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Comparison of plastic stents with self-expandable metal stents in palliative treatment of malignant biliary obstruction: a meta-analysis

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Abstract. – OBJECTIVE: The present study is to compare plastic stents (PS) with self-expandable metal stents (SEMS) in patients with malignant bile duct obstruction.

PATIENTS AND METHODS: Literature search in PubMed (Medline) and Embase databases was performed for all prospective randomized trials that compared SEMS with PS for the treatment of malignant biliary obstruction between January 1966 and January 2015. Research studies were included in the present meta-analysis if they met the inclusion criteria. In the meta-analysis, summary risk ratio estimates for major outcome were calculated. Forest plots were used to assess overall risk estimate, and funnel plots were used to assess overall publication bias. Meta-analysis was performed using STATA 11.0 software.

RESULTS: Ten articles with 810 patients were eligible for inclusion in the present meta-analysis. SEMS is not significantly associated with complications or 30-day mortality when compared with PS (p = 0.069 and 0.167, respectively). Further stratified analysis showed similar results. For other therapeutic effects, SEMS offered 2.27-fold 6-month stent patency rate (95% CI = 1.30-3.95), and 36% reduction in a recurrent obstruction (95% CI = 0.17-0.51), as compared with PS. In addition, SEMS was associated with fewer hospitalization days than PS (p = 0.023) in a random model. With fixed model, the corresponding p-value was less than 0.001.

CONCLUSIONS: The present meta-analysis demonstrates that SEMS cannot result in lower risks of complications and mortality, but can provide a lower risk of recurrent obstruction and longer stent patency for the palliation of malignant bile duct obstruction when compared with PS.

Key Words:

Self-expandable metal stents, Plastic stents, Palliative treatment, Malignant biliary obstruction.

Introduction

Malignant tumors, such as pancreatic cancer, gallbladder cancer, and cholangiocarcinoma, are among the most morbid and lethal diseases in elderly people worldwide, although therapies for these cancers have already had great developments[1,2]. One important reason is that these specific cancers are commonly associated with bile obstruction. The curative operation is the only therapy, but few patients have respectable lesions at the time of diagnosis[3].

Biliary stent placement is considered a good palliative treatment for patients with malignant biliary strictures. It plays an important role in maintaining disease condition, improving the quality of life, and reducing complications and mortality[4,5]. Since the late 1970s, plastic stents (PS) have been used in biliary stent placement, but self-expandable metallic stents (SEMS) are becoming more and more popular in recent years[6]. Several groups of researchers have compared the efficacy of PS with that of SEMS in patients with bile obstruction, but their results do not agree with each other[5,7,8]. Two prospective randomized controlled trials show that endoscopic metal stents provide longer survival than endoscopic plastic stents in patients with hilar and common malignant biliary obstruction[5,7]. However, one meta-analysis shows that there are no significant differences in complications and mortality between metal and plastic stents[8]. These differences may be explained by the confounding of the position of bile obstruction[9]. However, there are few data that compare SEMS with PS in patients with different malignant biliary obstruction positions. For these reasons, we conduct a meta-analysis of prospective ran-

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domized trials to compare SEMS with PS in the palliative management of malignant biliary obstruction.

Patients and Methods

Search Strategy

We conducted a literature search in PubMed (Medline) and Embase databases for all prospective randomized trials that compared SEMS with PS for the treatment of malignant biliary obstruction between January 1966 and January 2016. The key search terms utilized in this process were: "biliary obstruction", "distal biliary obstruction", "hilar biliary obstruction", "bile duct obstruction", "stent", "biliary stent", and "palliative therapy" in combination with "tumor", "ampullary tumor", "cancer", "pancreatic cancer", "gallbladder cancer", "cholangiocarcinoma", and "hepatic carcinoma". Also, we scrutinized references of retrieved literature to identify further relevant studies.

Study Selection

Research studies were included in the present meta-analysis if they met the following criteria: (1) the study design was prospective and randomized; (2) comparison was carried out between SEMS and PS; and (3) the article included a description of specified number of patients with malignant biliary obstruction. In contrast, articles that involved or were focused on non-human studies, conference abstracts, editorials, comments, and unpublished articles were excluded from the present meta-analysis. If a study had been reported for more than once, we used the most recently published results.

Data Extraction

For each study, the following information was extracted: name of first author, year of publication, study location, study design, age and gender of participants, number of participants, stent type, technical success of the procedures, complications, mortality, and recurrence of biliary obstruction.

Data Analysis

In the meta-analysis, summary risk ratio (RR) estimates for major outcome were calculated using the method published previously[10]. Heterogeneity among studies was assessed using I^2 statistic, which described the proportion of total variation in point estimate caused by heterogeneity. For I^2 metric, I^2 values of 25%, 50%, and 75% were considered as cut-off points for low, moderate, and high degrees of heterogeneity, respectively. When heterogeneity was significant, we used a random effects model; otherwise, we used a fixed effects model. Forest plots were used to assess the overall risk estimate, and funnel plots were used to assess the overall publication bias. The meta-analysis was performed using STATA 11.0 software (StataCorp LP, College Station, TX, USA).

Results

Study Search

A total of 1,763 research articles from PubMed and Embase databases were obtained using the keywords previously outlined. After applying the inclusion criteria, only 12 research articles satisfied the criteria. Further critical evaluation of the selected 12 articles showed that two articles still failed to meet the inclusion criteria[5,11], one article's design was retrospective[5], and one article's study was not only for malignant bile obstruction but also for benign bile obstruction[11]. Therefore, after evaluation of all research articles, only 10 were included in the present meta-analysis (Figure 1).

