

Traumatic complications linked to prophylactic drain placement after hepatectomy: A meta-analysis

*Zhenhao Fei^C, Xingfu Duan^B, Junhua Liang^D, *Zhiwei Sun^A, Jianzhong Tang^{E,F}

Department of Hepatobiliary Pancreatic Surgery, The First People Hospital of Yunnan Province, Kunming, China

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation;

D – writing the article; E – critical revision of the article; F – final approval of the article

Advances in Clinical and Experimental Medicine, ISSN 1899–5276 (print), ISSN 2451–2680 (online)

Adv Clin Exp Med. 2025;34(12):2017–2024

Address for correspondence

Zhiwei Sun

E-mail: zwsun6345@163.com

Funding sources

None declared

Conflict of interest

None declared

*Zhenhao Fei and Zhiwei Sun contributed equally to this article

Received on August 9, 2024

Reviewed on January 24, 2025

Accepted on February 10, 2025

Published online on July 31, 2025

Abstract

Background. Research documenting the results of liver trauma surgery revealed a connection between prophylactic drainage (PD) and escalating infections or septic consequences.

Objectives. Meta-analysis research was conducted to review the wound complications (WCs) frequency of PD in liver resections (LRs).

Materials and methods. Up until June 2024, comprehensive literature study was completed, and 757 related studies were reviewed. The 10 selected studies included 5,459 LRs at the beginning; 2,918 of them were drained and 2,541 were not. The dichotomous approaches and a fixed or random model were used to assess the WCs frequency of PD in LRs using odds ratios (ORs) and 95% confidence intervals (95% CIs).

Results. Prophylactic drainage had significantly higher surgical site wound infection rate (OR = 1.97; 95% CI: 1.09–3.55, $p = 0.02$) compared to non-PD in LR patients, though no significant difference was found among PD and non-PD in LR patients in infected intra-abdominal collections (IIACs; OR = 3.17; 95% CI: 0.93–10.80, $p = 0.07$).

Conclusions. Prophylactic drainage had a considerably greater surgical site wound infection rate, and there was no discernible difference between IIACs and non-PD in LR individuals. Nevertheless, because there were not many studies nominated for comparison in the meta-analysis, care must be used when working with its outcomes, and further research is warranted to confirm these findings.

Key words: liver resections, prophylactic drainage, infected intra-abdominal collections, surgical site wound infection

Cite as

Fei Z, Duan X, Liang J, Sun Z, Tang J. Meta-analysis of the incidence of traumatic complications of prophylactic drainage in hepatectomy. *Adv Clin Exp Med.* 2025;34(12):2017–2024. doi:10.17219/acem/201227

DOI

10.17219/acem/201227

Copyright

Copyright by Author(s)

This is an article distributed under the terms of the Creative Commons Attribution 3.0 Unported (CC BY 3.0) (<https://creativecommons.org/licenses/by/3.0/>)

Highlights

- Meta-analysis of liver resections shows prophylactic drainage (PD) markedly increases surgical-site infection (SSI) risk compared to no drain placement.
- PD does not significantly alter intra-abdominal abscess rates compared with non-PD approaches.
- Limited trial pool and borderline p-values (~ 0.05) temper confidence and signal the need for larger, high-quality studies.
- Surgeons should balance routine PD use against elevated SSI risk when planning liver-resection aftercare.

Background

Franco et al. confirmed in 1989 that prophylactic drainage (PD) was not required following simple liver resections (LRs) and suggested a no-drainage treatment in elective LRs.¹ Patients may experience an accumulation of fluid in the abdominal cavity, referred to as ascites. This may occur due to various factors, including elevated pressure in one of the primary hepatic blood arteries (portal vein).² A physician can prescribe medications to alleviate fluid retention.

The predominant reason for a biliary drain is an obstruction or constriction (stricture) of a bile duct. This results in cholestasis, characterized by the deceleration or cessation of bile flow from the liver.³ Various disorders may lead to bile duct obstruction and cholestasis, including pancreatitis (inflammation of the pancreas). Abdominal drainage is a technique designed to remove fluid from the peritoneal cavity, the area between the abdominal wall and the organs.² Traditionally, in patients undergoing hepatic resection, an abdominal drain is typically placed in the subphrenic or subhepatic space next to the resection surface. This facilitates the alleviation of intra-abdominal pressure caused by ascitic fluid accumulation and enables the observation of postoperative intra-abdominal hemorrhage, in addition to the identification and drainage of any bile leakage. Research documenting the results of liver trauma surgery revealed a connection among PD and escalating infections or septic consequences.² Fang et al. found that there was no indication to support the usual utilization of PD in elective LRs in their meta-analysis of 6 randomized controlled trials (RCTs) comprising 465 persons.³ The studies included in that meta-analysis showed no significant variations in postoperative illness between patients with or without PD.³ Drainage after elective LRs is still frequently utilized in existing practice and appears to be more based on experience than on scientific research. A multi-institutional investigation of 1,041 persons found that 564 of them had drains put at the operator's discretion, with a frequency of utilization of 54%. When compared to the non-drained cohort, the drained cohort showed higher rates of complications, bile leaks and 30-day readmissions.

