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Passive drainage to gravity and closed-suction drainage following pancreatoduodenectomy lead to similar grade B and C postoperative pancreatic fistula rates. A meta-analysis

Mahir Gachabayov, Shekhar Gogna, Rifat Latifi, Xiang D. Dong*

Department of Surgery, Westchester Medical Center, New York Medical College, Valhalla, NY, USA

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ABSTRACT

Introduction: There is no level 1a evidence regarding the impact of passive drainage to gravity (PDG) and closed-suction drainage (CSD) following pancreatoduodenectomy on clinical outcomes. The aim of this meta-analysis was to evaluate the impact of PDG versus CSD on surgical outcomes following pancreaticoduodenectomy in high risk patients who would benefit from pancreatic drainage.

Methods: The Pubmed, EMBASE, and Cochrane Library were systematically searched. Postoperative pancreatic fistula (POPF) rate was the primary endpoint. A subgroup meta-analysis of randomized controlled trials (RCT) was performed in addition to a meta-analysis of all eligible studies. Mantel-Haenszel method (random-effects model) with odds ratios and 95% confidence intervals (OR (95%CI)) as an effect measure was utilized.

Results: Six studies, whereof 3 RCTs, involving 1519 patients (806 PDG and 713 CSD) were included. In meta-analysis of all studies, overall [OR (95%CI) = 0.81 (0.42, 1.56); $p = 0.53$; $I^2 = 79\%$; $Tau^2 = 0.54$]; grade A [OR (95%CI) = 0.71 (0.33, 1.53); $p = 0.39$; $I^2 = 65\%$; $Tau^2 = 0.47$]; grade B [OR (95%CI) = 1.23 (0.74, 2.05); $p = 0.42$; $I^2 = 0\%$]; and grade C [OR (95%CI) = 1.08 (0.56, 2.09); $p = 0.82$; $I^2 = 5\%$] POPF rates did not differ. Subgroup analysis of RCTs confirmed the finding that grade B and C POPF rates did not significantly differ with low heterogeneity [OR (95%CI) = 1.55 (0.79, 3.04); $p = 0.20$; $I^2 = 0\%$]. No publication bias was found ($t = 0.48$; $p = 0.64$).

Conclusion: This meta-analysis found no difference in short-term clinical outcomes including, clinically relevant, grade B and C POPF rates between PDG and CSD. Furthermore, postoperative complication rates were similar with the use of either drain.

1. Introduction

Pancreatic surgery has made tremendous progress over the last several decades. However, it remains a formidable surgery with significant postoperative complications ranging from hemorrhage, infection to post-operative pancreatic fistulas (POPF) [1–3]. There have been various modifications to the surgical technique since the operation was first described to mitigate the risks of intraoperative and postoperative complications [4–8]. However, the development of post-operative pancreatic fistula (POPF), which can range from 5% to 48% of patients, leads to significant postoperative morbidity [9–11].

The presence of post-operative pancreatic fistulas often leads to various other complications such as sepsis, hemorrhage and poor wound healing mandating interventions such as percutaneous drainage or operative interventions [12–16]. Pancreatic fistulas are categorized into types A through C, with types B and C leading to clinically relevant POPF [11]. Mortality associated with POPFs positively correlate with the severity of the anastomotic disruption ranging from 1 to 2% for type A fistulas to over 40% for type C fistulas [10,17].

The routine use of pancreatic drains has seemed to limit the morbidity of POPF [7,13,18–20]. The benefits and risks of drain use makes this a controversial subject [16]. Current literature has questioned the use of pancreatic drains in decreasing the morbidity associated with pancreatic head resections [15,16]. Drains are able to limit proinflammatory effects of the leaking effluent on the surrounding anastomosis. It can also detect early signs of hemorrhage as well as limit postoperative collections that may develop into abscesses that require further treatment. However, drains are also sources of ascending infection, potentially keeping small anastomotic disruptions open and leading to development of wound infections. With studies reporting

* Corresponding author. Taylor Pavilion, Suite D-365 100 Woods Road, Valhalla, NY, 10595, USA.
E-mail address: xiang.dong@wmchealth.org (X.D. Dong).

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significant increases in both morbidity and mortality in the absence of drainage, especially in patients at high risk of POPF, the routine use of pancreatic drains is still recommended in those patients [7,21,22].

There are two types of surgical drains typically employed in pancreatic surgery, passive drains (PDG) and closed suction drains (CSD). PDG can be open or closed while suction drains are typically closed to the atmosphere. The use of drains seems to be an efficient means to empty peripancreatic fluid collections and detect early anastomotic disruptions that can lead to interventions. However, because of surgical practice patterns and negative reviews of its use in other gastrointestinal surgeries such as colorectal and liver resections, there remains controversy in the selection of drain type following pancreatic surgery. The aim of this meta-analysis was to comparatively evaluate the impact of PDG versus CSD on surgical outcomes following pancreaticoduodenectomy.