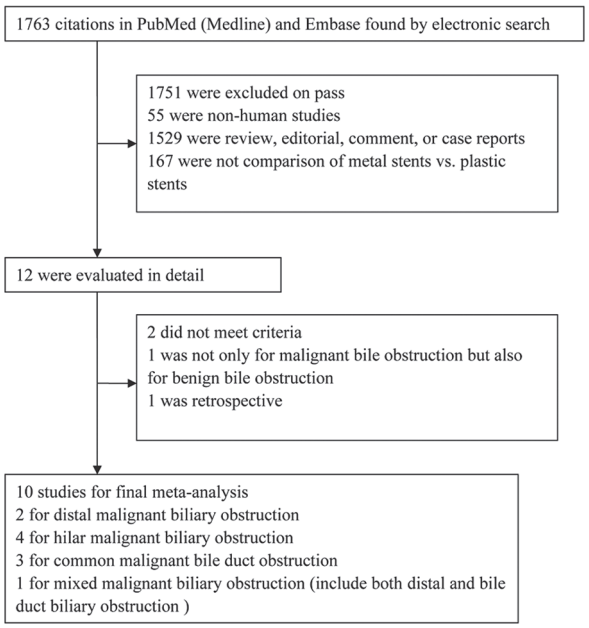

Figure 1. Literature search procedure. A literature search was conducted in PubMed (Medline) and Embase databases for all prospective randomized trials that compared SEMS versus PS for the treatment of malignant biliary obstruction between January 1966 and January 2016.

Study Characteristics

General characteristics of the included studies showed that the 10 studies included 810 patients with malignant biliary obstruction (Table I). Among all studies, two studies compared SEMS with PS for distal malignant biliary obstruction[12-13], four studies compared the two for hilar malignant biliary obstruction[14-17], three studies compared the two for common malignant bile duct obstruction[7,18-19], and one study compared the two for mixed malignant biliary obstruction (distal and bile duct biliary obstruction)[20]. In addition, one trial by Prat et al[19] divided patients into three treatment groups: group 1 (polyethylene stent to be exchanged in case of dysfunction), group 2 (polyethylene stent to be exchanged every 3 months), and group 3 (SEMS). Because group 1 and group 2 may have deistical treatment effect, we divided this trial into two studies: one study comprised groups 1 and 3, and the other comprised groups 2 and 3.

Technical Success

Overall analysis of all studies revealed that, when compared with PS, SEMS had no significantly lower technical success [RR (95% CI) = 0.97 (0.94-1.01), p = 0.104]. Further stratified analysis showed similar results. The two stents had essentially equal technical success rates for patients with distal malignant biliary obstruction [RR (95% CI) = 0.98 (0.93-1.03), p = 0.436], hilar malignant biliary obstruction [RR (95% CI) = 0.99 (0.91-1.06), p = 0.697], common malignant bile duct obstruction [RR (95% CI) = 0.96 (0.92-1.01), p = 0.101], and mixed distal and bile duct malignant obstruction [RR (95% CI) = 0.96 (0.92-1.01), p = 0.190]. Overall, hilar and common bile duct obstruction groups were not heterogeneous in terms of technical success (I^2 = 0 for all; p = 0.513, 0.623, and 0.945, respectively). In distal malignant biliary obstruction group, we excluded a trial because of its 100% technical success rate in both stents. Therefore, we could not conclude its heterogeneity. In mixed group, we could not conclude the heterogeneity for only one trial (Figure 2).

Complications and Mortality

The RR of major complications and 30-day mortality for each trial and 95% CI are shown in Figures 2 and 3, respectively. According to Figure 2, SEMS had a marginal statistically significant reduction (34%) in the RR of complication rates than PS for patients with hilar malignant biliary

Table I. Characteristics of included studies.

Authors	Year	N	Location	Design	Biliary obstruction types	Metal stent type	Plastic stent type
Davids P	1992	105	Netherlands	Randomized	Distal malignant biliary	Endoscopic SEMS	Endoscopic polyethylene
Wagner H	1993	20	Germany	Randomized	Hilar malignant biliary	SEMS	Large-bore plastic
Lammer J	1996	101	Austria	Randomized	Common malignant bile duct	Transhepatic SEMS	Transhepatic endoprostheses
Prat F	1998	105	France	Randomized	Common malignant bile duct	Endoscopic SEMS	Endoscopic polyethylene
Piñol V	2002	54	Spain	Randomized	Mixed malignant biliary	Percutaneous SEMS	Endoscopic polyethylene
Soderlund C	2006	100	Sweden	Randomized controlled	Common malignant bile duct	Endoscopic SEMS	Endoscopic polyethylene
Sangchan A	2012	108	Thailand	Randomized controlled	Hilar malignant biliary	Endoscopic SEMS	Endoscopic polyethylene
Moses P	2013	120	North American	Randomized	Hilar malignant biliary	Endoscopic SEMS	Endoscopic polyethylene
Mukai T	2013	60	Japan	Randomized controlled	Hilar malignant biliary	Endoscopic SEMS	Endoscopic polyethylene
Schmidt A	2014	37	Germany	Randomized trial	Distal malignant biliary	Endoscopic SEMS	Endoscopic wing-shaped plastic