Objectives

Our goal was to review the routine utilization of PD after LRs by reviewing the most recent research. To compare drained with non-drained patients, a meta-analysis was conducted with the aim to evaluate the wound complications (WCs) frequency of PD in LRs.

Materials and methods

We conducted a meta-analysis to assess studies demonstrating the frequency of WC in PD cases involving LR.⁴

Information sources

Figure 1 characterizes the study selection process. When the inclusion criteria were satisfied, the following literature was included in the study^{5,6}:

1. The investigation was prospective, observational, RCT, or retrospective research.
2. Persons with LRs were the investigated patients.
3. The intervention was PD.
4. The research appraised the effect of PD and non-PD in the management of LRs on surgical site wound infection (SSWI) and infected intra-abdominal collections (IIACs)

Studies that did not evaluate the effect of PD and non-PD in the management of LRs on SSWI and IIACs, and studies with no comparison were also excluded.^{7–9}

Search strategy

Based on the PICOS approach, we identified a search protocol operation and described it as follows: PD was the “intervention” or “exposure”, SSWI and IIACs were the “outcome” and “research design”, and PD was the “population” for people with LRs. The planned research was not restricted in any way.¹⁰

A comprehensive literature search was conducted through June 2024 across the following databases: Google Scholar, Embase, Cochrane Library, PubMed, and Ovid. We used a keyword organization and additional keywords for LRs, PD, IIAC, and SSWI, as shown in Table 1. Duplicate records were removed, and the remaining studies were

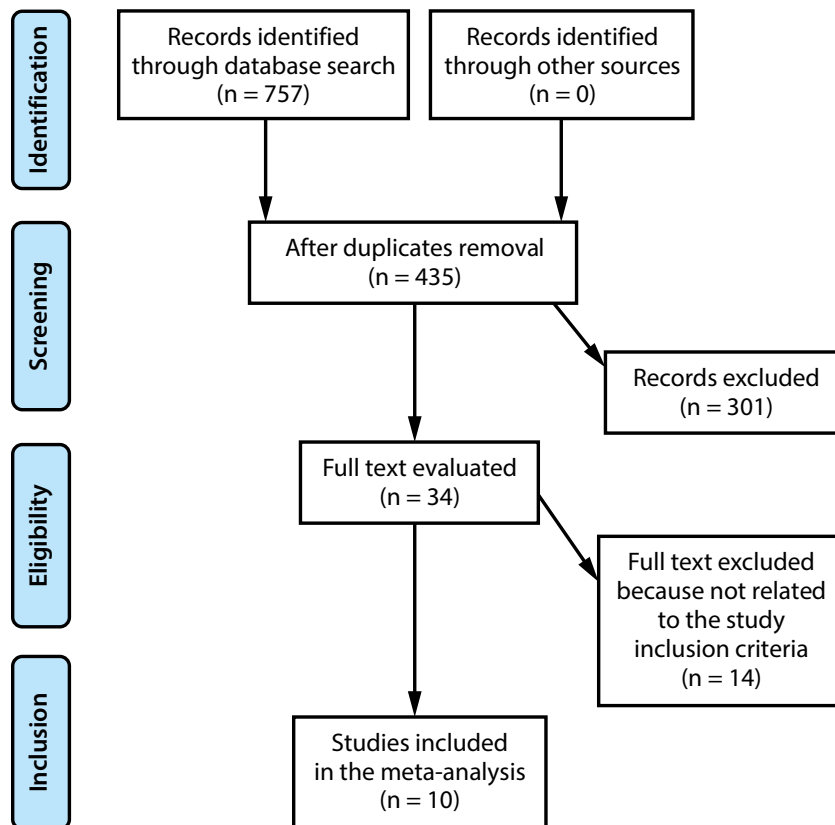


Fig. 1. Flow diagram illustrating the study selection process used in the meta-analysis

