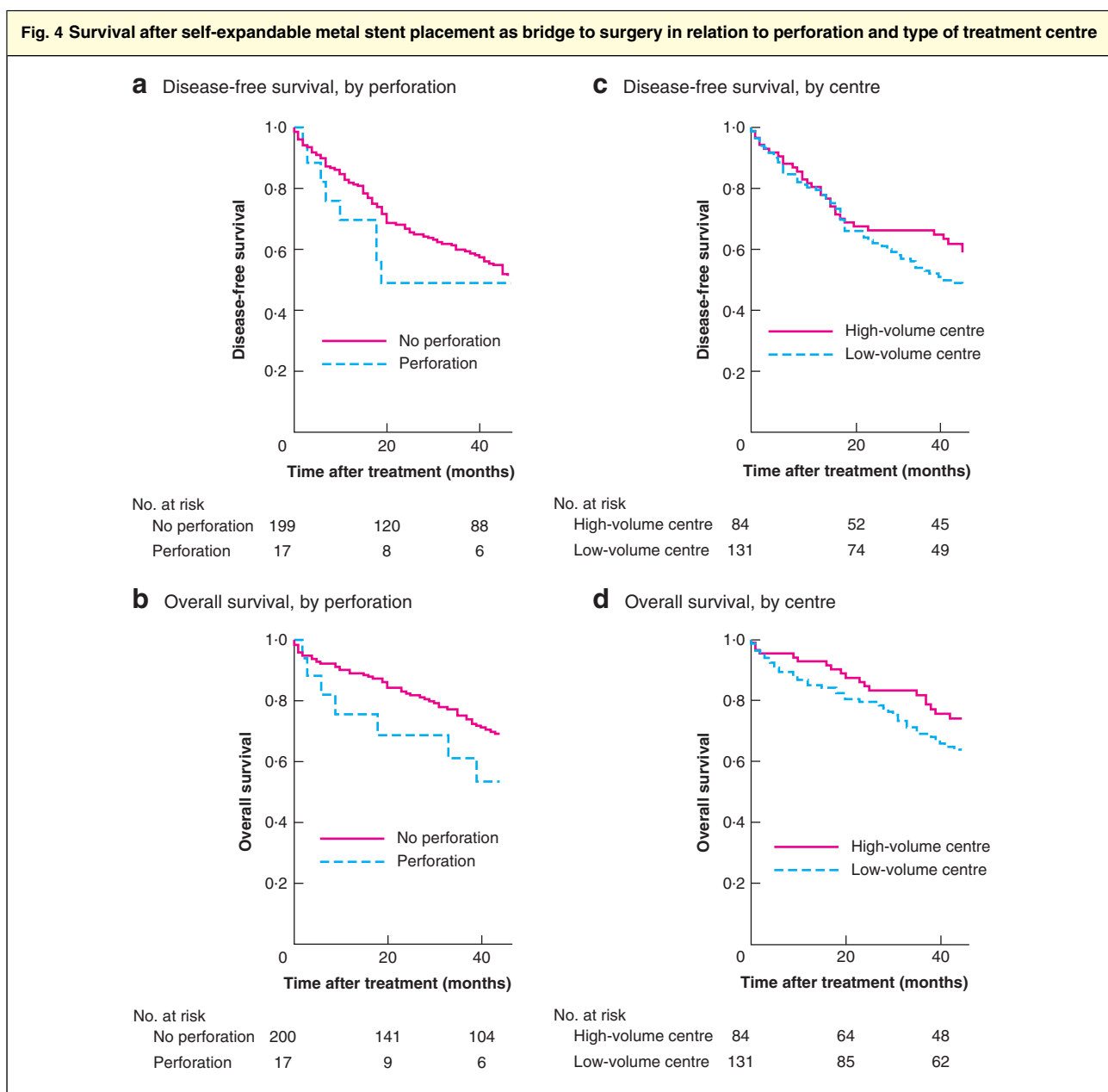
Fig. 3 Kaplan–Meier curves comparing disease-free and overall survival after emergency resection *versus* self-expandable metal stent placement as bridge to surgery



a Disease-free survival and **b** overall survival. SEMS, self-expandable metal stent; BTS, bridge to surgery. **a** $P = 0.175$, **b** $P = 0.231$ (frailty analysis).