2. Materials and methods

This systematic review was performed according to the Cochrane Handbook for Systematic Reviews of Interventions [23] and follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Assessing the Methodological Quality of Systematic Reviews (AMSTAR 2) guidelines [24,25]. The protocol of this systematic review was developed prospectively and registered in the International prospective register of systematic reviews PROSPERO: CRD42018112036. The literature search, screening of the records, study selection, extraction and analysis of the data, followed by critical appraisal, were performed by two independent researchers (GM and GS). The research question was formulated within the PICOTS framework as following:

(P) Population: Adults older than 18 years old undergoing pancreatoduodenectomy.

(I) Intervention: PDG (passive drainage to gravity)

(C) Comparator intervention: CSD (closed-suction drainage)

(O) Outcomes: POPF rate, postoperative overall and serious complication rate, intraabdominal collection rate, intraabdominal bleeding rate, incisional surgical site infection rate, postoperative mortality, length of hospital stay.

(T) Time: Short-term.

(S) Setting: Inpatient.

2.1. Eligibility criteria, definitions and endpoints

All experimental and observational clinical studies comparing PDG and CSD after pancreatoduodenectomy for benign and malignant disease were included. Non-comparative descriptive studies; studies comparing any of the interventions of interest to an irrelevant intervention such as no drainage; and review articles were excluded.

POPF was defined according to the 2016 update of the definition and grading by the International Study Group on Pancreatic Surgery [10]. Postoperative complications were classified according to Clavien-Dindo classification [26]. Serious complications were defined as postoperative complications Clavien-Dindo class 3 or higher. Surgical site infections (SSI) were defined according to the Center for Disease Control National Nosocomial Infections Surveillance System [27].

Primary endpoint of this systematic review was POPF rate.

Secondary endpoints included: overall postoperative complication rate, postoperative serious complication rate, intraabdominal fluid collection rate, intraabdominal bleeding rate, surgical site infection, Postoperative mortality, and length of stay (LOS).

2.2. Search strategy and study selection

The Pubmed, EMBASE, and Cochrane Library were systematically searched using the following MeSH terms: ‘suction’, ‘drainage’, ‘pancreas’ combined with the Boolean operator ‘AND’ and all synonyms combined with the Boolean operator ‘OR’. In addition, clinicaltrials.gov was searched for any ongoing studies. Relevant articles were identified, and the results of the search were screened through the title, abstract and/or full text article. The sensitivity of the search strategy was tested by screening the references of included articles for additional publications.

2.3. Data extraction and quality assessment

The data from the included articles were collected to predefined Microsoft Excel tables and studies were assessed for validity by two researchers independently. Quality assessment of each individual study was performed according to Cochrane Handbook for Systematic Reviews of Interventions on the following items: selection, performance, detection, attrition, selective reporting, and other bias risks [23]. Quality assessment of observational studies was performed using Newcastle-Ottawa scale.

2.4. Statistical analysis

Inverse variance method with standardized mean difference (MD) and standard error was employed for continuous variables, whereas Mantel-Haenszel method with odds ratios and 95% confidence intervals (OR (95%CI)) was employed for dichotomous variables. In cases when continuous variables were reported in median and interquartile range in the included studies, mean and standard deviation were estimated using Hozo's formula [28]. Statistical heterogeneity among effect estimates was assessed using Cochran Chi^2 and I^2, and between-study variance was assessed using Tau^2 statistic when the I^2 was 50% or greater [29]. Random-effects model was utilized. The results of the meta-analysis were illustrated on forest plots. To assess clinical significance of the results, relative risk reduction (RRR), absolute risk reduction (ARR) and number needed to treat/harm (NNT) with 95%CI were calculated. Visual assessment of funnel plots, Rosenthal's and Orwin's fail-safe N-tests, Duval and Tweedie's trim and fill test, and Begg and Mazumdar rank correlation tests were utilized to assess publication bias. A p-value < 0.05 was considered statistically significant. Statistical analysis was performed using RevMan (version 5.3; Nordic Cochrane Center, Cochrane Collaboration, Copenhagen, Denmark) and CMA Software (Version 3; Biostat, NJ, USA).

3. Results

3.1. Literature search and study selection

Details of the search strategy are shown in Supplement 1 and details of study selection are presented in the PRISMA flowchart [Fig. 1]. Four searched databases revealed 178 records. Additional six articles were found at clinicaltrials.gov and four were found through the references of eligible studies. Six articles were included after excluding duplicates, irrelevant articles, and articles not reporting the outcome of interest.

3.2. Description of included studies

Six studies were selected among 43 potentially eligible studies [30–35] totaling 1519 patients (806 PDG and 713 CSD). The description of included studies is provided in Table 1. Three studies were randomized controlled trials (RCT) with 1b level of evidence [31–33], whereas the remaining three were observational studies with 2b level of evidence (1 prospective and 2 retrospective cohort studies) [30,34,35]. Four studies included patients undergoing pancreatoduodenectomy only [30,32,33,35], whereas two studies included patients with distal pancreatectomy in addition to those undergoing pancreatoduodenectomy [31,34]. Only patients undergoing pancreatoduodenectomy (n = 1338) were included in this meta-analysis. The primary endpoint in four studies was POPF rate [30–33]. Studies stratified by reported

