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Evidence-Based Choice of Esophageal Stent for the Palliative Management of Malignant Dysphagia

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Abstract
Background The type of stent used for the management of patients with malignant dysphagia is chosen according to subjective physician's preference. There is no recent study available to provide updated evidence on early outcomes related to the use of different types of stents.
Methods A literature search was performed using Embase, MEDLINE, Cochrane Library, and Google Scholar databases for comparative studies assessing different types of stents. The primary end point was stent-related mortality; secondary end points included: stent-related morbidity, successful palliation of dysphagia, and 30-day mortality. A random-effects model was used and heterogeneity was assessed.
Results Twelve studies that included 911 patients compared metallic (46.54%) and plastic stents (53.45%), and eight studies that included 564 patients compared covered (43.26%) and uncovered metal stents (56.73%). Meta-analysis of randomized, controlled trials showed that metallic stents were associated with significantly reduced stent-related mortality (1.7% vs. 11.1% for the plastic group, odds ratio (OR), 0.2; 95% confidence interval (CI), 0.06–0.74; $P = 0.02$), morbidity in the form of reduced esophageal perforation (1.4% vs. 9.4% for plastic stent, OR, 0.27; 95% CI, 0.08–0.89; $P = 0.03$), and stent migration, yet increased rate of tumor in-growth (13% vs. 1.6% for plastic stents, OR, 4.84; 95% CI, 0.99–23.76; $P = 0.05$). Covered metallic stents had significantly less tumor in-growth than the uncovered and an increased migration rate. There was no significant difference between metallic and plastic stents in terms of any other stent-related morbidity and 30-day mortality.
Conclusion Self-expanding metallic stents are superior to plastic stents in terms of stent insertion-related mortality, morbidity, and quality of palliation. The uncovered variety is disadvantaged by high rate of tumor in-growth; adequately designed randomized, controlled trials need to examine outcomes and cost-effectiveness of covered versus uncovered metallic stents.

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Introduction

More than 50% of patients with esophageal cancer are not suitable for curative surgical resection and need palliation at the time of diagnosis [1]. The main goal of endoscopic palliation is to improve swallowing. The optimal procedure would avoid relapsing dysphagia that requires reintervention, while minimizing complications and treatment costs. Stents—plastic or metal—are more widely used for the palliation of malignant dysphagia than other endoscopic options [2]. The available stents still have drawbacks, including hemorrhage, perforation, risk of migration, malignant or granulomatous overgrowth, difficulties in stent removal, or repositioning and high cost [3].

There is no general consensus on using a particular type of stents. For instance, the United Kingdom national guidelines had only grade B evidence to base the

recommendations for using metal stents [4]. In addition, complication rates must be interpreted with caution because of differing insertion techniques, small number of patients in published studies, and different center policies in terms of the choice of stent type used [5].

This study was designed to compare early outcomes of different types of stents used to treat patients with malignant dysphagia by using published, randomized, controlled trials to obtain higher level of evidence, which may guide the choice of stent type within the current clinical practice. The specific questions that our study attempted to answer are: 1) which type of stents are associated with less stent-related mortality and morbidity rates; and 2) which type of stent offers better quality of dysphagia palliation?

Materials and methods

A literature search was performed by using Embase, MEDLINE, Cochrane Library, and Google Scholar databases for comparative studies that assessed different types of stents published until 2007 and reports of esophageal stenting for palliation of malignant dysphagia. We compared metal versus plastic stents and, within the metal group, compared the covered versus the uncovered variety. The following Mesh headings were used: "comparative studies and esophageal stenting"; "malignant dysphagia"; and "inoperable esophageal carcinoma." Searches also were performed under the terms "metal versus plastic esophageal stents" and "covered versus uncovered esophageal stents." The "related articles" function was used to broaden the search, and all citations identified were reviewed irrespective of language. No studies comparing metal stents published before 1990 were found, therefore, comparative papers including this group were found that were published between 1990 and 2007. Search strategy and included studies are shown in Fig. 1.

Two reviewers (DY and RF) independently extracted the following data from each study: first author, year of publication, study population characteristics, study design, tumor characteristics, number of patients with different