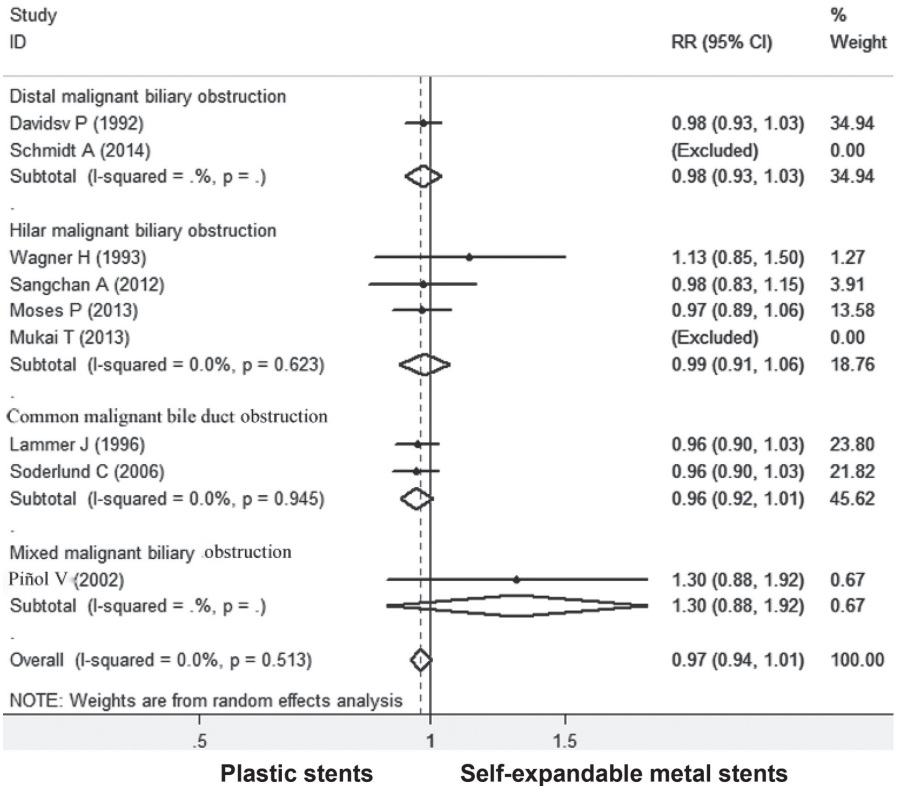

Figure 2. Forest plot for the association between SEMS and technical success. The meta-analysis was performed using STATA 11.0. RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.

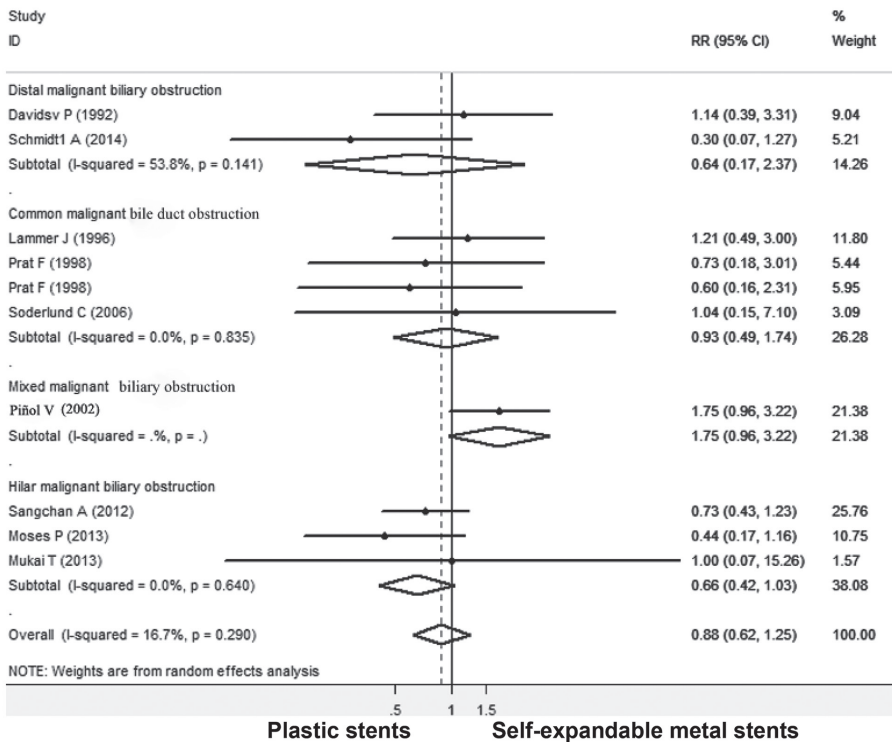

Figure 3. Forest plot for the association between SEMS and major complications. The meta-analysis was performed using STATA 11.0. RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.

obstruction (p = 0.069). For patients with mixed bile obstruction, SEMS had a marginal statistically significant increase (75%) in mixed bile than PS (p = 0.069). No significant result was observed when comparing SEMS with PS in other groups. Except for distal malignant biliary obstruction, PS and SEMS had no statistically significant difference in the incidence of severe complications (overall: I^2 = 16.7, p = 0.290; common: I^2 = 0, p = 0.835; hilar: I^2 = 0, p = 0.640). Among distal malignant biliary obstruction patients, there was moderate and insignificant heterogeneity in terms of major complications (I^2 = 53.8, p = 0.141) (Figure 3). In the present meta-analysis, seven studies evaluated 30-day mortality as an outcome measure. Overall, about 32% (97/300) of patients with SEMS died in 30 days, whereas 37% (110/295) of patients with PS died in 30 days [RR (95% CI) = 0.89 (0.76-1.05), p = 0.167]. The 30-days mortality of patients with SEMS was not significantly lower than that of patients with PS in common malignant bile duct obstruction group (RR = 0.89, p = 0.243), hilar malignant biliary obstruction group (RR = 0.72, p = 0.620), and mixed malignant biliary obstruction group (RR = 0.84, p = 0.292), respectively. Of note, the 30-day mortality of patients with SEMS in common malignant bile duct obstruction group was insignificantly higher than that of patients with PS (RR = 0.357, p = 0.101). No heterogeneity of effect estimates on RR was observed in terms of 30-day mortality in the seven trials (I^2 = 19.0, p = 0.285) (Figure 4).