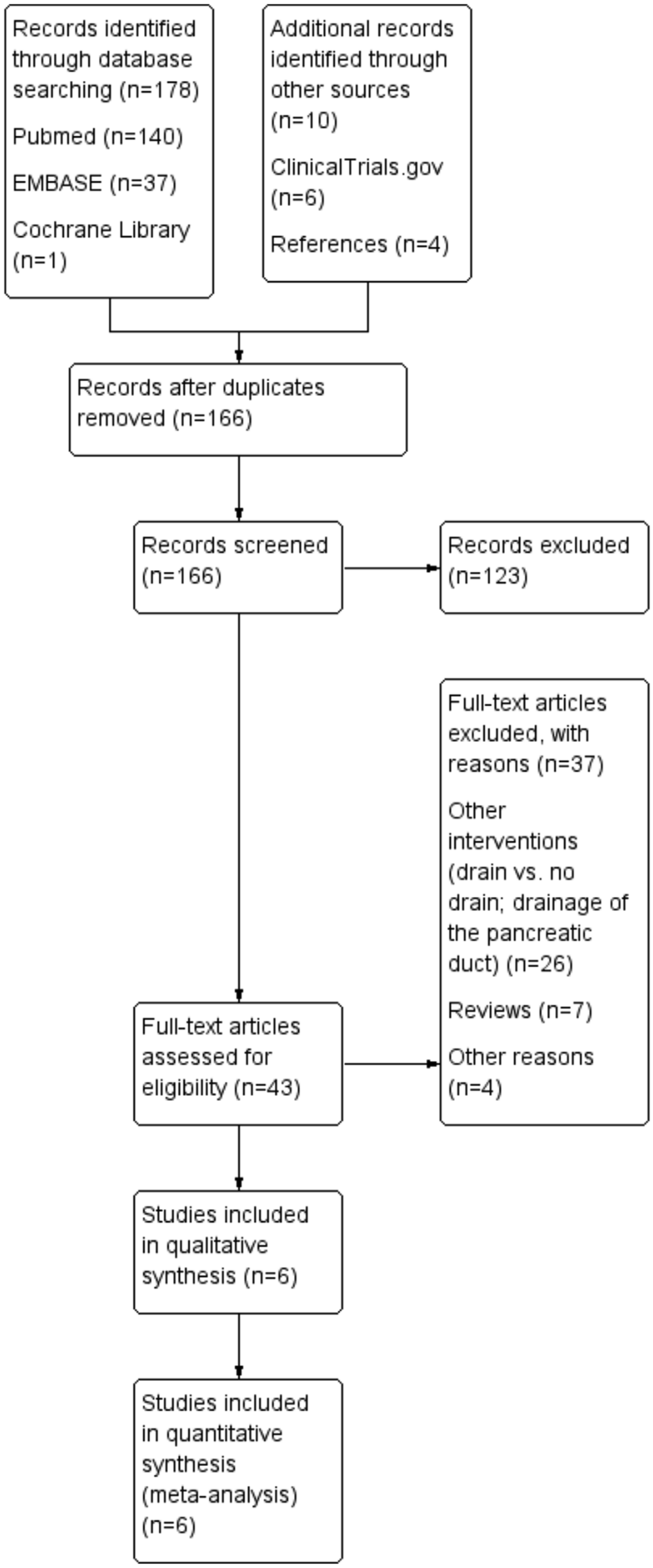

Fig. 1. PRISMA flow diagram.

endpoints are presented in Supplement 2. One of the six included studies was supported by external funding [31].

3.3. Description of study populations and interventions

Patients involved in six included studies were adults from 6

Table 1
Characteristics of included studies.

Author	Publication	Design	Primary endpoint(s)	Sample size (n = 1519)	Type of pancreatic surgery	Number of surgeons	Disease (B/M)	Number of patients in study arms (PDG vs. CSD) (806 vs. 713)	Removal of drains (POD)	NOS scale (S–C–O)	Level of evidence (Oxford CEBM)
Aumont	BMC Surg 2017 [30]	Retrospective cohort study (2012–2015)	POPF rate, POPF severity	197	PD	NR	B + M	132 vs. 65	5	3-2-1	2b
Čečka	Surgery 2018 [31]	Randomized controlled trial (2013–2016)	POPF rate	222	PD, DP	1	B + M	111 vs. 111	Between 4 and 6	N/A	1b
Jiang	Scand J Surg 2016 [32]	Randomized controlled trial (2010–2015)	POPF rate	160	PD	Same team	B + M	78 vs. 82	Between 5 and 7	N/A	1b
Lee	J Hepatobiliary Pancreat Surg 2009 [33]	Randomized controlled trial (2004–2006)	POPF rate	110	PD	NR	NR	55 vs. 55	NR	N/A	1b
Marchegiani	Surgery 2018 [34]	Prospective cohort study (2016–2017)	Bacterial contamination of the drainage fluid	320	PD, DP	Same team	B + M	189 vs. 131	Between 3 and 5	4-2-1	2b
Schmidt	HPB Surg 2009 [35]	Retrospective cohort study (1980–2002)	Different comparison arms[a]	510	PD	12	B + M	241 vs. 269	NR	3-2-1	2b

PDG, passive drain to gravity; CSD, closed-suction drain; POPF, postoperative pancreatic fistula; PD, pancreatoduodenectomy; distal pancreatectomy; POD, postoperative day; NOS, Newcastle-Ottawa score; S, selection; C, comparability; O, outcome; CEBM, Center for Evidence-Based Medicine.
[a] The study compared POPF to non-POPF.