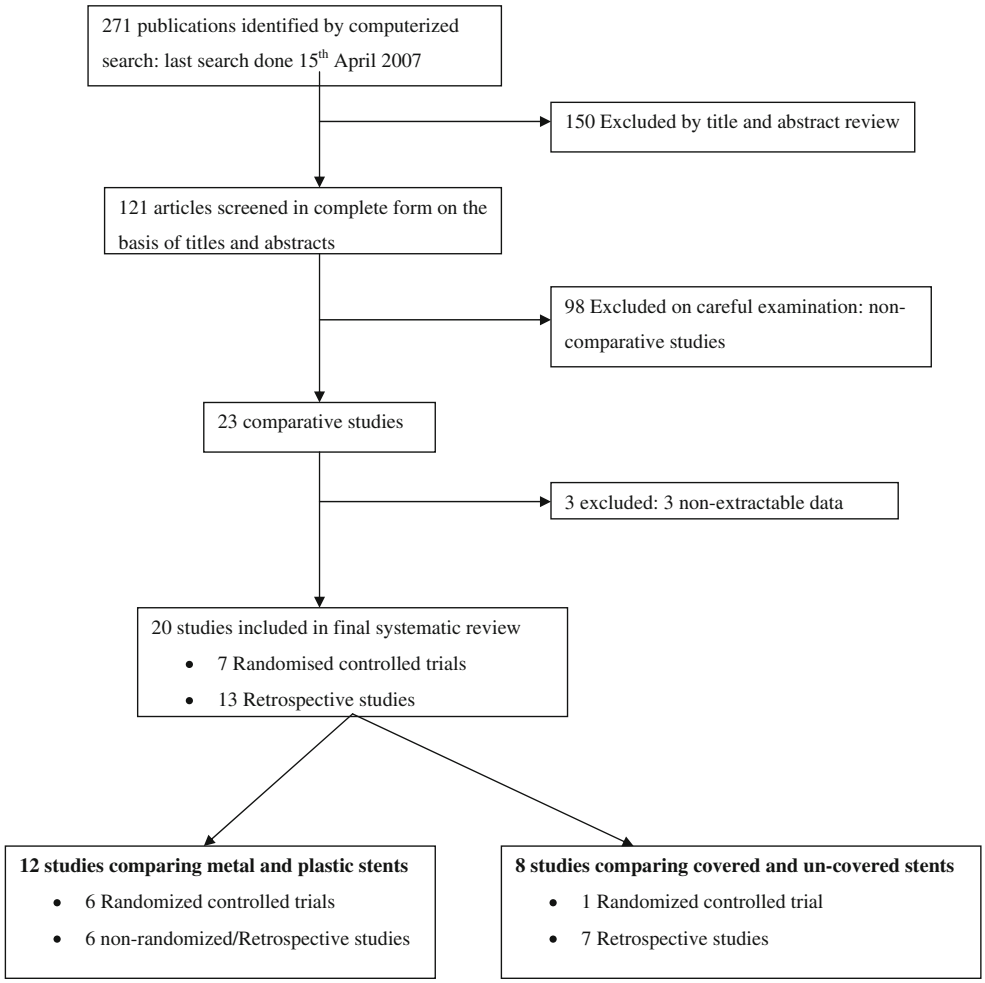

Fig. 1 Search strategy and selection of studies

types of esophageal stents, and different outcomes of interest reported for each type of esophageal stent.

Inclusion and exclusion criteria

To be eligible for inclusion in our meta-analysis, studies had to compare metal with plastic stents for malignant dysphagia regardless of primary tumor, include a patient group who underwent the procedure as a primary intervention, report at least one outcome of interest, and contain a previously unreported patient group. When two studies by the same institution reported the same outcomes, we included in our analysis the better quality or the most informative publication.

We excluded studies if the primary intervention strategy could not be defined and if the outcomes of interest were not reported or it was impossible to calculate these from the published results.

Outcomes of interest

The primary outcome of interest is stent-related mortality, defined as mortality during or with 24 hours of stent insertion. Secondary end points included stent-related morbidity and complications related to quality of palliation. Stent-related morbidity includes incidence of esophageal perforation, hemorrhage and post-stenting pain as an immediate complication detected within 24 hours of stent insertion.

Complications related to quality of palliation included: stent migration defined in the included studies as migration of the stent from its original position within three weeks after stent insertion; tumor in-growth defined as growth of the tumor invading the body of the stent and occluding its lumen; tumor outgrowth defined as growth of the tumor proximal or distal to the stent and leading to esophageal lumen occlusion and loss of stent function; need for repeated intervention defined as necessity of endoscopic reintervention to manage a complication or because of failure of relieve of dysphagia at any time point after stent insertion; food bolus impaction defined as impaction of ingested food at the proximal end or within the body of the stent; improvement of dysphagia using Atkinson and Ferguson's score [6] assessing the patient immediately and within a week after stent insertion. Demographic and clinical data of patients in studies included with a list of reported outcomes is demonstrated in Tables 1–6.

Statistical analysis

We performed our meta-analysis in line with Cochrane Collaboration recommendations and quality of reporting of meta-analyses guidelines [7, 8]. For categorical variables, we used the odds ratio as the summary statistic. This ratio represents the odds of an adverse event occurring in the treatment (metal stents) compared with control (plastic stents) group. An odds ratio of <1 favors the control group, and the point estimate of the odds ratio is considered statistically significant at the $P = 0.05$ level if the 95% confidence interval does not include the value 1. To translate these results into benefits to clinical outcome, we calculated the risk difference and number needed to treat. Risk difference (or absolute risk reduction) is the difference in the incidence of postoperative complications between treatment and control groups. Number needed to treat is the number of patients who must be treated as in the treatment group to prevent one complication event (NNT = 1/risk difference).

We used the Mantel-Haenszel method to combine the odds ratio for the outcomes of interest. We excluded studies with no events in either group. In this study we used a random-effects model, in which it is assumed that there is variation between studies, thus the calculated odds ratio has a more conservative value [9, 10]. In surgical research, meta-analysis using this model is preferred, particularly because patients undergoing surgery in different centers have varying risk profiles and selection criteria for each surgical technique. In our primary analysis, we focused on randomized, controlled trials (RCTs) to assess the highest quality of evidence available.

We used three strategies to assess heterogeneity. First, we reanalysed data by using both random- and fixed-effects models. Second, we evaluated publication bias graphically by using funnel plots [11]. Third, we undertook a sensitivity analysis of three subgroups: randomized, controlled trials, studies with 7 or more stars for comparability (assessment of study quality for observational studies), and studies with 50 patients or more in each group (sample size effect; Tables 7 and 8). Analysis was performed by using RevMan version 4.2, and STATA 9.0 was used for power analysis calculations. Results of randomized, controlled studies, overall, and subgroup analyses is demonstrated in Tables 9–13.

Power analysis

The mortality rate in plastic stents as reported in RCTs included was 13 of 117 (approximately 11%). To rule out a 50% relative risk reduction (from 11% to 5.5%) with a 5% significance level and 80% power, we calculated that a traditional randomized, controlled trial would require 428 patients in each arm.

Results

Selected studies

Twelve studies published between 1993 and 2003 matched our inclusion criteria, comparing 424 patients in the metal stents and 483 in the plastic group (total of 911 patients) [2,

Table 1 Demographic data of studies comparing plastic and metal stents

Study	Design	Patients		Mean age (yr)		Mean dysphagia score (Atkinson & Fergusson grade)		Stent types used		Adjuvant therapy		Matching criteria
		Plastic	Metal	Plastic	Metal	Plastic	Metal	Plastic	Metal	Plastic	Metal	
Knyrim, 1993	RCT	21	21	68.8	64.8	3	3	W	Wl	–	–	1, 5, 6, 7, 8
De Palma, 1996	RCT	20	19	69.4	67.8	3	2.9	W	U	–	–	1, 5, 8
Kozarek, 1996	RS	47	38	65	64	3	2.7	W, C ,A	Z, Wl, E, U	–	–	–
Segalin, 1997	PNRCT	84	75	65	65	–	–	W	Wl, U, I, S	–	–	–
Siersema, 1998	RCT	38	37	65.2	67.6	3.0	3.2	C	Z, W	15	13	1, 2, 4, 5, 6, 7, 8
Birch, 1998	RS	24	26	76.1	76.8	2.9	2.8	A	U	–	–	7
Roseveare, 1998	RCT	16	15	72	71	3	3	A	Z	–	–	1, 5, 6, 10
Taal, 1998	RS	73	59	67	67	–	–	tygon	Wl, U, S	25	37	–
Davies, 1998	PNRCT	46	41	78	74	–	–	A	Wl, N	–	–	–
Sanyika, 1999	RCT	20	20	–	–	3	3	P	Wl	–	–	–
O'Donnell, 2002	RCT	22	25	72.3	72.9	–	–	W	Wl, U	2	4	–
Mosca, 2003	RS	72	48	69.3	72.5	3.67	3.6	W, C, A	U	–	–	–