1.57; $P = 0.175$) (Fig. 3). Three-year overall survival rates were 68.3 and 74.0 per cent respectively (HR 0.85, 0.90 to 1.53; $P = 0.231$). Additional Cox regression analysis of the unmatched data set (2242 patients) similarly showed no significant difference between treatment groups in disease-free survival (HR 0.91, 0.61 to 3.76) or overall survival (HR 0.94, 0.64 to 5.21).

Three-year locoregional recurrence rates were 13.6 and 11.4 per cent in the emergency resection and SEMS groups



a Disease-free and **b** overall survival in patients with or without perforation; **c** disease-free and **d** overall survival in patients treated in high- or low-volume centres. **a** $P=0.717$, **b** $P=0.529$, **c** $P=0.169$, **d** $P=0.103$ (log rank test).

respectively (HR 0.84, 0.72 to 1.96; $P=0.457$). Patients in the emergency resection group were almost twice as likely to have a permanent stoma at the end of follow-up than those in the SEMS group (45.3 versus 23.9 per cent; HR 0.40, 0.28 to 0.57; $P<0.001$). Younger patients (aged less than 70 years) were significantly more likely to have a temporary stoma reversed than elderly patients: 73 of 137 (53.3 per cent) versus 30 of 216 (13.9 per cent) ($P<0.001$).

Whether the stoma was reversed was independent of the treatment approach.

Comparing oncological outcomes after SEMS as BTS with or without guidewire- or SEMS-related perforation, 3-year disease-free survival rates were 49 and 59.6 per cent ($P=0.717$), and 3-year overall survival rates 61 and 75.1 per cent ($P=0.529$), respectively (Fig. 4a,b). Three-year locoregional recurrence rates in patients with and without

perforation were 18 and 11.0 per cent ($P = 0.432$). Comparing patients treated at high- and low-volume SEMS centres revealed 3-year disease-free survival rates of 66 *versus* 55.7 per cent ($P = 0.169$), 3-year overall survival rates of 82 *versus* 68.9 per cent ($P = 0.103$) and 3-year locoregional recurrence rates of 12 *versus* 11.2 per cent ($P = 0.975$).

Discussion

In this study, SEMS placement as BTS with curative intent in patients presenting with LSOCC was not associated with impaired long-term oncological outcomes. Compared with emergency resection, no significant differences in locoregional recurrence, disease-free and overall survival rates were found. The SEMS-related perforation rate was 7.7 per cent, with worse oncological outcomes in this small subgroup, although they were not significantly different from those in patients who underwent stent placement without perforation. High-volume SEMS centres had better results, but not significantly different from those of low-volume centres. Patients in the SEMS group had significantly fewer permanent stomas at the end of follow-up, especially elderly patients.

Although the short-term benefits of SEMS placement have been well established, concerns have been raised about worse oncological outcomes^{14,16}. In particular, SEMS-related perforations have been associated with an increase in locoregional recurrence and possible worse survival in the past^{15,29–31}. The present results are consistent with this, as the 17 patients who suffered a SEMS-related perforation had a higher recurrence rate and worse survival, although there was insufficient statistical power for firm conclusions to be drawn.

Concerns about oncological outcomes have also been raised in the event of uncomplicated SEMS placement. Several studies^{11–16} have reported on pathophysiological mechanisms that could possibly lead to worse oncological outcome after SEMS insertion. These concerns are reflected in the current ESGE guideline¹⁰, which states that SEMS placement should be first choice only in palliative situations or in patients with an increased surgical risk (aged at least 70 years and/or ASA grade III or more) and in centres with substantial experience.

Since publication of the ESGE guideline, multiple studies, including recent meta-analyses, have investigated long-term outcomes following SEMS placement compared with emergency resection^{17,19}. They were not able to demonstrate a significant survival difference between treatment groups. Unfortunately, most studies were retrospective and underpowered, they seldom had recurrence and survival as the primary outcome measures, and

follow-up was often relatively short. Only a recent study by Kang and co-workers³², which compared 226 patients who had SEMS placement with 109 who underwent emergency resection using propensity score as a co-variable, focused specifically on long-term outcomes. Although matching in this cohort was not possible owing to lack of control patients and insufficient overlap of propensity scores between treatment groups, the methodology is stronger than that of previous studies. They also reported no significant difference in (locoregional) recurrence and survival rates³². The results of the present analysis of a propensity score-matched cohort, including 666 patients of whom 222 were treated with a SEMS, further strengthens the previously published conclusions regarding the oncological safety of stenting in LSOCC.