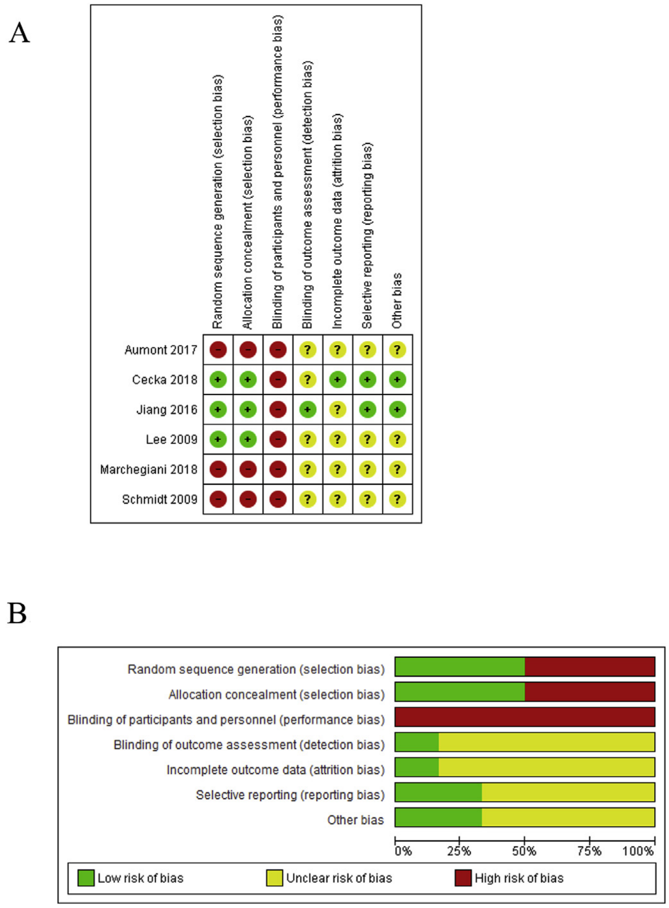

Fig. 2. A. Risk of bias summary. B. Risk of bias graph.

countries (France, Czech Republic, China, Korea, Italy, and USA) (Supplement 3). Five studies included patients with both benign and malignant disease as an indication for surgery [30–32,34,35], whereas in one study the authors did not report indications for pancreatoduodenectomy [33]. In one study all procedures were performed by the same surgeon [31] and in another study by 12 surgeons [35]. Two studies reported that all procedures were performed by the same team [32,34], whereas the remaining two studies did not report the number of involved surgeons [30,33]. Details, such as type and diameter of the drains used, were reported in one study [31]. Time of drain removal was reported by five studies [30–32,34,35] and varied from postoperative day 3 to day 7 (Table 1). Criteria of drain removal reported in included studies were absence of evidence of POPF, bile or intestinal leak.

3.4. Quality assessment

The risk of bias summary and graph of the included studies are presented in Fig. 2. Levels of evidence according to the Oxford Center for Evidence Based Medicine provided by each included study are presented in Table 1. Random sequence generation and allocation concealment to prevent selection bias was provided in 3 included RCTs only [31–33]. The risk of performance and detection bias is high in all studies including RCTs. Preventing performance and detection bias by blinding surgeons to the intervention and assessment of the outcome is impracticable and unethical. Attrition, reporting, and other bias risks are low in most studies.

3.5. Meta-analysis

All six studies regardless of the evidence level and risk of bias were included in the meta-analysis of all studies.

3.5.1. POPF rate

POPF was reported in all studies (702 PDG vs. 636 CSD) [30–35].