RCT randomized, controlled trial, PNRCT prospective, nonrandomized, controlled trial, RS retrospective study, W Wilson Cook stents (Wilson-Cook, Inc.,Winston Salem, NC), C Celestin stent (Medoc Ltd., Tetbury, UK), A Atkinson stent (KeyMed, Ltd., Southend, UK), Wl Wallstent (Schneider, Inc., Minneapolis, MN), Z Z-stent (Wilson-Cook, Inc.), E Esophacoil (InStent, Minneapolis, MN), U Ultraflex stent (Microvasive, Inc., Natck, MA), I Instent prothesis (Instent Inc., Israel and Eden Prairie, MN), S Song stent (Sooho Meditech Co., Fujinon Medical, The Netherlands), N Strecker Nitinol stents (Boston Scientific, St Albans, UK), P Procter Livingstone tube (Roynhardt, South Africa)

– No exact numbers or data were available for extraction and analysis

Matching criteria:

Patient factors

1. Age
2. Sex
3. Comorbidity
4. Pretreatments
5. Dysphagia score

Tumor factors

6. Pathological type of tumor
7. Site of tumor
8. Mean length of tumor
9. Tumor grade
10. Tumor stage

12–22], whereas eight studies published between 1994 and 2005 compared 267 in the covered and 320 in the uncovered metal stents (total of 564 patients) [23–30]. Both reviewers had 100% agreement on data extraction. Demographic and clinical characteristics of these studies are demonstrated in Tables 1–4.

Outcomes of interest: plastic versus metal stents

Primary outcome

Stent insertion-related mortality Nine studies reported on stent insertion procedure-related mortality rate: five of them were randomized, controlled trials; one prospective nonrandomized trial; and three retrospective studies. Analysis of randomized, controlled trials showed significantly less mortality rate in the metal stents group (1.7% vs. 11.1% for the plastic group, odds ratio (OR), 0.2; 95% confidence interval (CI), 0.06–0.74; $P = 0.02$, NNT = 14 patients). When all studies were considered, stent-related mortality was significantly less in the metal stents group (0.8% vs. 6.6% for plastic stent; OR, 0.23; 95% CI, 0.09–0.6; $P = 0.003$; Fig. 2). There was no heterogeneity detected between the studies. A funnel plot based on a fixed effect model showing no asymmetry is displayed in Fig. 3.

Table 2 Demographic data of studies comparing covered with uncovered self-expandable metal esophageal stents

Study	Design	No. of stents used		Mean age (yr)	Dysphagia score (Atkinson & Fergusson grade)				Stents used		Adjuvant therapy		Matching criteria
		Covered	Uncovered		1	2	3	4	Covered	Uncovered	Covered	Uncovered	
Ell, 1994	PNRCT	5	26	69	23	20	3	–	Wl	Wl	–	–	4, 5, 6, 7, 8
May, 1996	PNRCT	35	61	65	21	35	31	–	Z	Wl, U	–	–	–
Hills, 1998	PNRCT	16	14	65.5	–	–	–	–	Wl	U	–	–	–
De Ronde, 2000	RS	17	11	67	–	–	–	–	Wl, U, Z, S	N	2	9	1, 6, 8, 10
Vakil, 2001	RCT	32	30	72	–	–	–	–	–	–	–	–	–
Rozanes, 2002	RS	57	59	61	8	45	35	28	Wl, S, Fl	U	–	–	–
Yang, 2005	RS	7	65	52.7	–	–	42	24	–	–	–	–	–
Saranovic, 2005	RS	98	54	64	–	–	–	–	U	N	–	–	–

RCT randomized, controlled trial, PNRCT prospective, nonrandomized, controlled trial, RS retrospective study, Wl Wallstent (Schneider, Inc., Minneapolis, MN), Z Z-stent (Wilson-Cook, Inc.), U Ultraflex stent (Microvasive, Inc., Natck, MA), S Song stent (Sooho Meditech Co., Fujinon Medical, The Netherlands), N Strecker Nitinol stents (Boston Scientific, St Albans, UK)

No exact numbers or data were available for extraction and analysis

Matching criteria:

Patient factors

1. Age
2. Sex
3. Comorbidity
4. Pretreatment
5. Dysphagia score

Tumor factors

6. Pathological type of tumor
7. Site of tumor
8. Mean length of tumor
9. Tumor grade
10. Tumor stage

Table 3 Tumor characteristics of studies comparing plastic and metal stents

Study	Esophageal tumor site								Esophageal tumor type						Tumor length (cm)	
	Plastic				Metal				Plastic			Metal			Plastic	Metal
	U	M	L	C	U	M	L	C	S	A	O	S	A	O		
Knyrim, 1993	–	10	11	–	–	9	12	–	11	9	1	11	8	2	6.1 ± 0.7	6 ± 0.55
De Palma, 1996	–	–	–	–	–	–	–	–	16		–	16		–	–	–
Kozarek, 1996	–	–	–	–	–	–	–	–	22		18	21		17	–	–
Segalin, 1997	–	–	–	–	–	–	–	–	–		–	–		–	–	–
Siersema, 1998	–	10	18	10		6	20	11	13		24	1		12	25	–
Birch, 1998	–	40%	60%	–		35%	65%	–	30%	61%	–	50%	31%	–	–	–
Roseveare, 1998	1	4	11	–	1	3	11	–	3	12	1	3	9	3	–	–
Taal, 1998	–	–	–	–	–	–	–	–	23	18	32	21	16	22	5	7
Davies, 1998	3	14	29	–	–	9	32	–	19	27	–	13	28	–	4 ± 2	4 ± 3
Sanyika, 1999	–	–	–	–	–	–	–	–	10	14	1	13	12	–	–	–
O'Donnell, 2002	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–
Mosca, 2003	3	18	44	–	4	20	24	–	66	–	37	–	–	–	2–12	2–12

U upper third of esophagus, *S* squamous cell carcinoma, *M* middle third of esophagus, *A* adenocarcinoma, *L* lower third of esophagus, *O* other, *C* cardia of the stomach tumor

