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Review Article

The Impacts of Negative Pressure Wound Therapy on Patients with Cancer Surgical Wounds: Systematic Review and Meta-Analysis

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SUMMARY

Background: Cancer is a prevalent medical condition that frequently requires surgical intervention. As a result, the management of surgical wounds in cancer patients becomes a pivotal aspect of nursing care. This meta-analysis explores the effects of negative pressure wound therapy (NPWT), a cutting-edge wound management technique, on healing outcomes in cancer-related surgical wounds.
Methods: This systematic review and meta-analysis included randomized clinical trials comparing NPWT with standard wound care in cancer patients. Key outcomes assessed were surgical site infection (SSI), seroma formation, and hospital readmission. Only trials that reported these outcomes in cancer-related surgical wounds were considered eligible.
Results: A total of 10 randomized trials involving 1,322 patients with surgical wounds were included in the analysis. Across all cancer types, NPWT did not demonstrate statistically significant advantages compared to conventional wound care in reducing: Surgical site infections: $p = 0.11$; Seroma formation: $p = 0.38$; Hospital readmissions: $p = 0.68$. However, subgroup analysis revealed a notable exception: NPWT significantly reduced the incidence of surgical site infections in colorectal cancer patients ($p = 0.0002$).
Conclusion: The findings suggest that NPWT may offer targeted benefits, particularly for colorectal cancer patients, by lowering the risk of postoperative infections. However, for other cancer types, NPWT did not demonstrate significant improvements in SSI, seroma, or hospital readmission rates compared to standard care. This highlights the need for further research to determine the contexts in which NPWT can be most beneficial in cancer wound management.

1. Introduction

Cancer represents a significant challenge to healthcare systems worldwide, exerting a profound influence on public health outcomes. Surgical intervention remains a cornerstone of treatment for many types of cancer, making postoperative wound care a critical area of focus for clinical staff to minimize the risk of complications.[1,2] Effective management of these wounds is essential to ensure smooth recovery and reduce the chances of adverse events.

Despite the widespread use of standard wound care techniques, such as regular dressing changes, these methods come with limitations.[3,4] For example, frequent dressing changes not only increase the risk of disrupting the wound healing process but also add to the workload of nursing staff, straining healthcare resources.[5] The experimental and advanced wound care method might be necessary under such a kind of situation.

One such advanced technique is negative pressure wound therapy (NPWT), which may offer several advantages over conventional dressings in the management of open wounds. These benefits include lower treatment costs, faster wound healing, and a reduced risk of complications.[6–8] A Cochrane review by Dumville et al.[9] reported no significant difference in outcomes between NPWT and other alternative wound care methods, raising questions about its broad applicability. In contrast, another review suggested that NPWT can significantly lower the risk of surgical site infections (SSI) and other wound-related complications in patients with cancer-related surgical wounds, without increasing the risk of cancer recurrence.[6] A large non-randomized study focusing on patients who underwent abdomino-perineal resection found that NPWT significantly reduced wound-related complications, particularly by lowering the incidence of SSI following resection.[10] However, randomized controlled trials (RCTs) have not consistently demonstrated such benefits across various cancer types and surgeries. For instance, Andrianello et al.[11] reported that NPWT was not associated with a significant reduction in non-organ-space SSI, highlighting its limited impact in certain surgical scenarios. Similarly, De Rooij et al.[12] found that NPWT did not meaningfully reduce postoperative wound complications in breast cancer patients following mastectomy. In the same trial, NPWT also failed to lower the incidence of seroma formation or decrease hospital readmission rates.

However, contrasting evidence has emerged from another RCT involving breast cancer patients. This study found that NPWT significantly decreased wound complications within one year of immedi-

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ate breast reconstruction surgery,[13] suggesting that specific surgical contexts may influence NPWT's effectiveness.

In other cancer types, NPWT has shown limited benefits. For example, it did not demonstrate any significant impact on short-term or long-term postoperative complications in pancreatic cancer patients.[14] Additionally, an RCT with a relatively large sample size in gynecological cancer patients found that NPWT had no influence on postoperative outcomes following laparotomy.[15] In contrast, the use of NPWT in colorectal cancer patients has shown promising results. An RCT involving high-risk patients undergoing open surgery reported a significant reduction in both surgical site infections and seroma formation.[16] Similar findings were echoed in another RCT on colorectal cancer patients after ileostomy, reinforcing NPWT's potential in this specific patient group.[17] Given these mixed findings, the role of NPWT in cancer surgical wound management remains an open question. While NPWT seems to offer targeted benefits in specific cancer types — particularly in colorectal cancer — its effectiveness in other contexts appears inconsistent. This divergence in outcomes highlights the need for further research to clarify the conditions under which NPWT provides optimal value. Identifying patient subgroups and surgical scenarios where NPWT can be most beneficial will be crucial to improving postoperative care for cancer patients.

This systematic review and meta-analysis aim to evaluate the therapeutic impact of NPWT compared to standard wound care in patients undergoing cancer-related surgeries. The central hypothesis is that NPWT may offer significant benefits, particularly by reducing the risk of SSI, seroma formation, and hospital readmission rates. These advantages are believed to stem from NPWT's potential to minimize postoperative complications, promoting more effective healing after cancer surgery or tumor resection. To enhance the robustness and reliability of the findings, the review focused exclusively on RCTs within this field. By narrowing the scope to high-quality RCTs, the authors sought to provide stronger evidence regarding NPWT's efficacy in improving clinical outcomes for cancer surgical wounds.