Stent Patency and Recurrent Obstruction

The present meta-analysis of 6-month patency involved 5 studies. The pooled estimates for stent patency in random model showed that the 6-month patency rate for SEMS was 2.27-fold of that for PS (95% CI = 1.30-3.95, p = 0.004). The result in fixed model is similar [SEMS versus PS: RR (95% CI) = 2.24 (1.69-2.97), p < 0.001]. The five studies were moderately heterogeneous in terms of 6-month patency (I^2 = 62.3, p = 0.031) (Figure 5). Further stratified analysis by random model consistently showed that patients with SEMS were in favor of significantly or marginally significantly higher patency rate in all groups, as compared with patients with PS (p was less than 0.05 or near 0.05 for all) (Figure 6). By fixed model, patients with SEMS were in favor of significantly higher patency rate in all groups than patients with PS (p < 0.01 for

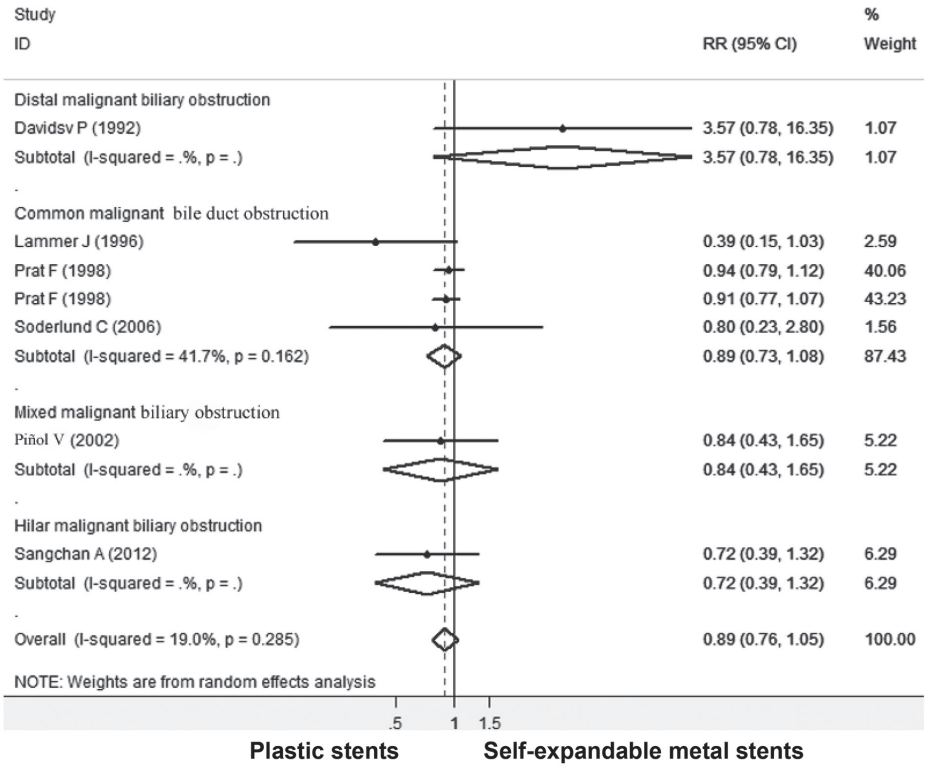

Figure 4. Forest plot for the association between SEMS and 30-days mortality. RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.

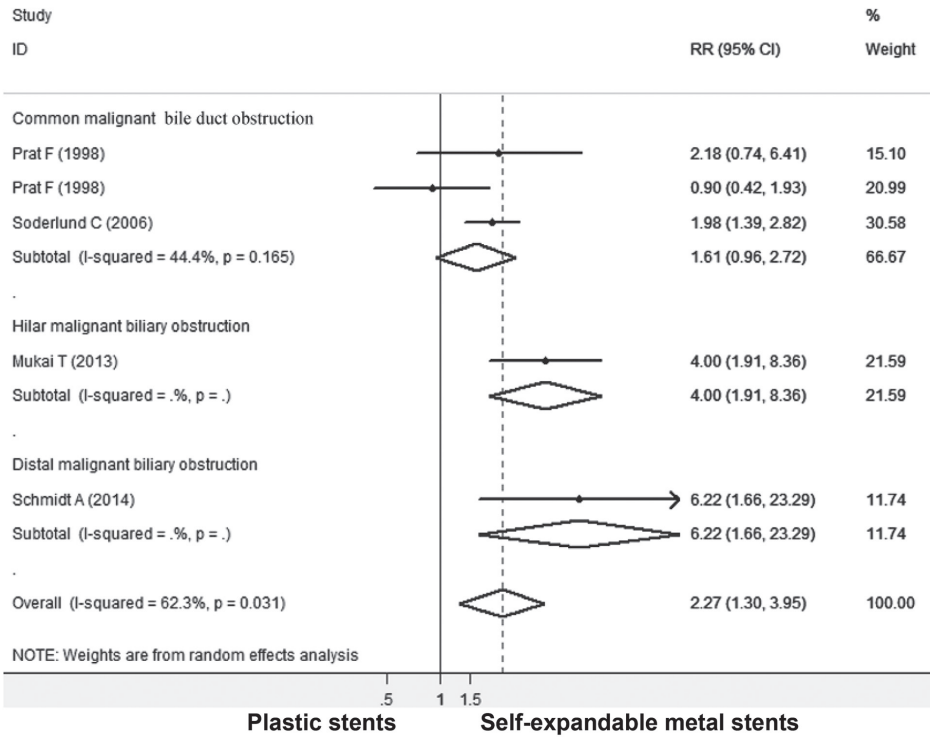

Figure 5. Forest plot for the association between SEMS and 6-month patency. RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.