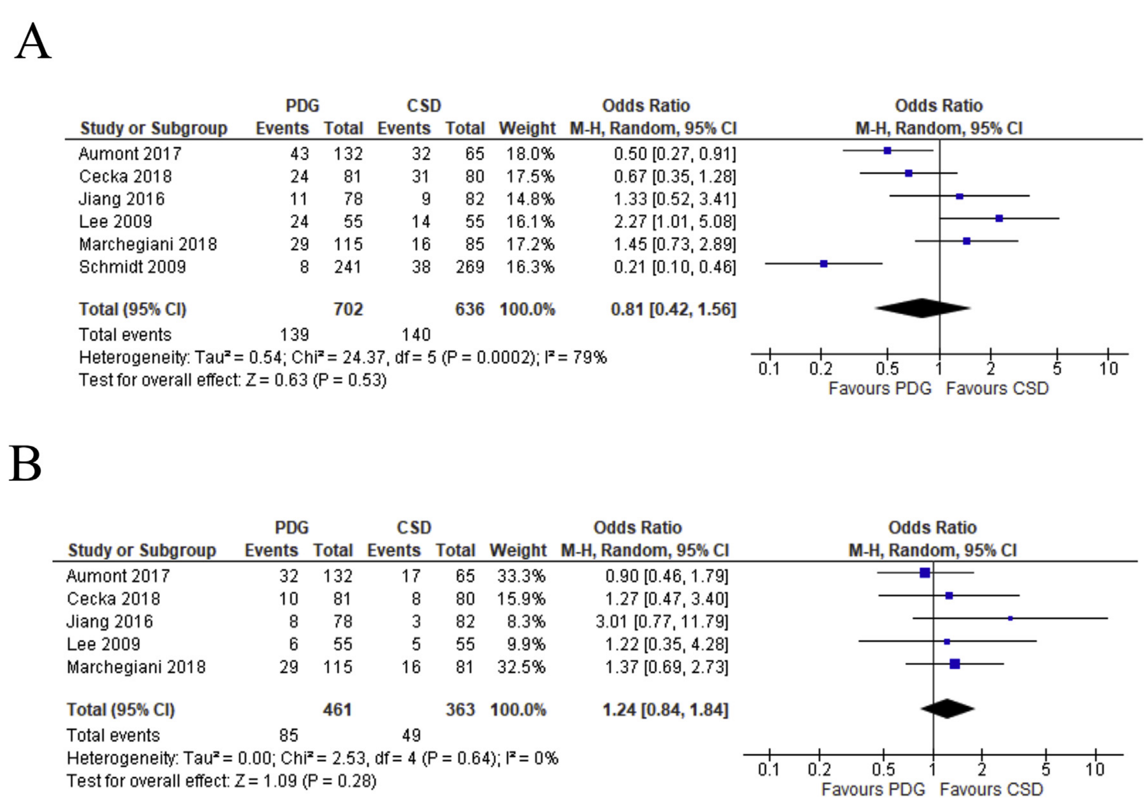

Fig. 3. Meta-analysis of all studies: A. Postoperative pancreatic fistula rates, overall. B. Postoperative pancreatic fistula, grades B & C (clinically relevant).

Table 2
Clinical significance of primary and secondary endpoints in all studies (passive drain to gravity vs. closed-suction drain).

Endpoints	RRR	ARR (95%CI)	NNT (95%CI)
POPF rate	0.10	0.022 (−0.021, 0.066)	46 (> 15.2 to benefit, > 46.4 to harm)
POPF, Grade A rate	0.28	0.044 (−0.003, 0.091)	23 (> 11.0 to benefit, > 305.9 to harm)
POPF, Grade B rate	0.32	0.028 (−0.016, 0.072)	36 (> 13.8 to benefit, > 61.6 to harm)
POPF, Grade C rate	0.44	0.024 (−0.013, 0.060)	43 (> 16.6 to benefit, > 77.2 to harm)
POPF, Grade B&C rate	0.36	0.049 (−0.000, 0.099)	21 (> 10.1 to benefit, > 2030.5 to harm)
Postoperative complication rate	0.10	0.050 (−0.024, 0.123)	21 (> 8.1 to benefit, > 41.3 to harm)
Postoperative serious complication rate	0.41	0.076 (0.005, 0.148)	14 (6.8, 211.0)
Intraabdominal collection rate	0.33	0.055 (−0.011, 0.121)	19 (> 8.3 to benefit, > 88.5 to harm)
Intraabdominal bleeding rate	0.09	0.007 (−0.035, 0.048)	157 (> 21.0 to benefit, > 28.7 to harm)
Incisional SSI rate	0.20	0.019 (−0.033, 0.071)	53 (> 14.2 to benefit, > 30.6 to harm)
Postoperative mortality	0.33	0.017 (−0.018, 0.052)	59 (> 19.2 to benefit, > 55.8 to harm)

RRR, relative risk reduction; ARR, absolute risk reduction; NNT, numbers needed to treat; 95%CI, 95% confidence interval; POPF, postoperative pancreatic fistula.

Statistical among-study heterogeneity was high ($I^2 = 79\%$; $Tau^2 = 0.54$). POPF rate was 19.8% (139/702) in PDG vs. 22% (140/636) in CSD. This difference was neither statistically nor clinically significant [OR (95%CI) = 0.81 (0.42, 1.56); p = 0.53; NNT (95%CI) = 46 (> 15.2 to benefit, > 46.4 to harm)] (Fig. 3A) (Table 2).

Grade A POPF was reported in five studies and appeared to be 11.1% (51/461) in PDG vs. 15.4% (56/363) in CSD with high among-study heterogeneity ($I^2 = 65\%$; $Tau^2 = 0.47$) [30–34]. This difference was neither statistically nor clinically significant [OR (95%CI) = 0.71 (0.33, 1.53); p = 0.39; NNT (95%CI) = 23 (> 11.0 to benefit, > 305.9 to harm)] (Supplement 4) (Table 2).

Grade B POPF was reported in four studies and appeared to be 11.6% (47/406) in PDG vs. 8.8% (27/308) in CSD with low among-study heterogeneity ($I^2 = 0\%$) [30–32,34]. This difference was neither statistically nor clinically significant [OR (95%CI) = 1.23 (0.74, 2.05); p = 0.42; NNT (95%CI) = 36 (> 13.8 to benefit, > 61.6 to harm)] (Supplement 5) (Table 2).