Table 4 Tumor characteristics of studies comparing covered with uncovered metal stents

Study	Tumor site				Tumor type			Tumor length (cm)	
	Upper	Middle	Lower	Anastomotic	Squamous cell carcinoma	Adenocarcinoma	Others	Covered	Uncovered
Ell, 1994	2	8	10	3	11	9	–	7.5 ± 2.2	
May, 1996	9	25	47	5	48	24	7	–	–
Hills, 1998	3	12	15	–	12	12	6	–	–
De Ronde, 2000	3	14	10	1	–	–	–	–	–
Vakil, 2001	–	–	–	–	–	–	10	7.5 ± 0.5	7.8 ± 0.5
Rozanes, 2002	7	34	75	–	75	33	8	–	–
Yang, 2005	8	48	10	–	43	15	8	7.5 ± 0.8	
Saranovic, 2005	–	–	–	–	117	22	13	6.7	7.7

Table 5 Outcomes reported in studies comparing plastic and metal stents

Study	Outcomes measured																
	TS	PEr	H	FI	ID	RI	LOS	SM	TI	TO	IE	P	C	MD	M-30	S	QOL
Knyrim, 1993	✔	✔		✔	✔	✔	✔	✔	✔	✔			✔	✔	✔	✔	✔
De Palma, 1996	✔	✔	✔	✔	✔			✔	✔	✔				✔		✔	
Kozarek, 1996		✔	✔	✔	✔			✔	✔	✔	✔	✔		✔		✔	
Segalin, 1997	✔	✔	✔	✔	✔		✔	✔		✔		✔		✔	✔	✔	
Siersema, 1998	✔	✔		✔	✔		✔	✔		✔			✔		✔		
Birch, 1998		✔			✔	✔	✔	✔		✔			✔	✔	✔	✔	
Roseveare, 1998		✔	✔		✔	✔		✔		✔				✔		✔	
Taal, 1998	✔	✔	✔				✔	✔				✔			✔	✔	
Davies, 1998		✔	✔		✔		✔	✔		✔	✔	✔	✔				
Sanyika, 1999	✔	✔	✔	✔		✔		✔	✔	✔		✔	✔	✔	✔	✔	
O'Donnell, 2002	✔	✔	✔	✔	✔		✔	✔	✔	✔				✔	✔	✔	

TS technical success, *Per* perforation, *H* hemorrhage, *FI* food bolus impaction, *ID* improvement of dysphagia, *RI* repeated intervention, *LOS* length of hospital stay, *SM* stent migration, *TI* tumor in-growth, *TO* tumor outgrowth, *IE* insufficient expansion, *P* pain, *C* cost, *MD* directly-related mortality, *M-30* 30-day mortality, *S* survival (average), *QOL* quality of life (Karnofsky's score)

Table 6 Outcomes measured in studies comparing covered and uncovered metal stents

Study	TS	Per	H	FI	ID	RI	SM	TI	TO	IE	P	MD	S	QOL
Ell, 1994	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	
May, 1996	✔	✔	✔		✔	✔	✔	✔		✔	✔		✔	
Hills, 1998					✔	✔							✔	
De Ronde, 2000		✔	✔	✔	✔	✔		✔	✔	✔		✔	✔	
Vakil, 2001			✔	✔	✔	✔	✔	✔		✔	✔		✔	✔
Rozanes, 2002		✔	✔	✔	✔	✔	✔	✔	✔	✔			✔	
Yang, 2005	✔		✔	✔	✔		✔		✔	✔	✔	✔	✔	
Saranovic, 2005	✔	✔		✔	✔	✔	✔	✔	✔					

TS technical success, *Per* perforation, *H* hemorrhage, *FI* food bolus impaction, *ID* improvement of dysphagia, *RI* repeated intervention, *LOS* length of hospital stay, *SM* stent migration, *TI* tumor in-growth, *TO* tumor outgrowth, *IE* insufficient expansion, *P* pain, *C* cost, *MD* directly-related mortality, *M-30* 30-day mortality, *S* survival (average), *QOL* quality of life (Karnofsky's score)

Table 7 Quality assessment scoring of studies comparing plastic and metal stents

Study	Selection for treatment			Comparability of groups in studies										Outcome assessment		Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Knyrim, 1993	**	*	*	*				*	*	*	*			**	*	12
De Palma, 1996	**	*	*	*				*			*			*	*	9
Kozarek, 1996		*	*											**	*	5
Segalin, 1997		*	*											**	*	5
Siersema, 1998	**	*	*	*	*			*	*	*	*			**	*	13
Birch, 1998		*	*											*		3
Roseveare, 1998	**	*	*	*				*	*				*	*	*	10
Taal, 1998		*	*											*	*	4
Davies, 1998		*	*											*	*	4
Sanyika, 1999	**	*	*											*		5
O'Donnell, 2002	**	*	*											**	*	7
Mosca, 2003		*	*											**	*	5

Sensitivity of 7 (mean of all scores) or more stars will be undertaken representing high-quality studies

Quality of studies scoring:

Quality of studies will be determined by the number of stars they receive. One star will be assigned for fulfilling each of the following criteria

Selection for treatment:

1. Randomization: 2 stars
2. Representability of patients undergoing plastic stent insertion
3. Representability of patients undergoing metal stent insertion

Comparability between groups:

4. Age
5. Sex
6. Co morbidity
7. Pretreatment
8. Dysphagia score
9. Tumor histological type
10. Tumor site
11. Tumor length
12. Pathological grade of tumors
13. Tumor stage

Outcome assessment:

14. 1–10 outcomes clearly recorded: one star; >10: two stars
15. Quality of follow-up: one star if >90% of patients were followed up until death

Secondary outcomes

Stent insertion-related morbidity

Perforation All 12 studies reported on the incidence of esophageal perforation; analysis of the six randomized, controlled studies included showed significantly less perforation rate with use of metal stents (1.4% vs. 9.4% for plastic stent; OR, 0.27; 95% CI, 0.08–0.89; $P = 0.03$; NNT = 14). Analysis of all studies showed that metal stents patients had significantly less incidence of esophageal perforation (1.65% (7/424) for metal stents versus 7.24% (35/483) for plastic (OR, 0.29; 95% CI, 0.14–0.61; $P < 0.001$; Fig. 4). There was no heterogeneity detected between the studies. A funnel plot based on a fixed effect model showing no asymmetry is displayed in Fig. 5.