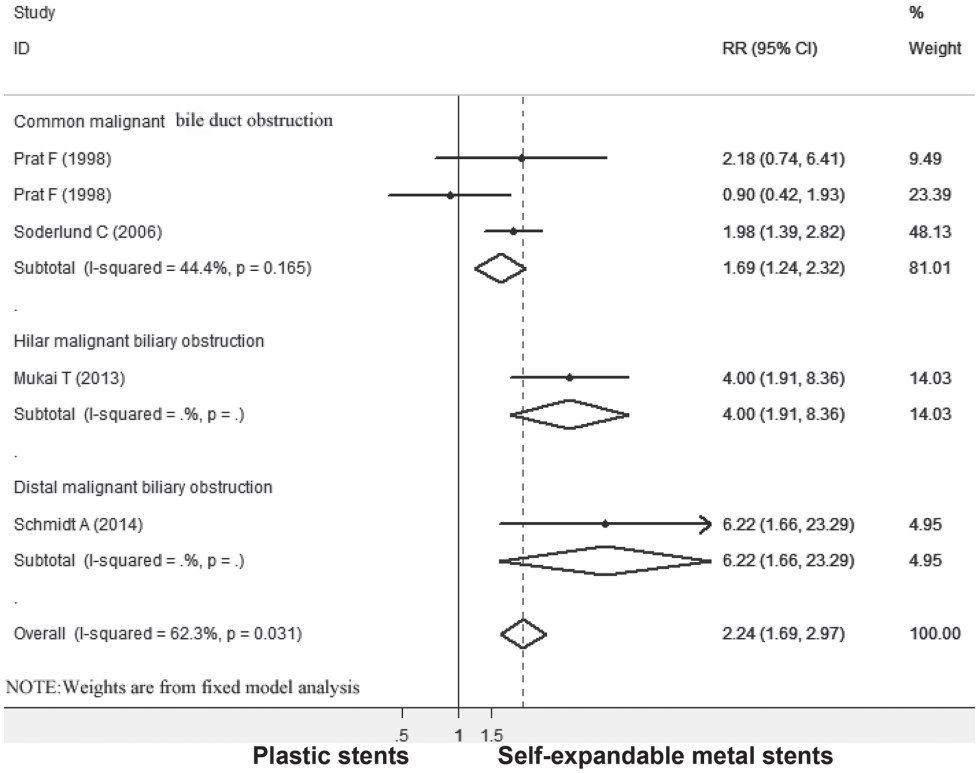

Figure 6. Forest plot for the association between SEMS and recurrent bile obstruction (*random mode*l). RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.0

all). Of the four included studies, two studies demonstrated that recurrent bile obstruction after SEMS placement was less frequent than that after PS placement; the other two studies showed no difference (Figure 7). The overall RR (SEMS vs. PS) was 0.64 (95% CI = 0.49-0.83, $p = 0.001$). No heterogeneity was observed in terms of recurrent obstruction among the four included studies ($I^2 = 0$, $p = 0.760$). In the present meta-analysis, about 31% (50/159) of patients with SEMS had recurrent bile obstruction, while 50% (78/157) of patients with PS had recurrent bile obstruction (Figure 7).

Hospitalization Days

A total of five studies included hospitalization days. Results by random model showed that patients with SEMS had an average of 1.13-day reduction in hospitalization days compared to patients with PS (95% CI = 0.15-2.11, $p = 0.023$) (Figure 8). By fixed model, the reduction of hospitalization days was 1.03 (95% CI = 0.77-1.29, $p < 0.001$). Except for mixed malignant biliary obstruction group, we recorded a reduction of more than 0.69 day in hospitalization days when comparing SEMS with PS in different bile obstruction position groups ($p < 0.05$ in both random and fixed model for all). In mixed malignant biliary obstruction group, we observed an insignificant increase in hospitalization days (0.32) in patients with SEMS, as compared with patients with PS, in both random model and fixed model (all $p = 0.375$) (Figure 9).

Discussion

The present meta-analysis has identified no significant association between stent types and patient survival. SEMS placement is not associated with fewer complications and mortality than PS placement. Similar results are observed in stratified analysis based on bile obstruction position. However, SEMS placement is associated with a higher long-time stent patency rate and less frequent recurrence of obstruction when compared with PS placement in malignant biliary obstruction patients. Furthermore, patients after SEMS placement have shorter hospitalization days as compared with patients after PS placement.

To date, most random clinical trials have shown no significant difference between metal stents and plastic stents in late complication and mortality among malignant biliary obstruction