Grade C POPF was reported in four studies and appeared to be 7.9% (32/406) in PDG vs. 5.5% (17/308) in CSD with low among-study heterogeneity ($I^2 = 5\%$) [30–32,34]. This difference was neither statistically nor clinically significant [OR (95%CI) = 1.08 (0.56, 2.09); p = 0.82; NNT (95%CI) = 43 (> 16.6 to benefit, > 77.2 to harm)] (Supplement 6) (Table 2).

Grade B and C POPF, combined as clinically relevant POPF, was reported in five studies and appeared to be 18.4% (85/461) in PDG vs. 13.5% (49/363) in CSD with low among-study heterogeneity ($I^2 = 0\%$) [30–34]. This difference was neither statistically nor clinically significant [OR (95%CI) = 1.24 (0.84, 1.84); p = 0.28; NNT (95%CI) = 21 (> 10.1 to benefit, > 2030.5 to harm)] (Fig. 3B) (Table 2).

3.5.2. Secondary endpoints

Overall postoperative complication rate did not significantly differ [56.9% (231/406) in PDG vs. 51.9% (160/308) in CSD] [OR (95%CI) = 1.03 (0.70, 1.52); p = 0.89] with low among-study heterogeneity ($I^2 = 32\%$) (Fig. 4) (Table 2).

Postoperative serious complication rate did not significantly differ [26.1% (76/291) in PDG vs. 18.5% (42/227) in CSD] [OR (95%CI) = 1.49 (0.55, 4.09); p = 0.43] with high among-study heterogeneity ($I^2 = 73\%$; $Tau^2 = 0.55$) (Supplement 7). However, the difference was found to be clinically significant with the NNT of 14 patients (Table 2).

Intraabdominal collection rate did not significantly differ [22.1% (72/325) in PDG vs. 16.7% (38/228) in CSD] [OR (95%CI) = 1.23 (0.60, 2.51); p = 0.57] with moderate among-study heterogeneity ($I^2 = 44\%$; $Tau^2 = 0.17$) (Supplement 8) (Table 2).

Intraabdominal bleeding rate did not significantly differ [8.1% (33/406) in PDG vs. 8.8% (27/308) in CSD] [OR (95%CI) = 0.89 (0.51, 1.56); p = 0.69] with low among-study heterogeneity ($I^2 = 0\%$) (Supplement 9) (Table 2).

Incisional SSI rate did not significantly differ [10.9% (30/274) in PDG vs. 9% (22/243) in CSD] [OR (95%CI) = 1.18 (0.66, 2.13); p = 0.57] with low among-study heterogeneity ($I^2 = 0\%$) (Supplement 10) (Table 2).

Postoperative mortality rate did not significantly differ [6.9% (28/406) in PDG vs. 5.2% (16/308) in CSD] [OR (95%CI) = 1.07 (0.55, 2.07); p = 0.84] with low among-study heterogeneity ($I^2 = 0\%$) (Supplement 11) (Table 2).

Length of hospital stay did not significantly differ [MD (95%CI) = 0.92 (−0.64, 2.48); p = 0.25] with moderate among-study heterogeneity ($I^2 = 53\%$; $Tau^2 = 1.16$) (Supplement 12) (Table 2).

Several additional endpoints including operating time, intestinal leak, bile leak, reintervention, and readmission rates were reported by two studies only (Supplements 13-17).

3.5.3. Subgroup analysis of experimental studies

The findings of subgroup analysis of experimental studies are presented in Fig. 5. Three RCTs with 1b level of evidence and low overall risk of bias were included. No statistically significant difference was found in overall [OR (95%CI) = 1.22 (0.57, 2.61); p = 0.61; $I^2 = 63\%$, $Tau^2 = 0.29$] (Fig. 5A), grade A [OR (95%CI) = 0.90 (0.30, 2.72); p = 0.85; $I^2 = 73\%$, $Tau^2 = 0.69$] (Supplement 18), and grade B&C [OR (95%CI) = 1.55 (0.79, 3.04); p = 0.20; $I^2 = 0\%$] (Fig. 5B) POPF rates.

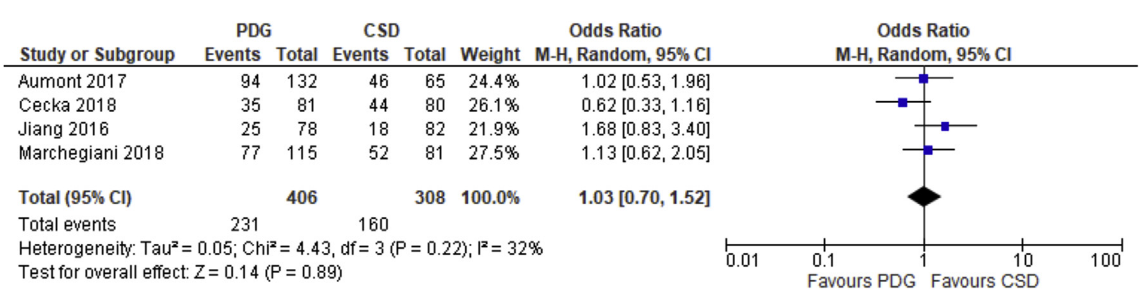

Fig. 4. Meta-analysis of all studies, secondary endpoints: Overall postoperative complication rate.