There was no significant difference between the two groups in the incidence of hemorrhage and pain after stenting, and no heterogeneity was detected between groups in reporting these outcomes.

Complications-related to quality of palliation

Stent migration All 12 studies reported on the incidence of stent migration; analysis of the six randomized,

Table 8 Quality assessment scoring of studies comparing covered and uncovered metal stents

Study	Selection for treatment			Comparability of groups in studies										Outcome assessment		Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Ell, 1994		*	*											**	*	5
May, 1996		*	*				*	*	*	*	*			**	*	10
Hills, 1998		*	*											*	*	4
De Ronde, 2000		*	*	*							*	*	*	**	*	9
Vakil, 2001	**	*	*											**	*	7
Rozanes, 2002		*	*											**	*	5
Yang, 2005		*	*											**	*	5
Saranovic, 2005		*	*											*		3

Sensitivity of 7 (mean of all scores) or more stars will be undertaken representing high-quality studies

Quality of studies scoring:

Quality of studies will be determined by the number of stars they receive. One star will be assigned for fulfilling each of the following criteria

Selection for treatment:

1. Randomization: 2 stars
2. Representability of patients undergoing Plastic stent insertion
3. Representability of patients undergoing Metal stent insertion

Comparability between groups:

4. Age
5. Sex
6. Comorbidity
7. Pretreatment
8. Dysphagia score
9. Tumor histological type
10. Tumor site
11. Tumor length
12. Pathological grade of tumors
13. Tumor stage

Outcome assessment:

14. 1–10 outcomes clearly recorded: one star; >10: two stars
15. Quality of follow-up: one star if >90% of patients were followed up until death

controlled studies showed significantly less migration rate with use of metal stents (2.1% vs. 13.1% for plastic stent; OR, 0.24; 95% CI, 0.08–0.73; $P = 0.01$; NNT = 11). When all studies were considered, no significant difference was found (5.1% with metal stents vs. 10.1% with plastic stents; OR, 0.54; 95% CI, 0.27–1.09; $P = 0.09$; Fig. 4).

Tumor in-growth Six groups reported tumor in-growth: three are randomized, controlled trials, one prospective nonrandomized study, and two retrospective studies. Analysis of randomized, controlled trials showed significantly higher incidence of tumor in-growth in metal stents (13% vs. 1.6% for plastic stents; OR, 4.84; 95% CI, 0.99–23.76; $P = 0.05$; NNT = 9). Inclusion of all studies showed similar trend 8.21% (18/219) for metal stents versus 0.37% (1/266) for plastic stents (OR, 6.84; 95% CI, 2.12–22.01; $P = 0.001$; Fig. 4).

Food bolus impaction Eight studies reported on food bolus impaction, including four randomized, controlled trials, one prospective nonrandomized study, and three retrospective studies. Analysis of randomized, controlled trials did not show a significant difference between the two groups. When high-quality studies or those with >50 patients in each arm were considered, still no significant difference could be found. However, when all studies were considered, the metal stents group showed less incidence of food bolus impaction: 3.1% *v* 8.3% for plastic (OR, 0.41; 95% CI, 0.17–0.96; $P = 0.04$; NNT = 20).

There was no significant difference between the two groups in terms of repeated intervention, tumor outgrowth, or 30-day mortality rates (Tables 9–13). There was no heterogeneity between randomized, controlled studies in any of the main outcomes reported.

Table 9 Analysis of randomized, controlled trials comparing plastic and metal stents

Outcome	No. of studies	No. of patients	OR/ WMD	95% CI	*p* value	HG χ^2	HG *p* value
Technical success	5	243	2.59	(0.68–9.88)	0.16	3.04	0.55
Perforation	6	274	0.27	(0.08–0.89)	**0.03**	2.55	0.77
Hemorrhage	4	201	0.56	(0.17–1.81)	0.33	1.53	0.67
Food bolus impaction	4	193	0.64	(0.16–2.54)	0.53	4.45	0.22
Length of hospital stay	2	117	−4.61	(–9.61 to 0.39)	0.07	23.39	**<0.001**
Stent migration	6	264	0.24	(0.08–0.75)	**0.01**	3.56	0.61
Tumor ingrowth	3	125	4.84	(0.99–23.76)	**0.05**	0.37	0.83
Tumor outgrowth	6	267	1.82	(0.81–4.09)	0.14	4.01	0.55
Insufficient expansion	1	40	0.07	(0–1.34)	0.08	N/A	N/A
Pain	3	162	0.77	(0.23–2.6)	0.67	5.11	0.08
Repeated intervention	3	120	1.14	(0.37–3.55)	0.82	2.73	0.26
Direct-related motality	5	234	**0.02**	(0.06–0.74)	0.02	0.33	0.95
30-day mortality	4	195	0.68	(0.35–1.32)	0.26	1.05	0.79

OR odds ratio, *HG* heterogeneity, *CI* confidence interval, *WMD* weighted mean difference

Numbers in bold are the only statistically significant results in overall effect and heterogeneity

Table 10 Analysis of all studies comparing plastic and metal stents

Outcome	No. of studies	No. of patients	OR/ WMD	95% CI	*p* value	HG χ^2	HG *p* value
Technical success	8	654	1.16	(0.55–2.42)	0.7	5.86	0.56
Perforation	12	907	0.29	(0.14–0.61)	**0.001**	4.42	0.96
Hemorrhage	9	784	0.75	(0.35–1.59)	0.45	3.9	0.87
Food bolus impaction	8	598	0.41	(0.17–0.96)	**0.04**	6.66	0.46
Length of hospital stay	4	280	−3.62	(−6.62 to–0.62)	**0.02**	52.54	**<0.001**
Stent migration	12	897	0.55	(0.28–1.1)	0.09	15.3	0.17
Tumor ingrowth	6	485	6.84	(2.12–22.01)	**0.001**	0.9	0.97
Tumor outgrowth	11	808	2.06	(0.79–4.21)	0.16	14.59	0.15
After stenting dysphagia score	2	160	0.16	(−0.42 to 0.75)	0.58	3.79	**0.05**
Insufficient expansion	2	199	0.86	(0.01–120.17)	0.95	5.6	**0.02**
Pain	6	493	0.8	(0.44–1.47)	0.47	5.7	0.34
Repeated intervention	5	337	1.12	(0.46–2.7)	0.81	8.98	0.06
Direct-related motality	9	730	0.23	(0.09–0.6)	**0.003**	2.4	0.93
30-day mortality	6	332	0.74	(0.44–1.23)	0.25	1.79	0.88