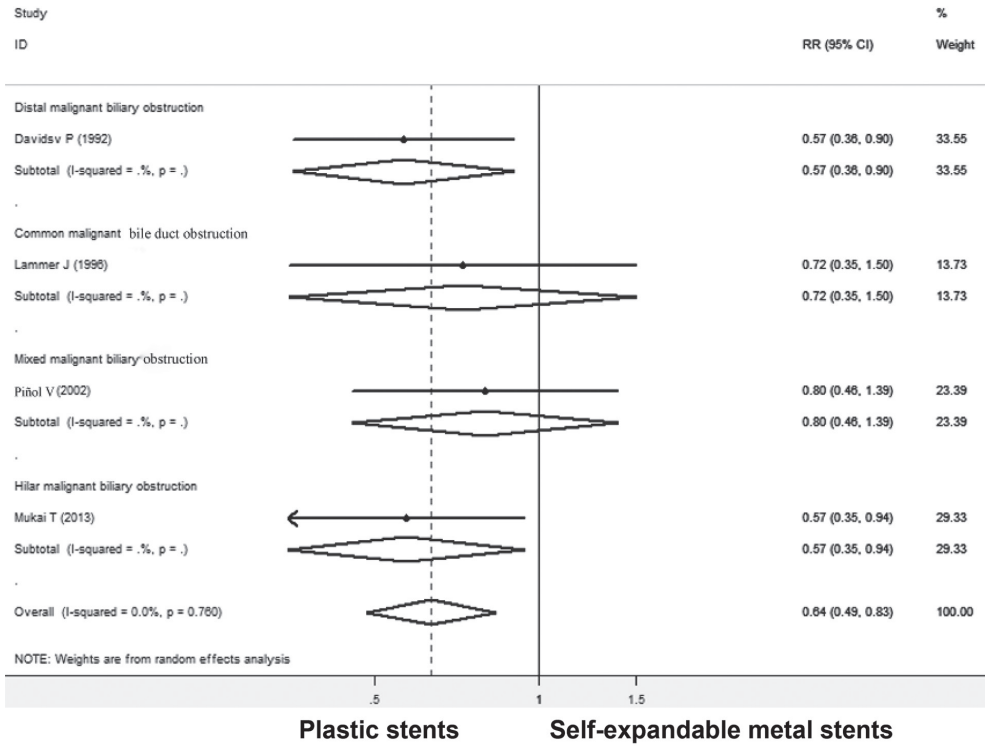

Figure 7. Forest plot for the association between SEMS and recurrent bile obstruction (*fixed model*). RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.

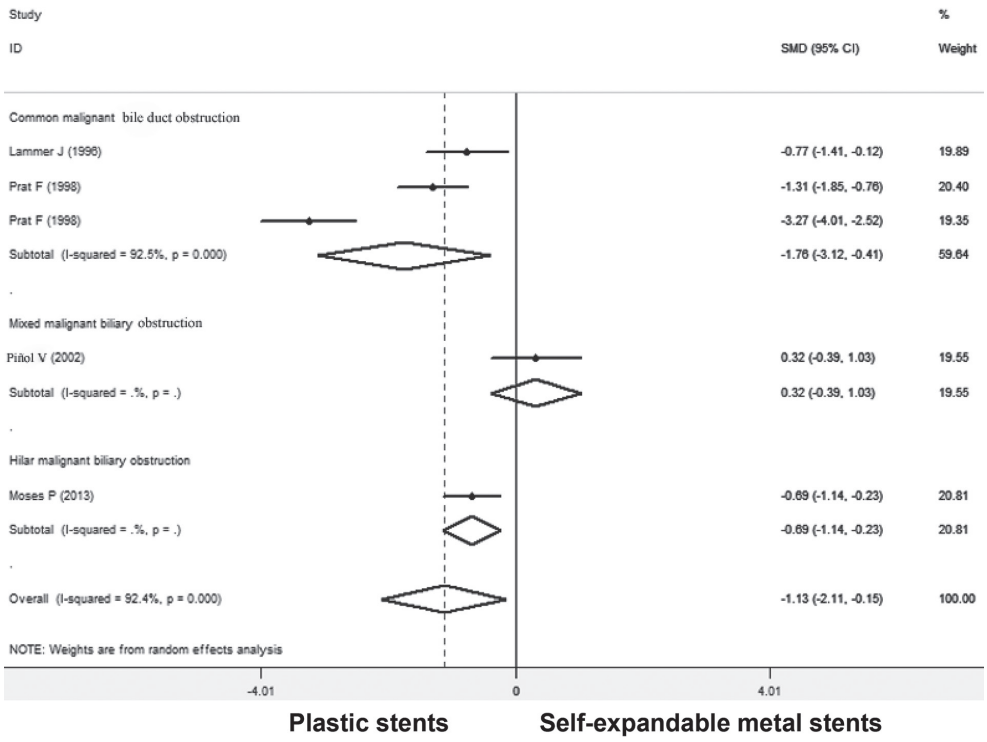

Figure 8. Forest plot for the association between SEMS and hospitalization days analyzed by random model. RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.