Overall, the 7.7 per cent perforation rate and its impact on survival did not seem to influence the oncological outcome in the complete SEMS group, as recurrence and survival rates were similar in both treatment groups. Worse survival owing to perforation might therefore be counterbalanced by a positive impact of stenting in other SEMS subgroups. For instance, several studies have shown that postoperative complications (which tended to occur more frequently in the emergency resection group in the present study) also have a negative effect on oncological outcome³³. Therefore, different risks and potential advantages related to both strategies should be considered when deciding on optimal management for the individual patient. For example, a young fit patient with a low operative risk profile and absence of competing mortality risks (cardiovascular) might not want to take the risk of perforation during stent insertion. On the other hand, the risk of perforation might be outweighed by the high operative risk in elderly patients or those with significant co-morbidity. The difference in risk of permanent stoma between age groups should also be taken into account, underlining the need for patient-tailored treatment and shared decision-making in patients with LSOCC.

Given its oncological impact, it is crucial to minimize perforation risk. Experience of the endoscopist seems important³⁴. The present results support this, as subanalysis of high- *versus* low-volume SEMS centres showed a lower perforation rate in the high-volume centres, where SEMS placement is undertaken only by experienced endoscopists.

An important strength of the present study is the high participation rate (92.0 per cent of identified patients were registered). In total, 75 of the 77 centres contributed to this national cohort study, resulting in good representation of current nationwide practice. In addition, small pretreatment differences suggested a low risk of selection bias,

probably related to the fact that treatment choices were mostly according to institutional protocol, rather than selective allocation to a certain intervention. Furthermore, detailed retrospective review of the original patient files enabled validation and enrichment of the DCRA data set. Finally, the robustness of the findings is supported by the fact that two different analytical methods resulted in similar outcomes.

Nonetheless, several limitations should be kept in mind. Only patients who underwent colonic resection are included in the DCRA registry. Thus, patients who died as a consequence of SEMS placement remained beyond the scope of the present study. However, as no postoperative deaths after SEMS placement have been reported in any RCT reporting on SEMS as BTS, the influence of this shortcoming is expected to be negligible⁸. In addition, defining acute colonic obstruction is difficult in the absence of international consensus, and using retrospective chart review. Inherent to real-world evidence, the authors were not informed about the degree of adherence to guidelines regarding follow-up, although there is strong evidence that differences in intensity of follow-up after colorectal cancer treatment do not influence survival³⁵. No specific data on the surgeons who performed the (emergency) resections were available owing to the retrospective nature of the study. Finally, although propensity score matching was used to minimize selection bias, there might still be residual confounding due to unknown factors.

Overall, the data from this propensity score-matched population study indicate that SEMS as BTS is not negatively associated with long-term oncological outcomes and has a lower risk of permanent stoma than emergency resection. Therefore, SEMS placement appears to be a valid and safe alternative in dedicated centres. Nevertheless, the risk of SEMS-related perforation, as well as permanent stoma risk, might influence shared decision-making in individual patients with LSOCC.

Collaborators

Members of the Dutch Snapshot Research Group: H. Algera (Jeroen Bosch Hospital, Den Bosch); G. D. Algie (Medical Centre Zuiderzee, Lelystad); C. S. Andeweg (St Jansdal Hospital, Harderwijk); T. Argillander (Gelre Hospital, Apeldoorn); M. N. N. J. Arron (Radboud University Medical Centre, Nijmegen); K. Arts (Maxima Medical Centre, Eindhoven); T. H. J. Aufenacker (Rijnstate Hospital, Arnhem); I. S. Bakker (Treant Hospital, Hoogeveen); M. van Basten Batenburg (Rijnstate Hospital, Arnhem); A. J. N. M. Bastiaansen (Haga Hospital, the Hague); G. L. Beets (Antoni van Leeuwenhoek Hospital, Amsterdam); A. van den Berg (Rivierenland Hospital, Tiel); B. van de Beukel (Canisius-Wilhelmina Hospital, Nijmegen); R. L. G. M. Blom (Onze Lieve Vrouwen Hospital, Amsterdam); B. Blomberg (Ter Gooi Hospital, Hilversum); E. G. Boerma