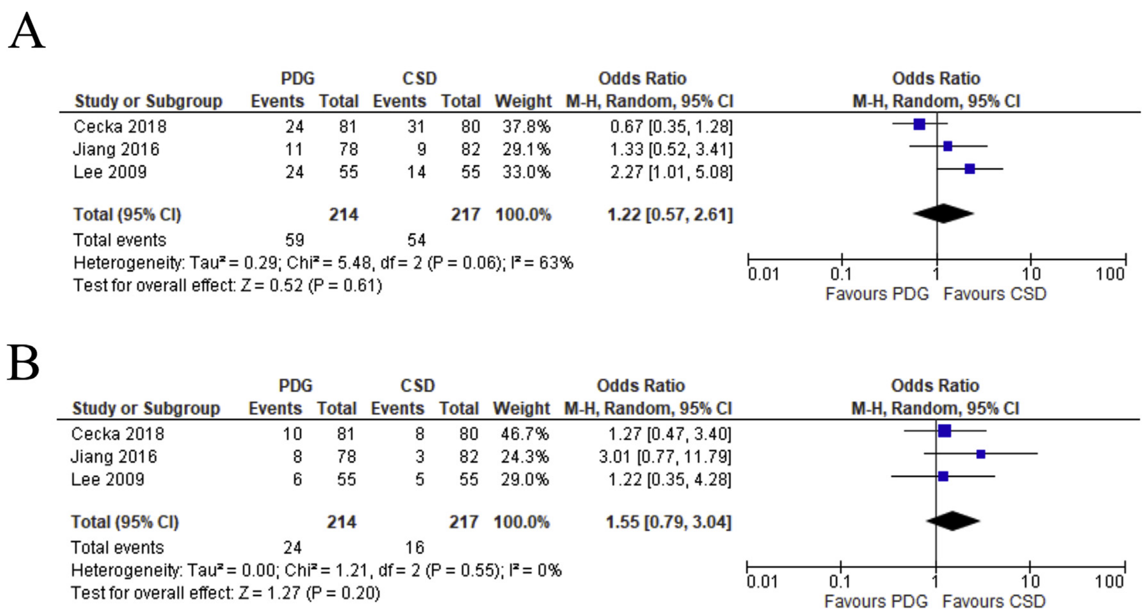

Fig. 5. Subgroup analysis of RCTs: A. Postoperative pancreatic fistula. B. Postoperative pancreatic fistula, grades B & C (clinically relevant).

3.6. Sensitivity analysis and publication bias

A sensitivity analysis of the included observational studies was performed by excluding the studies with the highest risk of bias. This did not affect the findings. Publication bias was evaluated by visual assessment of symmetry on the funnel plot (Fig. 6) and using Egger's test and other tests including Rosenthal's and Orwin's fail-safe N-tests, Duval and Tweedie's trim and fill test, and Begg and Mazumdar rank correlation tests (t = 0.48; p = 0.64) (Supplements 19-22). No publication bias was found.

4. Discussion

The main finding of this meta-analysis was that there was no difference in POPF rates between PDG and CSD following pancreatoduodenectomy. As there was substantial heterogeneity in overall and grade A POPF rates both in meta-analysis of all studies and subgroup analysis of RCTs, no robust conclusions should be drawn. Nonetheless, grade B and C POPF, clinically relevant pancreatic fistula, rates were similar with low statistical among-study heterogeneity allowing robust and clinically sound conclusion. In addition, none of the secondary endpoints differed. Short-term clinical outcomes including overall postoperative complication rate, intraabdominal collection, intraabdominal bleeding, incisional SSI, and postoperative mortality rates demonstrated no difference with low among-study heterogeneity and variance allowing to draw robust conclusions. These findings provide level 1a evidence against such commons beliefs that exist among surgeons as CSD may increase the risk of intraabdominal bleeding, or PDG is insufficient for adequate drainage of peripancreatic collections.

The use of drains to mitigate morbidity associated of pancreatic surgery has been debated [36,37]. Although there are a several randomized controlled trials supporting o drainage following