Table 1. Search strategy used for each database

Database	Search strategy
PubMed	#1 "liver resections"[MeSH Terms] OR "surgical site wound infection"[MeSH Terms] [All Fields] #2 "infected intra-abdominal collections"[MeSH Terms] OR "prophylactic drainage"[MeSH Terms] [All Fields] #3 #1 AND #2
Embase	#1 'liver resections'/exp OR 'surgical site wound infection' #2 'infected intra-abdominal collections'/exp OR 'prophylactic drainage' #3 #1 AND #2
Cochrane Library	#1 (liver resections):ti,ab,kw (surgical site wound infection):ti,ab,kw (Word variations have been searched) #2 (infected intra-abdominal collections):ti,ab,kw OR (prophylactic drainage):ti,ab,kw (Word variations have been searched) #3 #1 AND #2

compiled into an EndNote library (Clarivate, London, UK). Titles and abstracts were re-evaluated to exclude studies unlikely to contribute meaningfully to the assessment of the association between the frequency of PD in LRs and WCs.¹¹

Selection process

The procedure that followed the epidemiological announcement was then arranged and evaluated using the meta-analysis method.^{12–19}

Data collection process

The data collection criteria included authors' names, study date and year, geographical location, population type, medical and treatment characteristics, study categories,

methods of quantitative and qualitative assessment, data sources, outcome evaluation, and statistical analysis. When the study yielded different results, we separately gathered the data depended on an estimation of the WCs frequency of PD in LRs.

Research risk of bias assessment

We evaluated the methodology of the chosen publications to determine the potential for bias in each analyzed study. The technical quality was assessed utilizing the "risk of bias instrument" from the Cochrane Handbook for Systematic Reviews of Interventions, v. 5.1.0.²⁰ Each study was classified according to the assessment criteria and assigned a corresponding level of risk of bias. The research was classified as having a medium bias risk if 1 or more quality criteria were unmet and as having a low bias risk

if all criteria were satisfied. The research was considered to have a substantial risk of bias if several quality requirements were either completely or partially met.

Effect estimates

Sensitivity analysis was restricted to studies that estimated and characterized the WCs frequency of PD in LR. A subclass analysis was utilized to compare the sensitivity of LR persons with and without PD.

Statistical analyses

A dichotomous approach was used, and either a random-effects or fixed-effects model was applied to calculate the odds ratio (OR) and the corresponding 95% confidence interval (95% CI). The I^2 index was assessed on a scale from 0 to 100%. At 0%, 25%, 50%, and 75% of the data, there was no, low, moderate, and significant heterogeneity, respectively.²¹ To validate the suitability of the chosen model, additional frameworks were analyzed, focusing on those demonstrating a high degree of similarity among the included studies. The random effect model was utilized. A subgroup analysis was conducted by dividing the original estimation into the previously defined consequence groups. A p-value of less than 0.05 meant statistical significance of differences among subgroups.

Reporting bias assessment

We employed Egger's regression test and funnel plots – plotting the logarithm of the ORs against their standard errors (SEs) – to assess publication bias both quantitatively and visually. A $p \geq 0.05$ was interpreted as indicative of no significant publication bias.²²

Certainty assessment

Two-tailed testing was employed to analyze each p-value. Graphs and statistical analyses were generated utilizing Reviewer Manager (RevMan) v. 5.3 (The Nordic Cochrane Centre, Cochrane Collaboration, Copenhagen, Denmark).

Results

Out of 757 relevant studies that met the inclusion criteria, 10 papers published between 1993 and 2021 were selected for analysis.^{23–32} The details of these studies are presented in Table 2. At the outset of the included research, a total of 5,459 LR were analyzed, of which 2,918 were drained and 2,541 were not. The sample sizes of the individual studies ranged from 81 to 1,868 patients.

Prophylactic drainage was associated with a significantly higher risk of superficial surgical SSWI, with OR of 1.97 (95% CI: 1.09–3.55, $p = 0.02$), and substantial heterogeneity among studies ($I^2 = 79\%$), as shown in Fig. 2. However, no statistically significant difference was observed between the PD and non-drainage groups in terms of IIACs, with an OR of 3.17 (95% CI: 0.93–10.80, $p = 0.07$) and no heterogeneity ($I^2 = 0\%$), as illustrated in Fig. 3.

The use of stratified models to assess the effects of specific factors – such as age, gender and ethnicity – on comparative outcomes was not feasible due to insufficient data. The quantitative Egger's regression test and visual inspection of the funnel plots (Fig. 4,5) indicated no evidence of publication bias ($p = 0.86$ and 0.92 , respectively). Nonetheless, selective reporting bias was ruled out, although most of the included RCTs exhibited inadequate procedural quality.