(Zuyderland Medical Centre, Sittard); F. C. den Boer (Zaans Medical Centre, Zaandam); N. D. Bouvy (Maastrisch University Medical Centre, Maastricht); J. E. Bouwman (Wilhelmina Hospital, Assen); N. D. A. Boye (Leids University Medical Centre, Leiden); H. T. Brandsma (VU Medical Centre, Amsterdam); A. R. M. Brandt (Erasmus University Medical Centre, Rotterdam); A. Breijer (Van Weel Bethesda Hospital, Dirksland); W. van den Broek (St Anna Hospital, Geldrop); M. E. E. Bröker (Erasmus University Medical Centre, Rotterdam); E. R. J. Bruns (Gelre Hospital, Apeldoorn); J. P. M. Burbach (University Medical Centre Groningen, Groningen); T. A. Burghgraef (Meander Medical Centre, Amersfoort); R. M. P. H. Crolla (Amphia Hospital, Breda); M. Dam (Elkerliek Hospital, Helmond); L. Daniels (Westfries Gasthuis, Hoorn); J. W. T. Dekker (Reinier de Graaf Hospital, Delft); A. Demirkan (Rode Kruis Hospital, Beverwijk); K. van Dongen (Maas Hospital Pantein, Cuijk); S. F. Durmaz (Alrijne Hospital, Leiderdorp); A. van Esch (Bernhoven Hospital, Uden); J. A. van Essen (St Jans Gasthuis, Weert); J. W. Foppen (St Jansdal, Harderwijk); E. J. B. Furnee (University Medical Centre Groningen, Groningen); A. A. W. van Geloven (Ter Gooi Hospital, Hilversum); M. F. Gerhards (Onze Lieve Vrouwen Gasthuis, Amsterdam); E. A. Gorter (Haga Hospital, The Hague); W. M. U. van Grevenstein (University Medical Centre Utrecht, Utrecht); J. van Groningen (Haaglanden Hospital, The Hague); I. de Groot (Lange Land Hospital, Zoetermeer); H. Haak (Flevo Hospital, Almere); J. W. A. de Haas (Isala Hospital, Zwolle); P. van Hagen (Ijsselland Hospital, Capelle aan den IJssel); J. T. H. Hamminga (Treant Hospital, Hoogeveen); E. van der Harst (Maasstad Hospital, Rotterdam); K. Havenga (University Medical Centre Groningen); J. Heeren (Bravis Hospital, Bergen op Zoom); B. H. M. Heijnen (Lange Land Hospital, Zoetermeer); L. Heijnen (Medical Centre Alkmaar, Alkmaar); J. T. Heikens (Rivierenland Hospital, Tiel); M. van Heinsbergen (VieCurie Hospital, Venray); B. van den Hengel (Martini Hospital, Groningen); D. A. Hess (Antonius Hospital, Sneek); N. Heuchemer (Franciscus Hospital, Rotterdam); C. Hoff (Medical Centre Leeuwarden, Leeuwarden); W. Hogendoorn (Maasstad Hospital, Rotterdam); A. P. J. Houdijk (Medical Centre Alkmaar, Alkmaar); N. Hugem (Rijnstate Hospital, Arnhem); B. Inberg (Queen Beatrix Hospital, Winterswijk); T. Janssen (Amphia Hospital, Breda); D. Jean Pierre (Zuyderland Medical Centre, Heerlen); W. J. de Jong (Haaglanden Medical Centre, The Hague); A. C. H. M. Jongen (Maastrisch University Medical Centre, Maastricht); A. V. Kamman (Ikazia Hospital, Rotterdam); J. M. Klaase (Medical Spectrum Twente, Twente); W. Kelder (Martini Hospital, Groningen); E. F. Kelling (Bovenij Hospital, Amsterdam); G. W. De Klein (Isala Hospital, Zwolle); R. Klicks (Bovenij Hospital, Amsterdam); F. W. H. Kloppenberg (Treant Hospital, Hoogeveen); J. L. M. Konsten (VieCurie Hospital, Venray); L. J. E. R. Koolen (Zuyderland Medical Centre, Heerlen); V. Kornmann (Radboud University Medical Centre, Nijmegen); R. T. J. Kortekaas (Franciscus Hospital, Rotterdam); A. Kreiter (Queen Beatrix Hospital, Winterswijk); B. Lamme (Albert Schweizer Hospital, Dordrecht); J. F. Lange (Erasmus University Medical Centre, Rotterdam); T. Lettinga (St. Jans Gasthuis, Weert); D. Lips (Jeroen Bosch Hospital, Den Bosch); G. Lo (Zorggroep Twente, Twente); F. Logeman (Rivas Hospital, Gorinchem); Y. T. van Loon (Twee Steden Hospital, Tilburg); M. F. Lutke Holzik (Ziekenhuisgroep Twente, Twente); C. C. M. Marres (Flevo Hospital, Almere); I. Mas-selink (Ziekenhuisgroep Twente, Twente); A. Mearadj (Bravis Hospital, Bergen op Zoom); G. Meisen (Elkerliek Hospital, Helmond); A. G. Menon (Haven Hospital, Rotterdam); J. Merkus (Haga Hospital, the Hague); D. de Mey (Zorgzaam Terneuzen Hospital, Terneuzen); H. C. J. van der Mijle (Nij Smellinghe Hospital, Drachten); D. E. Moes (Slotervaart Hospital, Amstelveen); C. Molenaar (Spaarne Gasthuis Hospital, Hoofddorp); P. A. Neijenhuis (Alrijne Hospital, Leiderdorp); M. J. Nieboer (Medical Centre Zuiderzee, Lelystad); K. Nielsen (Westfries Gasthuis, Hoorn); G. A. P. Nieuwenhuijzen (Catharina Hospital, Eindhoven); P. Oomen