OR odds ratio, *HG* heterogeneity, *CI* confidence interval, *WMD* weighted mean difference

Numbers in bold are the only statistically significant results in overall effect and heterogeneity

Table 11 Sensitivity analysis performed for high-quality studies comparing plastic and metal stents

Outcome	No. of studies	No. of patients	OR/ WMD	95% CI	*p* value	HG χ^2	HG *p* value
Technical success	4	203	1.67	(0.37–7.48)	0.5	1.4	0.71
Perforation	5	234	0.29	(0.08–1.05)	0.06	2.47	0.65
Hemorrhage	3	161	0.68	(0.19–2.39)	0.54	0.94	0.63
Food bolus impaction	4	193	0.64	(0.16–2.54)	0.53	4.45	0.22
Length of hospital stay	2	117	−4.61	(−9.61 to 0.39)	0.07	23.39	**<0.001**
Stent migration	5	224	0.28	(0.08–1.04)	0.06	3.39	0.5
Tumor ingrowth	3	125	4.84	(0.99–23.76)	**0.05**	0.37	0.83
Tumor outgrowth	5	227	1.76	(0.77–4.05)	0.18	3.89	0.42
Pain	2	122	1.02	(0.21–4.95)	0.98	3.8	0.05
Repeated intervention	3	120	1.14	(0.37–3.55)	0.82	2.73	0.26
Direct-related motality	5	234	0.2	(0.06–0.74)	**0.02**	0.33	0.95
30-day mortality	4	195	0.68	(0.35–1.32)	0.26	1.05	0.79

OR odds ratio, *HG* heterogeneity, *CI* confidence interval, *WMD* weighted mean difference

Numbers in bold are the only statistically significant results in overall effect and heterogeneity

Table 12 Overall analysis of outcomes comparing covered and uncovered metal stents

Outcome	No. of studies	No. of patients	OR/ WMD	95% CI	*p* value	HG χ^2	HG *p* value
Perforation	5	402	0.4	(0.13–1.22)	0.11	0.64	0.89
Hemorrhage	6	405	1.17	(0.23–6.01)	0.85	8.57	**0.04**
Food bolus impaction	3	242	0.49	(0.16–1.45)	0.2	1.11	0.57
Stent migration	3	224	7.02	(1.17–41.98)	**0.03**	3.36	0.19
Tumor ingrowth	3	221	0.1	(0.01–0.91)	**0.04**	5.51	0.06
Tumor outgrowth	2	159	0.78	(0.23–2.68)	0.69	1.23	0.27
Pain	2	158	1.43	(0.64–3.16)	0.38	1.02	0.31
Repeated intervention	3	242	0.12	(0.06–0.24)	**<0.001**	2.01	0.37

OR odds ratio, *HG* heterogeneity, *CI* confidence interval, *WMD* weighted mean difference

Numbers in bold are the only statistically significant results in overall effect and heterogeneity

Table 13 Sensitivity analysis performed for studies comparing covered and uncovered metal stents

Outcome	No. of studies	No. of patients	OR/ WMD	95% CI	*p* value	HG χ^2	HG *p* value
High-quality studies							
Hemorrhage	3	186	0.87	(0.13–5.69)	0.88	7.42	**0.02**
Studies with >50 patients							
Perforation	3	343	0.37	(0.11–1.24)	0.11	0.53	0.77
Hemorrhage	4	346	2.53	(0.85–7.56)	0.1	0.3	0.86

OR odds ratio, *HG* heterogeneity, *CI* confidence interval, *WMD* weighted mean difference

Numbers in bold are the only statistically significant results in overall effect and heterogeneity

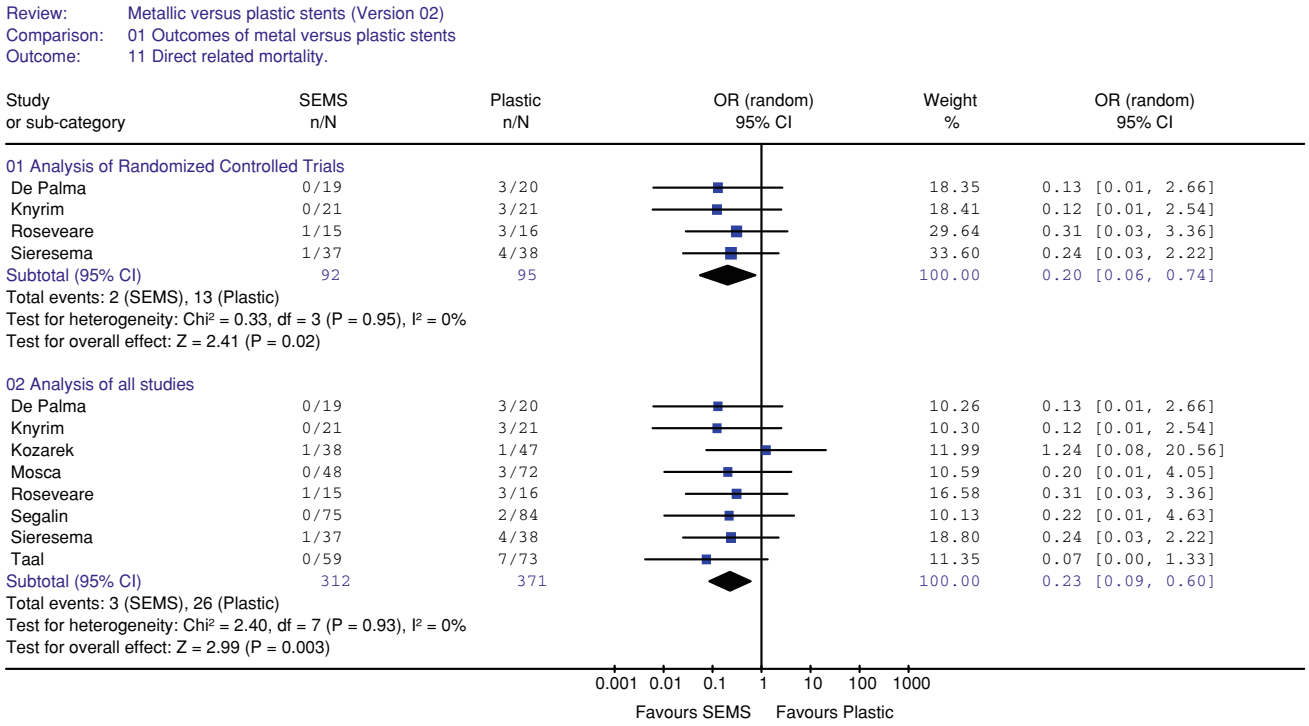

Fig. 2 Analysis of stent insertion-related mortality—metal versus plastic stents—RCT and overall analysis