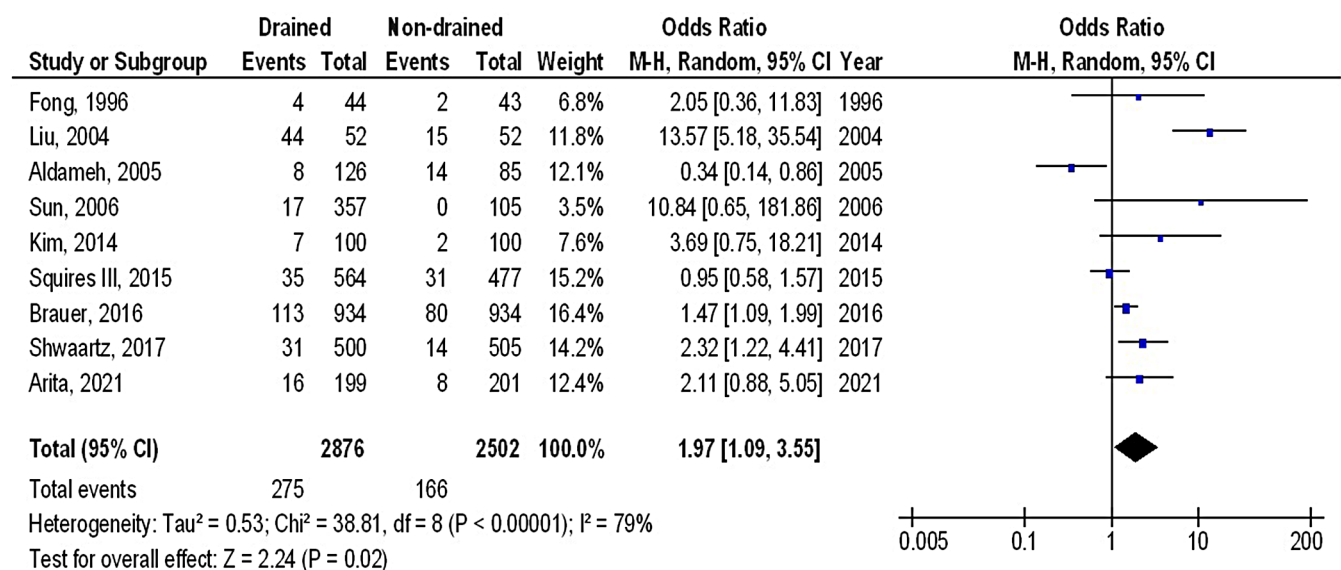


Fig. 2. Forest plot illustrating the effect of prophylactic drainage (PD) compared to no drainage on the incidence of surgical site wound infections (SSWI) following liver resections (LRs)

Table 2. Characteristics of the studies included in the meta-analysis

Research	Country	Total (PD/non-PD)	Major hepatectomy (PD/non-PD)	Ascitic leak (PD/non-PD)	Death (PD/non-PD)	Age [years] (PD/non-PD)
Belghiti et al., 1993 ²³	France	81 (42/39)	14/11	0/1	1/1	47/51
Fong et al., 1996 ²⁴	USA	87 (44/43)	44/43	0/2	2/2	57/57
Liu et al., 2004 ²⁵	China	104 (52/52)	33/29	2/0	0/0	60/58
Aldameh et al., 2005 ²⁶	New Zealand	211 (126/85)	0/0	9/8	3/1	53/52
Sun et al., 2006 ²⁷	China	462 (357/105)	37/44	6/4	0/1	50/49
Kim et al., 2014 ²⁸	South Korea	200 (100/100)	53/55	4/1	0/0	56/54
Squires et al., 2015 ²⁹	USA	1041 (564/477)	190/183	2/3	3/4	54/53
Brauer et al., 2016 ³⁰	USA	1868 (834/934)	200/176	3/2	4/5	60/58
Shwaartz et al., 2017 ³¹	USA	1005 (500/505)	201/210	4/6	3/5	57/60
Arita et al., 2021 ³²	Japan	400 (199/201)	37/44	6/5	6/5	51/50
Total		5,459 (2918/2541)	–	–	–	–

PD – prophylactic drainage.

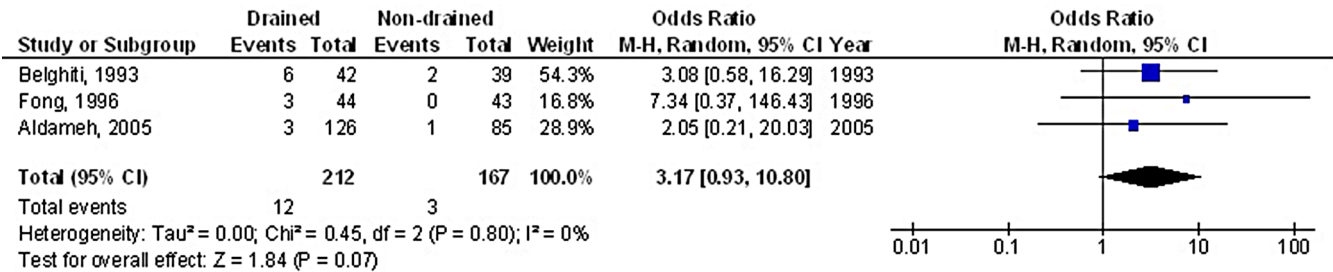


Fig. 3. Forest plot illustrating the effect of prophylactic drainage (PD) compared to no drainage on the incidence of infected intra-abdominal collections (IIACs) following liver resections (LRs)