(Twee Steden Ziekenhuis, Tilburg); N. van Oorschot (Ter Gooi Hospital, Hilversum); K. Parry (Jeroen Bosch Hospital, den Bosch); T. Paulides (Zaans Medical Centre, Zaandam); I. Paulusma (Nij Smellinghe Hospital, Drachten); K. C. M. J. Peeters (Leids University Medical Centre, Leiden); F. B. Poelmann (Medical Centre Leeuwarden, Leeuwarden); S. W. Polle (Canisius-Wilhelmina Hospital, Nijmegen); P. Poortman (Waterland Hospital, Purmerend); M. Raber (Ropecke Zweers Hospital, Hardenberg); B. M. M. Reiber (Slotervaart Hospital, Amstelveen); R. J. Renger (Rivas Hospital, Gorinchem); R. Roukema (Antonius Hospital, Sneek); W. M. J. de Ruijter (Admiraal de Ruijter Hospital, Goes); M. J. A. M. Russchen (Onze Lieve Vrouwen Gasthuis, Amsterdam); H. J. T. Rutten (Catharina Hospital, Eindhoven); J. Scheerhoorn (Laurentius Hospital, Roermond); S. Scheurs (Onze Lieve Vrouwen Gasthuis, Amsterdam); H. Schippers (Ikazia Hospital, Rotterdam); V. N. E. Schuermans (Maastricht University Medical Centre, Maastricht); H. J. Schuijt (Gelre Hospital, Apeldoorn); J. C. Sierink (Zaans Medical Centre, Zaandam); C. Sietses (Gelderse Vallei Hospital, Ede); R. Silvis (Sparne Gasthuis Hospital, Hoofddorp); J. van der Slegt (Amphia Hospital, Breda); G. Slooter (Maxima Medical Centre, Eindhoven); M. van de Sluis (Nij Smellinghe Hospital, Drachten); P. van der Sluis (University Medical Centre Utrecht, Utrecht); N. Smakman (Diakonessen Hospital, Utrecht); D. Smit (Groene Hart Hospital, Gouda); D. J. A. Sonneveld (Westfries Gasthuis, Hoorn); T. C. van Sprundel (Ommelander Hospital, Groningen); C. Steur (Waterland Hospital, Purmerend); J. Straatman (Rode Kruis Hospital, Beverwijk); M. C. Struijs (Fransiscus Hospital, Rotterdam); H. A. Swank (Albert Schweizer Hospital, Dordrecht); A. K. Talsma (Deventer Hospital, Deventer); M. Tenhagen (Rode Kruis Hospital, Beverwijk); J. A. M. G. Tol (Sparne Gasthuis Hospital, Hoofddorp); J. L. Tolenaar (University Medical Centre Utrecht, Utrecht); L. Tseng (Groene Hart Hospital, Gouda); J. B. Tuynman (VU Medical Centre, Amsterdam); M. J. F. van Veen (Medical Spectrum Twente, Twente); S. Veltkamp (Amstelland Hospital, Amstelveen); A. W. H. van de Ven (Flevo Hospital, Almere); L. Verkoete (St. Jans Gasthuis, Weert); M. Vermaas (Ijsselland Hospital, Capelle aan de IJssel); D. van Uden (Canisius-Wilhelmina Hospital, Nijmegen); L. Versluijs (Diaconessen Hospital, Meppel); H. P. Versteegh (Reinier de Graaf Hospital, Delft); T. Visser (Gelderse Vallei Hospital, Ede); W. J. Vles (Ikazia Hospital, Rotterdam); R. de Vos tot Nederveen Cappel (Admiraal de Ruyter Hospital, Goes); H. S. de Vries (Twee Steden Hospital, Tilburg); S. T. van Vugt (Wilhelmina Hospital, Assen); G. Vugts (Catharina Hospital, Eindhoven); J. A. Wegdam (Elkerliek Hospital, Helmond); T. Weijs (Antonius Hospital, Nieuwegein); B. J. van Wely (Bernhoven Hospital, Uden); C. Werker (Antonius Hospital, Nieuwegein); M. Westerterp (Haaglanden Hospital, The Hague); H. L. van Westreenen (Isala Hospital, Zwolle); B. Wiering (Slingeland Hospital, Doetinchem); N. A. T. Wijffels (Antonius Hospital, Nieuwegein); A. A. Wijkman (Deventer Hospital, Deventer); L. H. Wijngaarden (Maasstad Hospital, Rotterdam); J. H. W. de Wilt (Radboud University Medical Centre, Nijmegen); M. van de Wilt (Amstelland Hospital, Amstelveen); D. D. Wisselink (Amsterdam Medical Centre, Amsterdam); F. Wit (Tjongerschans Hospital, Heerenveen); E. S. van der Zaag (Gelre Hospital, Apeldoorn); D. Zimmerman (Twee Steden Hospital, Tilburg); T. Zwols (Medical Centre Leeuwarden, Leeuwarden).