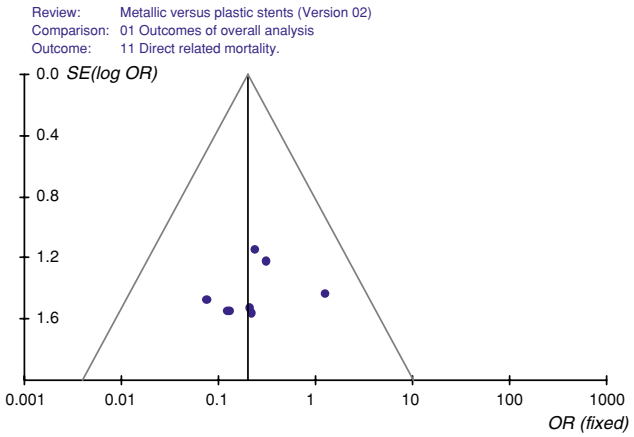

Fig. 3 Funnel plot showing reporting of stent insertion-related mortality in all studies

Outcomes of interest: covered versus uncovered metal stents

The studies included were different than those for comparison of metal and plastic stents; they included one randomized, controlled trial and seven retrospective studies.

Primary outcome

Stent-related mortality The two groups could not be compared reliably because data were reported in two studies or less.

Secondary outcomes

Stent insertion-related morbidity. There was no significant difference between the two groups in incidence of

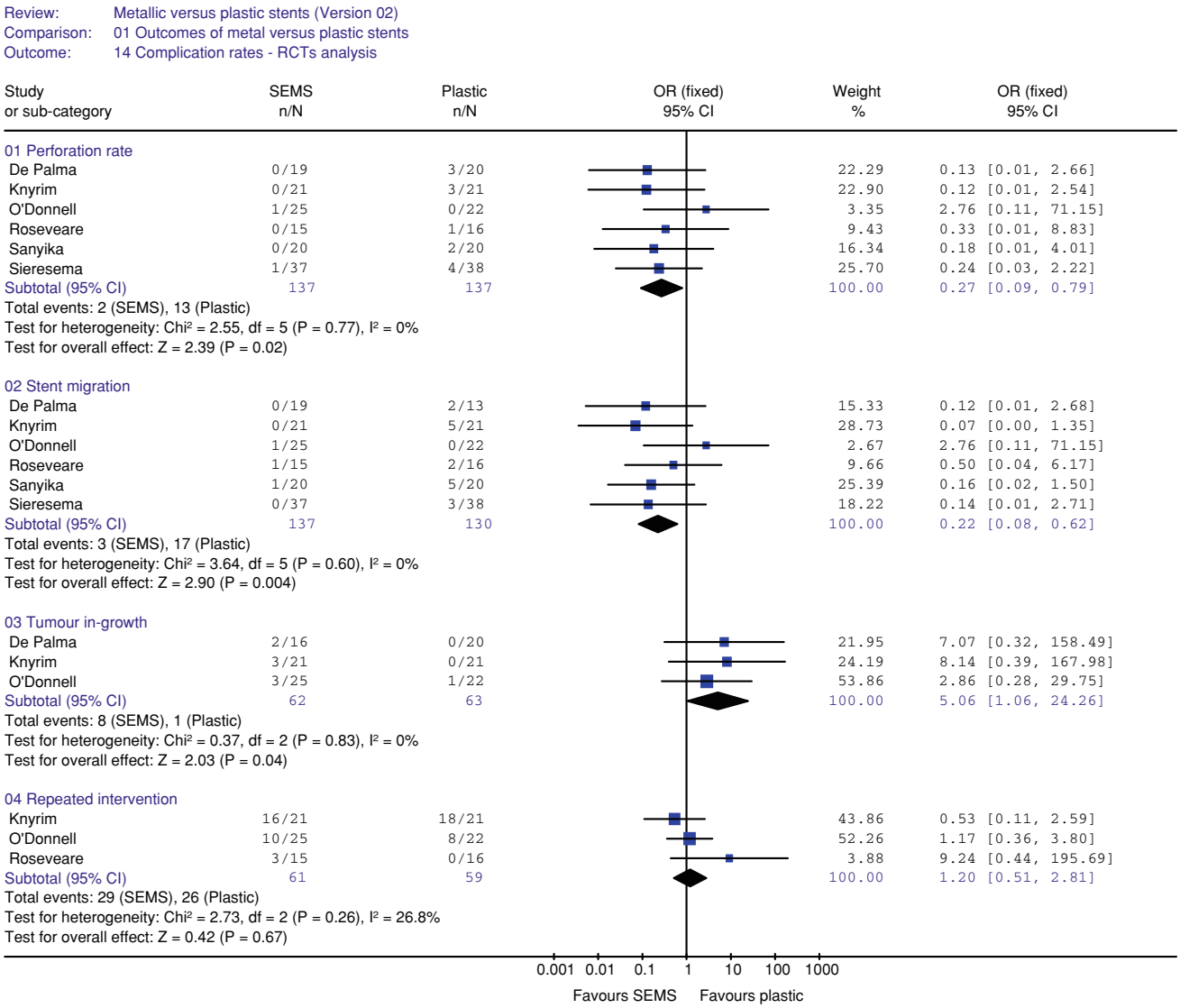

Fig. 4 Analysis of stent insertion-related morbidity—metal versus plastic stents—RCT analysis

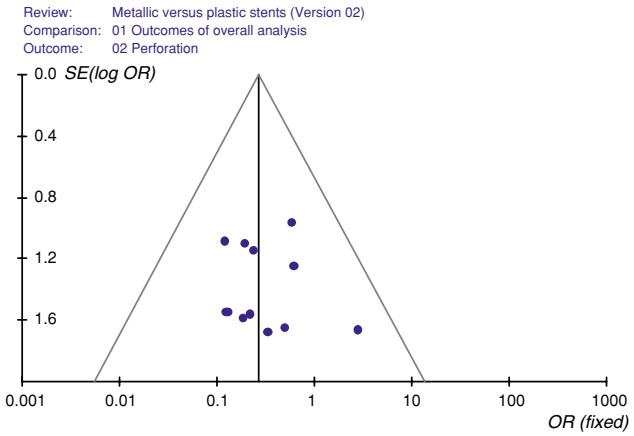

Fig. 5 Funnel plot showing reporting of perforation in all studies

perforation, hemorrhage, or pain after stenting. There was significant heterogeneity between studies in the reporting of incidence of hemorrhage; this has been overcome by the analysis of studies with 50 patients or more giving similar result to the overall analysis.