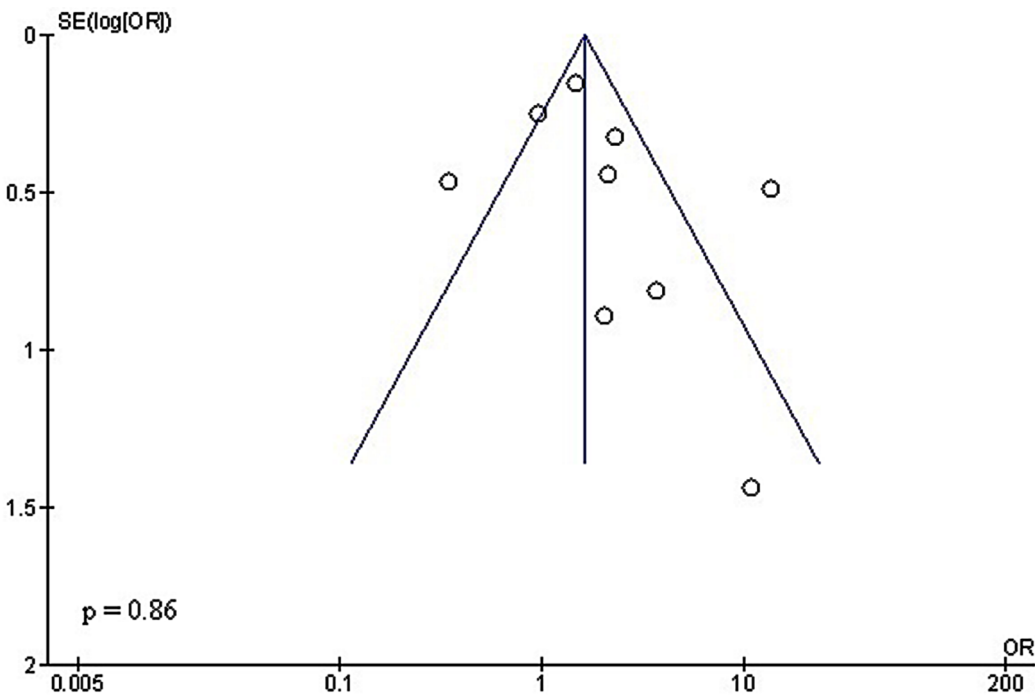


Fig. 4. Funnel plot illustrating the comparison of prophylactic drainage (PD) compared to no drainage on surgical site wound infections (SSWI) following liver resections (LRs)

Discussion

In the studies included in this meta-analysis, a total of 5,459 LR were initially reported. Of these, 2,918

procedures involved the use of PD, while 2,541 were performed without drainage.^{23–32} Each author employed a closed suction drain inserted through a separate stab incision.^{23–32} The use of surgical

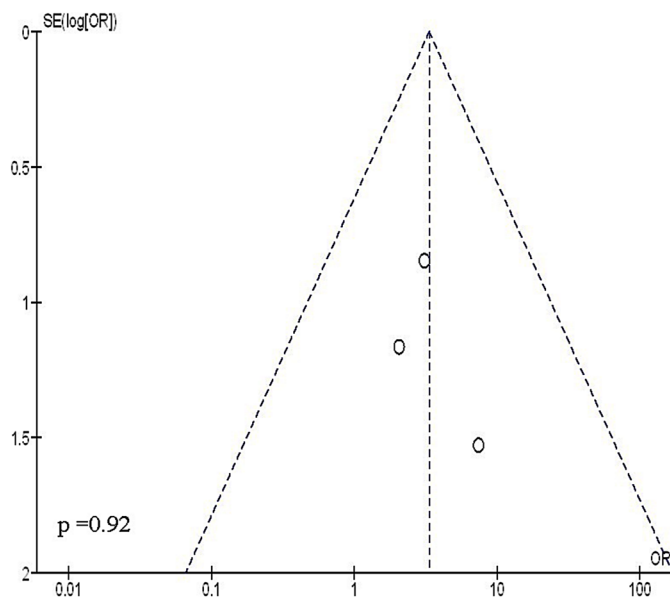


Fig. 5. Funnel plot illustrating the comparison of prophylactic drainage (PD) compared to no drainage on infected intra-abdominal collections (IIACs) following liver resections (LRs)