Acknowledgements

The authors thank R. Lindeboom for advice and help with the statistical analyses.

The study was funded by a grant from the Dutch Cancer Society (KWF) and Citrienfonds. The research plan was not preregistered. Outside of the submitted work, J. E.

van Hooft received a Grant from Cook Medical, and a consultancy fee from Boston Scientific and Medtronic.

Disclosure: The authors declare no other conflict of interest.

References

- Jullumstrø E, Wibe A, Lydersen S, Edna TH. Colon cancer incidence, presentation, treatment and outcomes over 25 years. *Colorectal Dis* 2011; **13**: 512–518.
- Yeo HL, Lee SW. Colorectal emergencies: review and controversies in the management of large bowel obstruction. *J Gastrointest Surg* 2013; **17**: 2007–2012.
- Tanis PJ, Paulino Pereira NR, van Hooft JE, Consten EC, Bemelman WA, Dutch Surgical Colorectal Audit. Resection of obstructive left-sided colon cancer at a national level: a prospective analysis of short-term outcomes in 1816 patients. *Dig Surg* 2015; **32**: 317–324.
- Cheyne N, Cortet M, Lepage C, Benoit L, Faivre J, Bouvier AM. Trends in frequency and management of obstructing colorectal cancers in a well-defined population. *Dis Colon Rectum* 2007; **50**: 1568–1575.
- Tekkis PP, Kinsman R, Thompson MR, Stamatakis JD, Association of Coloproctology of Great Britain, Ireland. The Association of Coloproctology of Great Britain and Ireland study of large bowel obstruction caused by colorectal cancer. *Ann Surg* 2004; **240**: 76–81.
- Leong QM, Koh DC, Ho CK. Emergency Hartmann's procedure: morbidity, mortality and reversal rates among Asians. *Tech Coloproctol* 2008; **12**: 21–25.
- Young CJ, De-Loyde KJ, Young JM, Solomon MJ, Chew EH, Byrne CM *et al.* Improving quality of life for people with incurable large-bowel obstruction: randomized control trial of colonic stent insertion. *Dis Colon Rectum* 2015; **58**: 838–849.
- Arezzo A, Passera R, Lo Secco G, Verra M, Bonino MA, Targarona E *et al.* Stent as bridge to surgery for left-sided malignant colonic obstruction reduces adverse events and stoma rate compared with emergency surgery: results of a systematic review and meta-analysis of randomized controlled trials. *Gastrointest Endosc* 2017; **86**: 416–426.
- Atukorale YN, Church JL, Hoggan BL, Lambert RS, Gurgacz SL, Goodall S *et al.* Self-expanding metallic stents for the management of emergency malignant large bowel obstruction: a systematic review. *J Gastrointest Surg* 2016; **20**: 455–462.
- van Hooft JE, van Halsema EE, Vanbiervliet G, Beets-Tan RG, DeWitt JM, Donnellan F *et al.*; European Society of Gastrointestinal Endoscopy. Self-expandable metal stents for obstructing colonic and extracolonic cancer: European Society of Gastrointestinal Endoscopy (ESGE) Clinical Guideline. *Endoscopy* 2014; **46**: 990–1053.
- Maruthachalam K, Lash GE, Shenton BK, Horgan AF. Tumour cell dissemination following endoscopic stent insertion. *Br J Surg* 2007; **94**: 1151–1154.
- Yamashita S, Tanemura M, Sawada G, Moon J, Shimizu Y, Yamaguchi T *et al.* Impact of endoscopic stent insertion on