Complications-related to quality of palliation

Stent migration Incidence was significantly higher in the covered group 12.59% vs. 3.09% in uncovered (OR, 7.02; 95% CI, 1.17–41.98; $P = 0.03$).

Tumor in-growth The rate of tumor in-growth was significantly less in the covered versus uncovered groups (36.69% vs. 63.41%, OR, 0.1; 95% 0.01–0.91; $P = 0.04$; Fig. 6).

Repeat intervention Incidence was significantly lower in the covered group (12.24% vs. 53.68%; OR, 0.12; 95% CI, 0.06–0.24; $P < 0.001$). The two groups could not be compared reliably in terms of tumor outgrowth because data were reported in two studies or less.

Discussion

The findings of this meta-analysis based on randomized, controlled trials suggests that the use of self-expanding metal stents is associated with less stent insertion-related mortality, less incidence of esophageal perforation, and stent migration compared with plastic stents. A possible explanation for this could be the design of metal stents, which enable easy insertion and positioning through a narrow lumen, and in case of uncovered varieties fixation of the stent in place by tumor growth into the fenestrations of the stent leading to prevention of its migration; on the other hand, this is a drawback when excessive tumor in-growth leads to loss of the intended stent function. A second finding of the present meta-analysis was that the uncovered variety of metal stents had a higher rate of tumor in-growth. It is important to note that evidence available on this group of stents was based on only one randomized, controlled trial and seven retrospective studies and, therefore, should be interpreted with caution.

It is important to deduce high-level evidence to guide selection of type of stent because this has a direct bearing on the incidence of mortality and morbidity of this group of patients [22, 30], in addition to quality of dysphagia palliation, patient satisfaction, and, last but not least, health care resources used in case of recovery of complications as a result of poor choice of stent [21].

Implications for practice

The aggressive nature of malignant dysphagia, whether the primary tumor is esophageal (most cases) or extraesophageal, the choice of use of the type of stent will influence the overall outcome. We have shown that metal stents have a less stent insertion-related mortality and less complications advantage; the question is whether to choose the uncovered

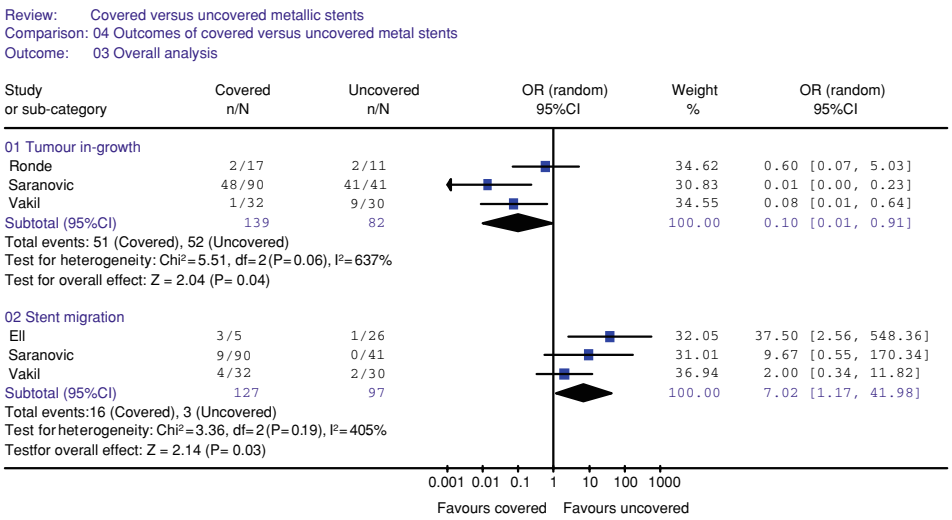

Fig. 6 Analysis of tumor in-growth and stent migration—covered versus uncovered SEMS

or the covered variety because each has its merit and defect as we displayed. We suggest that this should be individualized and tailored to the pathological characteristics of the tumor in terms of site, size, length, and tendency of invasiveness, i.e., vertical or luminal growth. This study has come at a time when the evidence comparing metal and plastic stents is available and the outcomes of their use can be quantified to obtain grade (A) evidence level of the recommended type to use. Proponents of plastic stents justify its use because of low cost and similar outcomes [31]. Metal stents have had less stent insertion-related mortality and perforation rates, which have definitive cost implications. Therefore, at present there is a real need to evaluate the cost-effectiveness of different types of metal stents by using an evidence synthesis approach to further support practical considerations when choosing a particular stent type. It seems that the covered stent has all the advantages except the migration problem. Future stents should concentrate on a design solution to this problem. "A covered metal stent that doesn't migrate seems to be the ideal stent."

Study limitations

Our meta-analysis has several limitations. First, neither the allocation of treatment nor the assessment of outcome was blinded in the case of retrospective and nonrandomized studies. Second, publication bias still needs to be born in mind, particularly in meta-analytic research based on published studies. Third, data on subjective patient satisfaction, quality of life, and survival were insufficient to draw meaningful results. Finally, the studies varied in inclusion criteria, study design, method of randomization, treatment protocols, and outcome assessment. It has been suggested that a meta-analysis such as this can highlight areas in which large, randomized trials comparing two interventions may be improved [32].

The data included in the studies used in the meta-analysis did not allow adequate assessment of the performance of different types of metal or plastic stents because the majority of the studies included has focused on the comparison between the metal and plastic categories, whereas the number of patients in subgroups was small for valid analysis. The evaluation of efficiency of different subtypes of stents needs to be examined in subsequent specifically designed randomized, controlled trials.

Conclusion

Self-expanding metal stents are superior to plastic stents in terms of stent insertion-related mortality, morbidity, and quality of palliation. The uncovered variety is disadvantaged by high rate of tumor in-growth; further adequately designed randomized, controlled trials need to examine outcomes and cost-effectiveness of covered versus uncovered metal stents.

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