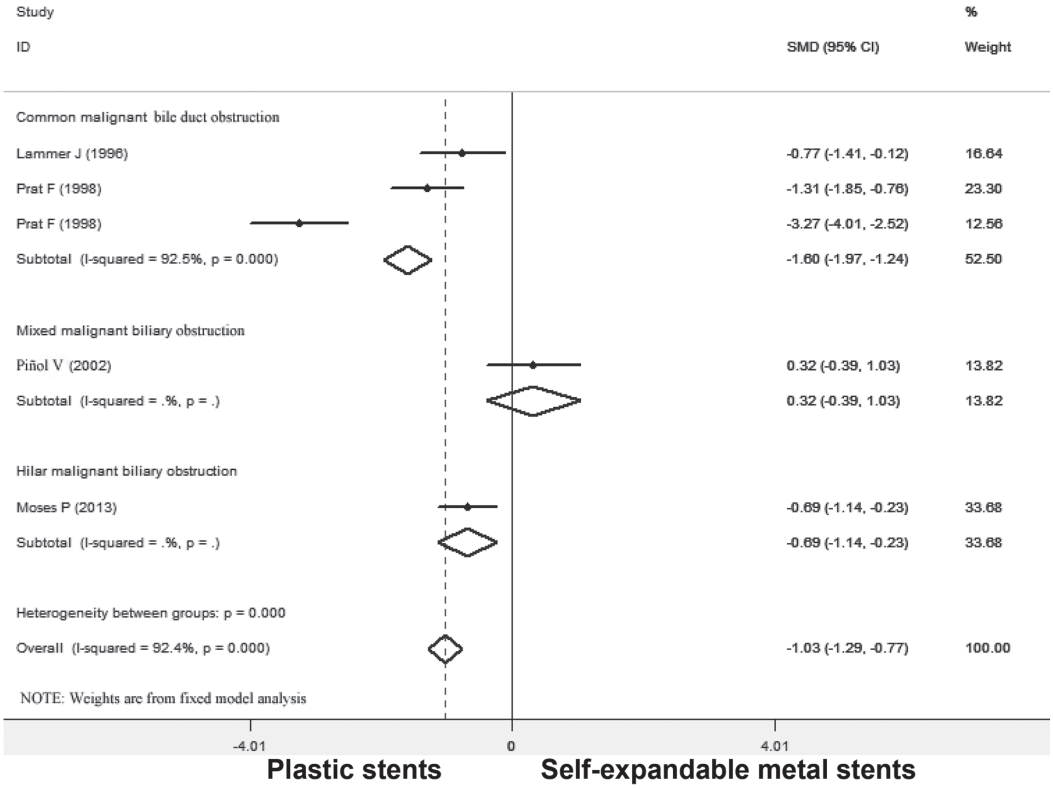

Figure 9. Forest plot for the association between SEMS and hospitalization days analyzed by fixed model. RR, risk ratio; I^2 statistic, the proportion of total variation in point estimate caused by heterogeneity.

patients[21-25]. However, Liberato et al[26] discover that SEMS insertion for the palliation of hilar cholangiocarcinoma provides lower early and late complication rates as compared with PS placement. However, this trial is retrospective and has not analyzed other malignant bile obstruction types. A single-center, open-label, randomized controlled trial from Southeast Asia shows 50% reduction in hazard risk of death in unrespectable hilar cholangiocarcinoma patients receiving metal stents compared with plastic stents[15]. A randomized trial from Austria discovers that use of SEMS is significantly associated with lower 30-day mortality rate than use of PS among patients with common malignancy bile duct obstruction[18]. Although stent type influences early complication rate, stent placement is still not a cure measure for malignant biliary strictures[6,27]. In addition, the majority of patients with stent placement have advanced cancer, and their long-time mortality is high, although they have received high-quality treatments. Moreover, location difference in response to different types of stents varies greatly and may affect the association between SEMS and complication or mortality rate[9].

Except for complication and mortality, SEMS is a good measure for other efficacies, such as stent patency and recurrent obstruction. Several studies show that metal stents are associated with longer stent patency compared to conventional PS[3,5,7]. In a random controlled trial, PS placement is still unable to offer equivalent 6-month patency compared to SEMS even after improvement[12]. Similarly, this trial shows that SEMS results in more reduction in obstruction recurrence frequency compared to PS after improvement[12]. This phenomenon may be attributed to higher frequency in bacterial formation in plastic stent than in metal stent, which usually results in stent clogging[28]. Another difference is that SEMS is associated with fewer hospitalization days when compared with PS. This difference may be explained by lower possibility of developing stent dysfunction in SEMS than in PS[29].

The present study has some advantages. First, the meta-analysis has included prospective random trials with a large sample size and long follow-up time, which have greatly increased the power to detect potential differences between SEMS and PS in the treatment of bile obstruction caused by cancer. Then, location-specific meta-analysis is carried out in the present study, because different locations of bile obstruction can result in different stent type responses. However, the number of high-quality clinical trials in different locations of bile obstruction is still too small to evaluate the association between location-specific stent type and efficacy of treatment. More high-quality clinical trials, especially prospective random controlled trials with large sample sizes are needed to validate the association between stent type and the effect of conservative treatment in the future.

Conclusions

SEMS cannot offer lower risks of complications and mortality than PS, but can provide lower risk of recurrent obstruction and longer stent patency for the palliation of malignant bile duct obstruction.

Acknowledgements

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Conflict of Interest

The Authors declare that they have no conflict of interests.

References

1) Lan BY, Kwee SA,Wong LL. Positron emission tomography in hepatobiliary and pancreatic malignancies: a review. Am J Surg 2012; 204: 232-241.
2) GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2015; 385: 117-171.
3) Katsinelos P, Paikos D, Kountouras J, Chatzimavroudis G, Paroutoglou G, Moschos I, Gatopoulou A, Beltsis A, Zavos C, Papaziogas B. Tannenbaum and metal stents in the palliative treatment of malignant distal bile duct obstruction: a comparative study of patency and cost effectiveness. Surg Endosc 2006; 20: 1587-1593.

4) Glazer ES, Hornbrook MC, Krouse RS. A meta-analysis of randomized trials: immediate stent placement vs. surgical bypass in the palliative management of malignant biliary obstruction. J Pain Symptom Manage 2014; 47: 307-314.

5) Kaassis M, Boyer J, Dumas R, Ponchon T, Coumaros D, Delcenserie R, Canard JM, Fritsch J, Rey JF, Burtin P. Plastic or metal stents for malignant stricture of the common bile duct? Results of a randomized prospective study. Gastrointest Endosc 2003 ; 57: 178-182.

6) Lefebvre AC, Maurel J, Boutreux S, Bouvier V, Reimund JM, Launoy G, Arsene D. Pancreatic cancer: incidence, treatment and survival trends--1175 cases in Calvados (France) from 1978 to 2002. Gastroenterol Clin Biol 2009; 33: 1045-1051.

7) Soderlund C, Linder S. Covered metal versus plastic stents for malignant common bile duct stenosis: a prospective, randomized, controlled trial. Gastrointest Endosc 2006; 63: 986-995.

8) Moss AC, Morris E, Leyden J, MacMathuna P. Do the benefits of metal stents justify the costs? A systematic review and meta-analysis of trials comparing endoscopic stents for malignant biliary obstruction. Eur J Gastroenterol Hepatol 2007; 19: 1119-1124.

9) Nakeeb A, Pitt HA, Sohn TA, Coleman J, Abrams RA, Piantadosi S, Hruban RH, Lillemoe KD, Yeo CJ, Cameron JL. Cholangiocarcinoma. A spectrum of intrahepatic, perihilar, and distal tumors. Ann Surg 1996; 224: 463-473; discussion 473-465.

10) DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986; 7: 177-188.

11) Kaffes A, Griffin S, Vaughan R, James M, Chua T, Tee H, Dinesen L, Corte C, Gill R. A randomized trial of a fully covered self-expandable metallic stent versus plastic stents in anastomotic biliary strictures after liver transplantation. Therap Adv Gastroenterol 2014; 7: 64-71.

12) Schmidt A, Riecken B, Rische S, Klinger C, Jakobs R, Bechtler M, Kähler G, Dormann A, Caca K. Wing-shaped plastic stents vs. self-expandable metal stents for palliative drainage of malignant distal biliary obstruction: a randomized multicenter study. Endoscopy 2015; 47: 430-436.

13) Davids PH, Groen AK, Rauws EA, Tytgat GN, Huibregtse K. Randomised trial of self-expanding metal stents versus polyethylene stents for distal malignant biliary obstruction. Lancet 1992; 340: 1488-1492.

14) Wagner HJ, Knyrim K, Vakil N, Klose KJ. Plastic endoprostheses versus metal stents in the palliative treatment of malignant hilar biliary obstruction. A prospective and randomized trial. Endoscopy 1993; 25: 213-218.

15) Sangchan A, Kongkasame W, Pugkhem A, Jenwitheesuk K, Mairiang P. Efficacy of metal and plastic stents in unresectable complex hilar cholangiocarcinoma: a randomized controlled trial. Gastrointest Endosc 2012; 76: 93-99.

16) Moses PL, Alnaamani KM, Barkun AN, Gordon SR, Mitty RD, Branch MS, Kowalski TE, Martel M, Adam V. Randomized trial in malignant biliary obstruction: plastic vs partially covered metal stents. World J Gastroenterol 2013; 19: 8638-8646.

17) Mukai T, Mukai T, Yasuda I, Nakashima M, Doi S, Iwashita T, Iwata K, Kato T, Tomita E, Moriwaki H. Metallic stents are more efficacious than plastic stents in unresectable malignant hilar biliary strictures: a randomized controlled trial. J Hepatobiliary Pancreat Sci 2013 ; 20: 214-222.

18) Lammer J, Hausegger KA, Flückiger F, Winkelbauer FW, Wildling R, Klein GE, Thurnher SA, Havelec L. Common bile duct obstruction due to malignancy: treatment with plastic versus metal stents. Radiology 1996; 201: 167-172.

19) Prat F, Chapat O, Ducot B, Ponchon T, Pelletier G, Fritsch J, Choury AD, Buffet C. A randomized trial of endoscopic drainage methods for inoperable malignant strictures of the common bile duct. Gastrointest. Endosc 1998; 47: 1-7.

20) Pinol V, Castells A, Bordas JM, Real MI, Llach J, Montañà X, Feu F, Navarro S. Percutaneous self-expanding metal stents versus endoscopic polyethylene endoprostheses for treating malignant biliary obstruction: randomized clinical trial. Radiology 2002; 225: 27-34.

21) Siddiqui AA, Kowalski TE, Loren DE, Khalid A, Soomro A, Mazhar SM, Isby L, Kahaleh M, Karia K, Yoo J, Ofosu A, Ng B, Sharaiha RZ. Stents for endoscopic drainage of pancreatic walled-off necrosis: clinical outcomes and success. Gastrointest Endosc 2017; 85: 758-765.

22) Bapaye A, Dubale NA, Sheth KA, Bapaye J, Ramesh J, Gadhikar H, Mahajani S, Date S, Pujari R, Gaadhe R. Endoscopic ultrasonography-guided transmural drainage of walled-off pancreatic necrosis: comparison between a specially designed fully covered bi-flanged metal stent and multiple plastic stents. Dig Endosc 2017; 29: 104-110.

23) Gao DJ, Hu B, Ye X, Wang TT, Wu J. Metal versus plastic stents for unresectable gallbladder cancer with hilar duct obstruction. Dig Endosc 2017; 29: 97-103.

24) Crippa S, Cirocchi R, Partelli S, Petrone MC, Muffatti F, Renzi C, Falconi M, Arcidiacono PG. Systematic review and meta-analysis of metal versus plastic stents for preoperative biliary drainage in resectable periampullary or pancreatic head tumors. Eur J Surg Oncol 2016; 9; 42: 1278-1285.

25) Song TJ, Lee JH, Lee SS, Jang JW, Kim JW, Ok TJ, Oh DW, Park DH, Seo DW, Lee SK, Kim MH, Kim SC, Kim CN, Yun SC. Metal versus plastic stents for drainage of malignant biliary obstruction before primary surgical resection. Gastrointest Endosc 2016; 84: 814-821.

26) Liberato MJ, Canena JM. Endoscopic stenting for hilar cholangiocarcinoma: efficacy of unilateral and bilateral placement of plastic and metal stents in a retrospective review of 480 patients. BMC Gastroenterol 2012; 9; 12: 103.

27) Linder S, Bostrom L, Nilsson B. Pancreatic cancer in sweden 1980-2000: a population-based study of hospitalized patients concerning time trends in curative surgery and other interventional therapies. J Gastrontest Surg 2006; 10: 672-678.

28) Donelli G, Guaglianone E, Di Rosa R, Fiocca F, Basoli A. Plastic biliary stent occlusion: factors involved and possible preventive approaches. Clin Med Res 2007; 5: 53-60.

29) Hong WD, Chen XW, Wu WZ, Zhu QH, Chen XR. Metal versus plastic stents for malignant biliary obstruction: an update meta-analysis. Clin Res Hepatol Gastroenterol 2013; 37: 496-500.