drains is well-established and based on various assumptions, including the need to monitor potential postoperative complications and to mitigate their effects.³³ Surgeons advocating for routine PD after LR argue that drains can divert ascitic fluid away from the incision, reduce bile leakage, prevent intra-abdominal fluid collections, and enable early detection and quantification of hemorrhage. Nevertheless, a number of authors have expressed concern that drains might raise morbidity.^{29,34} Since some of the research was led prior to the release of the extensively utilized Clavien–Dindo classification, we discovered that the concept of serious problems varies depending on the research.³⁵ Routine ultrasound evaluation of all patients may have contributed to overdiagnosis by detecting clinically insignificant findings that would not have otherwise manifested symptoms or required intervention.³⁶ Only 1 study concluded that ultrasound should be reserved for symptomatic patients, suggesting that routine imaging in asymptomatic individuals may lead to unnecessary interventions or overdiagnosis.³⁶ The findings of this research demonstrated that routine use of drainage did not improve major or secondary outcome measures, and, in fact, was associated with a significantly increased incidence of ascitic leakage. The likelihood of surgical SSWIs varies considerably depending on the type of LR performed, ranging from 9.7% in segmentectomies to 18.3% in trisectionectomies.³⁷ This highlights the importance of maintaining comparable rates of extended LRs across studies. Additionally, the criteria for drain removal varied between studies, further contributing to heterogeneity in outcomes. According to recent research employing the International Study Group of Liver Surgery (ISGLS) standardized definition and grading of bile leakage, drains should be removed on the 3rd postoperative day if the bilirubin concentration

in the drain fluid is less than 3 mg/dL.³⁸ The literature reports that the incidence of bile leakage following LRs ranges from 3.6% to 12%.³⁹ Additionally, another study found no significant difference in bile leakage rates between laparoscopic and open procedures, with reported rates ranging from 4% to 17%.⁴⁰ Given that these conditions could have potentially biased the outcomes in favor of patients who received drains, the absence of a statistically significant difference strongly supports a no-drain strategy.

Limitations

Due to the exclusion of several studies, variability bias may have emerged. However, the eliminated studies failed to satisfy the requisite criteria for inclusion in the meta-analysis. Furthermore, we lacked sufficient information to ascertain whether variables such as gender, race and age impacted the outcomes. The objective of the study was to determine the influence of PD and non-PD on SSWI for LRs management. Bias in this study may have been exacerbated by the inclusion of incomplete or erroneous data from previous research. Additionally, individual factors such as age, gender, race, and nutritional status likely contributed to variability and potential confounding. The absence of data on these variables limits subgroup analysis and may distort the results. Furthermore, the exclusion of unpublished studies and grey literature introduces a risk of publication bias, potentially skewing the overall findings.

Conclusions

Further research is essential. This need has also been emphasized in previous studies that showed comparable effect estimates using similar meta-analytic approaches. Future investigations should aim to address current data limitations, reduce heterogeneity and incorporate standardized methodologies to improve the reliability and generalizability of the findings.^{41–44} People who underwent LRs with PD had a significantly higher rate of SSWIs compared to those without PD. However, there was no statistically significant difference between the PD and non-PD groups in terms of IIACs. It is important to interpret these results cautiously, as the meta-analysis included a limited number of studies for some comparisons. In particular, the low p-value observed for IIACs may affect the reliability and statistical significance of the findings.

Consent for publication

Not applicable.

Use of AI and AI-assisted technologies

Not applicable.