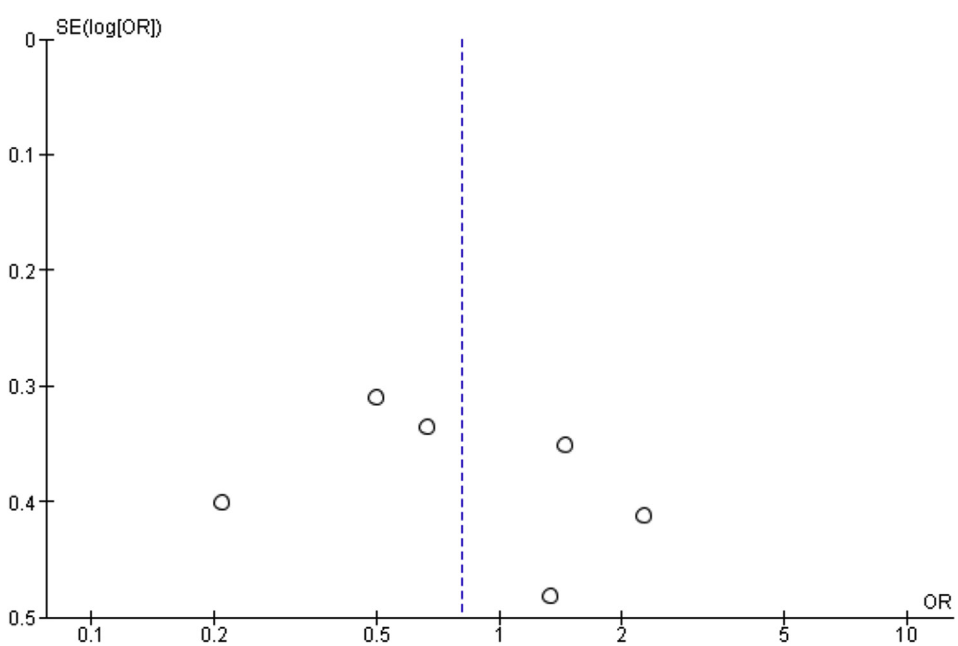

Fig. 6. Meta-analysis of all studies. Postoperative pancreatic fistula rate: funnel plot.

pancreaticoduodenectomy with low POPF rates [38], the selective use of drains with early drain removal based on amylase levels is still practiced by many pancreatic surgeons [38–41].

Both PDG and CSD offer an egress for intraabdominal fluid following surgical interventions. CSD is believed to promote fistula formation or leak in certain types of gastrointestinal surgeries. On the other hand, the drawbacks of PDG are the possibility of retrograde contamination of the abdominal cavity leading to infectious complications [42].

The only available evidence higher than level 1b comprises a meta-analysis concluding that active drain may slightly reduce length of hospital stay. However, only one trial was included in their review and the authors indicated that the level of evidence was of low quality [43]. Hence, this meta-analysis is the first providing level 1a evidence in comparison of the two drainage types.

The strength of this meta-analysis is that it is the first meta-analysis comparing the two types of intraabdominal drainage following pancreatoduodenectomy. Moreover, prospective development and registration of the protocol, rigorous literature search, calculation of absolute and relative risk ratios alongside with NNT are additional strengths.

This meta-analysis does have several limitations. Three out of six included studies had high risk of selection and reporting bias. In spite of the experimental design, all included RCTs were subject to high risk of performance and detection bias. Moreover, all studies reported short-term outcomes. The differences in surgical approaches across the globe and perioperative management contribute further to the heterogeneity and variance across included studies. The lack of details regarding the subtype of passive drains (open or close to atmosphere) adds additional heterogeneity. Although PDG and CSD were standardized in their mechanism of action, the type and diameter of the drains used as well as postoperative day and criteria of removal were not standardized across the studies.

This meta-analysis suggests that either PDG or CSD can be used following pancreatoduodenectomy with no adverse impact on the rates of grade B and C POPF. A post hoc power calculation of the RCT which randomized the largest number of patients undergoing pancreatoduodenectomy only was performed which showed the statistical power of 38%. In order to confirm the absolute difference in percentage points of 3.9% in POPF grade B and C rates between PDG and CSD, an experimental study would require the sample size of 1730 (865 in each arm) to maintain the power of 0.8 and the Type I error risk of 0.05. Considering the above-mentioned absolute difference in the primary endpoint with the involved sample size of 214 and 217 for PDG and CSD, respectively, the number of studies was sufficient to provide moderate evidence.

Further experimental studies powered on the findings of this meta-analysis are needed to determine whether drainage type affects overall and grade A POPF rates. Moreover, further studies should standardize subtypes and sizes of drains used as well as time and criteria of their removal. Either experimental or observational studies including patients with the same disease and evaluating long-term in addition to short-term outcomes would significantly add to the quality of evidence and strength of drawn conclusions and recommendations.

5. Conclusion

This meta-analysis found no difference in short-term clinical outcomes including grade B and C POPF rates, postoperative morbidity and mortality between PDG and CSD. Further randomized controlled trials are needed answer the question of the need for pancreatic drains in the current era, with selective use of either type of drain at the discretion of the surgeon.

Provenance and peer review

Not commissioned, externally peer reviewed.

Data statement

This is a summary design study. Data used for meta-analysis was extracted from previously published papers.

Conflicts of interest

None; Previously copyrighted material- None.

Funding

None.

Ethical approval

Not applicable.

Registration unique identifying number (UIN)

PROSPERO: CRD42018112036.

Author contribution

Study design: Gachabayov M, Gogna S, Latifi R, Dong XD.
Data collection: Gachabayov M, Gogna S, Dong XD.
Data analysis: Gachabayov M, Gogna S, Latifi R, Dong XD.
Writing manuscript: Gachabayov M, Gogna S, Latifi R, Dong XD.
Approved manuscript: Gachabayov M, Gogna S, Latifi R, Dong XD.

Guarantor

Dong XD.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.05.001.

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