- detection of viable circulating tumor cells from obstructive colorectal cancer. *Oncol Lett* 2018; **15**: 400–406.
- 13 Poon J, Pang R, Law W. The impact of colonic stenting on tumor cell dissemination in colorectal cancer patients. *Dis Colon Rectum* 2011; **54**: e160.
 - 14 Kim HJ, Choi GS, Park JS, Park SY, Jun SH. Higher rate of perineural invasion in stent-laparoscopic approach in comparison to emergent open resection for obstructing left-sided colon cancer. *Int J Colorectal Dis* 2013; **28**: 407–414.
 - 15 Sloothaak DA, van den Berg MW, Dijkgraaf MG, Fockens P, Tanis PJ, van Hooft JE *et al.*; collaborative Dutch Stent-In study group. Oncological outcome of malignant colonic obstruction in the Dutch Stent-In 2 trial. *Br J Surg* 2014; **101**: 1751–1757.
 - 16 Sabbagh C, Browet F, Diouf M, Cosse C, Brehant O, Bartoli E *et al.* Is stenting as ‘a bridge to surgery’ an oncologically safe strategy for the management of acute, left-sided, malignant, colonic obstruction? A comparative study with a propensity score analysis. *Ann Surg* 2013; **258**: 107–115.
 - 17 Ceresoli M, Allievi N, Coccolini F, Montori G, Fugazzola P, Pisano M *et al.* Long-term oncologic outcomes of stent as a bridge to surgery *versus* emergency surgery in malignant left side colonic obstructions: a meta-analysis. *J Gastrointest Oncol* 2017; **8**: 867–876.
 - 18 Matsuda A, Miyashita M, Matsumoto S, Matsutani T, Sakurazawa N, Takahashi G *et al.* Comparison of long-term outcomes of colonic stent as ‘bridge to surgery’ and emergency surgery for malignant large-bowel obstruction: a meta-analysis. *Ann Surg Oncol* 2015; **22**: 497–504.
 - 19 Amelung FJ, Borstlap WAA, Consten ECJ, Veld JV, van Halsema EE, van Hooft J *et al.* Long-term outcomes following SEMS placement as bridge to surgery *versus* a surgical approach for left-sided colonic obstructions. *Crit Rev Oncol Hematol* 2018; **131**: 66–75.
 - 20 van Hooft JE, Fockens P, Marinelli AW, Timmer R, van Berkel AM, Bossuyt PM *et al.*; Dutch Colorectal Stent Group. Early closure of a multicenter randomized clinical trial of endoscopic stenting *versus* surgery for stage IV left-sided colorectal cancer. *Endoscopy* 2008; **40**: 184–191.
 - 21 van Hooft JE, Bemelman WA, Oldenburg B, Marinelli AW, Lutke Holzik MF, Grubben MJ *et al.*; collaborative Dutch Stent-In study group. Colonic stenting *versus* emergency surgery for acute left-sided malignant colonic obstruction: a multicentre randomised trial. *Lancet Oncol* 2011; **12**: 344–352.
 - 22 Sherman RE, Anderson SA, Dal Pan GJ, Gray GW, Gross T, Hunter NL *et al.* Real-world evidence – what is it and what can it tell us? *N Engl J Med* 2016; **375**: 2293–2297.