ORCID iDs

Zhiwei Sun  <https://orcid.org/0009-0005-7246-5960>

References

1. Franco D, Karaa A, Meakins JL, Borgonovo G, Smadja C, Grange D. Hepatectomy without abdominal drainage: Results of a prospective study in 61 patients. *Ann Surg*. 1989;210(6):748–750. doi:10.1097/0000658-198912000-00009
2. Noyes LD, Doyle DJ, McSwain NE. Septic complications associated with the use of peritoneal drains in liver trauma. *J Trauma*. 1988;28(3):337–346. doi:10.1097/00005373-198803000-00009
3. Fang Y, Gurusamy KS, Wang Q, et al. Meta-analysis of randomized clinical trials on safety and efficacy of biliary drainage before surgery for obstructive jaundice. *Br J Surg*. 2013;100(12):1589–1596. doi:10.1002/bjs.9260
4. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: A proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *JAMA*. 2000;283(15):2008–2012. doi:10.1001/jama.283.15.2008
5. Elshazly H. Effectiveness of postoperative systemic antibiotic prophylaxis following cardiovascular implantable electronic device implantation: A systematic review and meta-analysis. *Int J Clin Med Res*. 2024;2(5):144–154. doi:10.61466/ijcmr2050001
6. Giong Z, Lie N. A meta-analysis of the impact of a phosphate-specific diet on serum phosphate levels in people receiving hemodialysis. *Int J Clin Med Res*. 2024;2(4):135–142. doi:10.61466/ijcmr2040005
7. Jiany L, Xiu W. A meta-analysis evaluated the effectiveness of Chinese herbal medicine as a supplement to conventional care for patients with diabetic foot ulcers. *Int J Clin Med Res*. 2024;2(4):116–123. doi:10.61466/ijcmr2040003
8. Weang Z. A meta-analysis examining the impact of antibiotic prophylaxis on surgical site wound infection during third molar surgery. *Int J Clin Med Res*. 2024;2(4):127–134. doi:10.61466/ijcmr2040004
9. Gu R, Xu G. A meta-analysis looking at the effects of continuous management for complications related to intraoperative pressure wound ulcers in women with breast cancer. *Int J Clin Med Res*. 2024;2(4):100–106. doi:10.61466/ijcmr2040001
10. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Med*. 2009;6(7):e1000100. doi:10.1371/journal.pmed.1000100
11. Koang Y. A meta-analysis on the use of photobiomodulation to regulate gingival wound healing in addition to periodontal therapies. *Int J Clin Med Res*. 2024;2(4):107–115. doi:10.61466/ijcmr2040002
12. Guo Y. Effect of resident participation in ophthalmic surgery on wound dehiscence: A meta-analysis. *Int J Clin Med Res*. 2024;2(2):50–56. doi:10.61466/ijcmr2020002
13. Zangeneh A, Zangeneh MM. The application of negative pressure wound treatment in oncoplastic breast surgery. *Int J Clin Med Res*. 2023;2(1):21–26. doi:10.61466/ijcmr2010003
14. Emad M, Osama H, Rabea H, Saeed H. Dual compared with triple antithrombotics treatment effect on ischemia and bleeding in atrial fibrillation following percutaneous coronary intervention: A meta-analysis. *Int J Clin Med Res*. 2023;1(2):77–87. doi:10.61466/ijcmr1020010
15. Osama H, Saeed H, Nicola M, Emad M. Neuraxial anesthesia compared to general anesthesia in subjects with hip fracture surgery: A meta-analysis. *Int J Clin Med Res*. 2023;1(2):66–76. doi:10.61466/ijcmr1020009
16. Sundaresan A. Wound complications frequency in minor technique gastrectomy compared to open gastrectomy for gastric cancer: A meta-analysis. *Int J Clin Med Res*. 2023;1(3):100–107. doi:10.61466/ijcmr1030012
17. Singh RK. A meta-analysis of the impact on gastrectomy versus endoscopic submucosal dissection for early stomach cancer. *Int J Clin Med Res*. 2023;1(3):88–99. doi:10.61466/ijcmr1030011
18. Amin MA. A meta-analysis of the eosinophil counts in the small intestine and colon of children without obvious gastrointestinal disease. *Int J Clin Med Res*. 2023;1(1):1–8. doi:10.61466/ijcmr1010001
19. Shaaban EA, Mohammed IE. Determining the efficacy of N-acetyl cysteine in treatment of pneumonia in COVID-19 hospitalized patients: A meta-analysis. *Int J Clin Med Res*. 2023;1(2):36–42. doi:10.61466/ijcmr1020006
20. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, eds. *Cochrane Handbook for Systematic Reviews of Interventions*. 2nd ed. Chichester, UK: Wiley & Sons; 2019. doi:10.1002/9781119536604
21. Perazzo H, Castro R, Luz PM, et al. Effectiveness of generic direct-acting agents for the treatment of hepatitis C: Systematic review and meta-analysis. *Bull World Health Organ*. 2020;98(3):188–197K. doi:10.2471/BLT.19.231522
22. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327(7414):557–560. doi:10.1136/bmj.327.7414.557
23. Belghiti J, Kabbej M, Sauvanet A, Vilgrain V, Panis Y, Fekete F. Drainage after elective hepatic resection: A randomized trial. *Ann Surg*. 1993;218(6):748–753. doi:10.1097/0000658-199312000-00008
24. Fong Y, Brennan MF, Brown K, Heffernan N, Blumgart LH. Drainage is unnecessary after elective liver resection. *Am J Surg*. 1996;171(1):158–162. doi:10.1016/S0002-9610(99)80092-0
25. Liu CL, Fan ST, Lo CM, et al. Abdominal drainage after hepatic resection is contraindicated in patients with chronic liver diseases. *Ann Surg*. 2004;239(2):194–201. doi:10.1097/01.sla.0000109153.71725.8c
26. Anweier N, Apaer S, Zeng Q, et al. Is routine abdominal drainage necessary for patients undergoing elective hepatectomy? A protocol for systematic review and meta-analysis. *Medicine (Baltimore)*. 2021;100(6):e24689. doi:10.1097/MD.00000000000024689
27. Sun HC, Qin LX, Lu L, et al. Randomized clinical trial of the effects of abdominal drainage after elective hepatectomy using the crushing clamp method. *Br J Surg*. 2006;93(4):422–426. doi:10.1002/bjs.5260
28. Kim YI, Fujita S, Hwang VJ, Nagase Y. Comparison of abdominal drainage and no-drainage after elective hepatectomy: A randomized study. *Hepatogastroenterology*. 2014;61(131):707–711. PMID:26176061.
29. Squires MH, Lad NL, Fisher SB, et al. Value of primary operative drain placement after major hepatectomy: A multi-institutional analysis of 1,041 patients. *J Am Coll Surg*. 2015;220(4):396–402. doi:10.1016/j.jamcollsurg.2014.12.029
30. Brauer DG, Nywening TM, Jaques DP, et al. Operative site drainage after hepatectomy: A propensity score matched analysis using the American College of Surgeons NSQIP Targeted Hepatectomy Database. *J Am Coll Surg*. 2016;223(6):774–783e2. doi:10.1016/j.jamcollsurg.2016.09.004
31. Shwaartz C, Fields AC, Aalberg JJ, Divino CM. Role of drain placement in major hepatectomy: A NSQIP analysis of procedure-targeted hepatectomy cases. *World J Surg*. 2017;41(4):1110–1118. doi:10.1007/s00268-016-3750-4
32. Arita J, Sakamaki K, Saiura A, et al. Drain placement after uncomplicated hepatic resection increases severe postoperative complication rate: A Japanese multi-institutional randomized controlled trial (ND-trial). *Ann Surg*. 2021;273(2):224–231. doi:10.1097/SLA.0000000000004051
33. Liu X, Chen K, Chu X, Liu G, Yang Y, Tian X. Prophylactic intra-peritoneal drainage after pancreatic resection: An updated meta-analysis. *Front Oncol*. 2021;11:658829. doi:10.3389/fonc.2021.658829
34. Burt BM, Brown K, Jarnagin W, DeMatteo R, Blumgart LH, Fong Y. An audit of results of a no-drainage practice policy after hepatectomy. *Am J Surg*. 2002;184(5):441–445. doi:10.1016/S0002-9610(02)00998-4
35. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240(2):205–213. doi:10.1097/01.sla.0000133083.54934.ae
36. Gurusamy KS, Samraj K, Davidson BR. Routine abdominal drainage for uncomplicated liver resection. *Cochrane Database Syst Rev*. 2007;3:CD006232. doi:10.1002/14651858.CD006232.pub2
37. Moreno Elola-Olaso A, Davenport DL, Hundley JC, Daily MF, Gedaly R. Predictors of surgical site infection after liver resection: A multicentre analysis using National Surgical Quality Improvement Program data. *HPB (Oxford)*. 2012;14(2):136–141. doi:10.1111/j.1477-2574.2011.00417.x
38. Yamazaki S, Takayama T, Moriguchi M, et al. Criteria for drain removal following liver resection. *Br J Surg*. 2012;99(11):1584–1590. doi:10.1002/bjs.8916
39. Erdogan D, Busch ORC, Van Delden OM, Rauws EAJ, Gouma DJ, Van Gulik TM. Incidence and management of bile leakage after partial liver resection. *Dig Surg*. 2008;25(1):60–66. doi:10.1159/000118024