 - 23 Dutch Snapshot Research Group. Benchmarking recent national practice in rectal cancer treatment with landmark randomized controlled trials. *Colorectal Dis* 2017; **19**: O219–O231.
 - 24 von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 2007; **370**: 1453–1457.
 - 25 Integraal Kankercentrum Nederland. *National Working Group on Gastrointestinal Cancers. Guideline Colon Cancer 3.0*; 2014. <http://www.oncoline.nl/colorectaalcarcinoom> [accessed 3 April 2018].
 - 26 Austin PC. Statistical criteria for selecting the optimal number of untreated subjects matched to each treated subject when using many-to-one matching on the propensity score. *Am J Epidemiol* 2010; **172**: 1092–1097.
 - 27 Rothman KJ, Greenland S. *Modern Epidemiology*. Lippincott Williams & Wilkins: Philadelphia, 1998.
 - 28 Breslow NE, Day NE. *Statistical Methods in Cancer Research. Vol. I. The Analysis of Case–Control Studies*. International Agency for Research on Cancer: Lyon, 1980.
 - 29 Avlund TH, Erichsen R, Ravn S, Ciplys Z, Andersen JC, Laurberg S *et al.* The prognostic impact of bowel perforation following self-expanding metal stent as a bridge to surgery in colorectal cancer obstruction. *Surg Endosc* 2018; **32**: 328–336.
 - 30 Gorissen KJ, Tuynman JB, Fryer E, Wang L, Uberoi R, Jones OM *et al.* Local recurrence after stenting for obstructing left-sided colonic cancer. *Br J Surg* 2013; **100**: 1805–1809.
 - 31 Gianotti L, Tamini N, Nespoli L, Rota M, Bolzonaro E, Frego R *et al.* A prospective evaluation of short-term and long-term results from colonic stenting for palliation or as a bridge to elective operation *versus* immediate surgery for large-bowel obstruction. *Surg Endosc* 2013; **27**: 832–842.
 - 32 Kang SI, Oh HK, Yoo JS, Ahn S, Kim MH, Kim MJ *et al.* Seoul Colorectal Group (SECOG). Oncologic outcomes of preoperative stent insertion first *versus* immediate surgery for obstructing left-sided colorectal cancer. *Surg Oncol* 2018; **27**: 216–224.
 - 33 Ha GW, Kim JH, Lee MR. Oncologic impact of anastomotic leakage following colorectal cancer surgery: a systematic review and meta-analysis. *Ann Surg Oncol* 2017; **24**: 3289–3299.
 - 34 Small AJ, Coelho-Prabhu N, Baron TH. Endoscopic placement of self-expandable metal stents for malignant colonic obstruction: long-term outcomes and complication factors. *Gastrointest Endosc* 2010; **71**: 560–572.
 - 35 Jeffery M, Hickey BE, Hider PN, See AM. Follow-up strategies for patients treated for non-metastatic colorectal cancer. *Cochrane Database Syst Rev* 2016; (11)CD002200.