40. Jin S, Fu Q, Wuyun G, Wuyun T. Management of post-hepatectomy complications. *World J Gastroenterol*. 2013;19(44):7983–7991. doi:10.3748/wjg.v19.i44.7983
41. Hajibandeh S, Hajibandeh S, Raza SS, Bartlett D, Dasari BVM, Sutcliffe RP. Abdominal drainage is contraindicated after uncomplicated hepatectomy: Results of a meta-analysis of randomized controlled trials. *Surgery*. 2023;173(2):401–411. doi:10.1016/j.surg.2022.10.023
42. Mori H, Maehira H, Nitta N, et al. Clinical impact of various drain-fluid data for the postoperative complications after hepatectomy: Criteria of prophylactic drain removal on postoperative day 1. *Langenbecks Arch Surg*. 2024;409(1):209. doi:10.1007/s00423-024-03401-0
43. Dezfouli SA, Ünal UK, Ghamarnejad O, et al. Systematic review and meta-analysis of the efficacy of prophylactic abdominal drainage in major liver resections. *Sci Rep*. 2021;11(1):3095. doi:10.1038/s41598-021-82333-x
44. Gavriilidis P, Hidalgo E, de'Angelis N, Lodge P, Azoulay D. Re-appraisal of prophylactic drainage in uncomplicated liver resections: A systematic review and meta-analysis. *HPB (Oxford)*. 2017;19(1):16–20. doi:10.1016/j.hpb.2016.07.010