2. Methods

2.1. Eligibility criteria

The target population for this meta-analysis consists of patients with cancer-related surgical wounds. The primary intervention under investigation is NPWT, with a comparison made to standard wound care in RCTs. The analysis focused on calculating odds ratios (OR) for three key outcomes: SSI, Seroma formation, Hospital readmission, The inclusion criteria for studies were as follows: RCTs evaluating postoperative outcomes in patients with cancer-related surgical wounds. Trials reporting data on odds ratios for SSI, seroma, and hospital readmission after NPWT vs. standard wound care. Only studies following a randomized design were included. Studies published in English and indexed in Science Citation Index (SCI) journals within the selected databases were eligible.

2.2. Information sources

To include the RCTs for the influences of NPWT to the risk of surgical site infection, seroma, and hospital readmission in the patients with cancer surgical wounds. The authors performed the literature search and selection within the Cochrane Central Register of Controlled Trials (CENTRAL), Google scholar, ScienceDirect, PubMed, Web of Science, EmBase, and Scopus databases.

2.3. Search strategy

In this meta-analysis, a comprehensive keyword search was conducted to identify relevant RCTs. Search terms included "negative pressure wound therapy", "negative pressure wound treatment", "cancer", "surgery", "surgical wounds", "infection", "surgical site", "seroma", "hospital", "readmission", "re-hospitalization", "hospitalization", "postoperative", "after surgery", "complications", "randomized", "clinical", "controlled", "trial", "outcome", "comparison", "versus", "treatment", "control". The search engine protocol was cance* OR malignan* OR neoplas* OR (post AND opera*) OR (re* AND admiss*) OR surg* OR surgical sit* OR infect* OR hospitali* OR serom* OR complica* OR woun*, "negative pressure wound*", OR nega* OR pressu* OR treat* OR thera* OR contro* OR versu* OR comparis* "randomized studies" OR "randomized clinical trials" OR "randomised studies" OR "randomized clinical trials" OR randomi* OR clinica* OR tria*) OR "risk"), OR ("odds" AND "ratio*")) OR ("case" AND "control*")). The related studies published or e-published online before May 2024 were enrolled into our systematic review and meta-analysis. The literature survey ended on April 30, 2024. The listed authors of this meta-analysis all participated the study and have meetings to discuss the progress of this project. The article screening process was conducted by MJ and ZX based on the eligible criteria.

2.4. The selection process, data collection process, and data items

MJ and ZX collected the following data. (1) The events of surgical site infection and subject number of NPWT vs. control wound care for the patients with cancer surgical wounds. The subgroup analysis of different categories of cancer was also performed to find which kind of cancer may have the significant benefits from NPWT. (2) The postoperative seroma complications events and subject number of NPWT vs. control wound care for the patients with cancer surgical wounds. (3) The postoperative hospital readmission events and subject number of NPWT vs. control wound care for the patients with cancer surgical wounds. The rationale to collect these data was that we wanted to find the impacts of NPWT on the patients with cancer surgical wounds in the above 3 outcome dimensions. MJ and ZX independently evaluated the title and abstracts at first, and then the full text version of the selected citations. It is a double screening process. MJ and ZX reviewed the text, tables, and figures of the enrolled articles to extract the focused parameters independently. The disagreements were noted and resolved by discussing and reaching a consensus. MJ and ZX reached a strong agreement (kappa = 0.9) for the collected data, and reviewing the final results was conducted by all listed authors. MJ and ZX used the GRADE (grading of recommendations, assessment, development, and evaluation) approach to assess the certainty of evidence.

2.5. Effect measures and synthesis methods

MJ and ZX performed the following meta-analysis process according to the Cochrane Collaboration Review Manager Software Package (Rev Man Version 5.4). For the surgical site infection (including subgroup analysis of different cancer categories), seroma, and hospital readmission, the pooled estimates of OR were generated. The Mantel-Haenszel RR using DerSimonian and Laird's random-effect models were applied by using the summary statistics. The risk estimates of individual studies were combined via the variance weighted averages in the random-effects model. The NPWT and control wound care were compared to each other to find if NPWT will be superior in the decreasing the events of surgical site infection (including subgroup analysis of different cancer categories), seroma, and hospital readmission.

2.6. Reporting bias assessment

In assessing reporting bias, the authors performed the systematic review and meta-analysis based on the Cochrane Handbook for Systematic Reviews and Interventions.[18] The risk of bias was assessed using the Revised Cochrane Risk of Bias Tool for Randomized Trials (RoB2) to evaluate potential biases across several dimensions.[19] Furthermore, the results were reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[20] This rigorous methodology reinforces the reliability and transparency of the findings, ensuring the integrity of the meta-analysis.

3. Results

3.1. Study selection and study characteristics

Our selection process was presented as the PRISMA flow chart in Figure 1. Finally, ten eligible studies with 624 patients under NPWT and 698 patients under control wound care were included[11–17,21–23] (Table 1).

3.2. Risk of bias in studies

The authors presented the risk of bias assessment of the included studies in Figure 2.

3.3. Results of individual studies and syntheses

3.3.1. The impacts of NPWT on patients with cancer surgical wounds: surgical site infection

In the random effects model, the authors failed to find significant OR of surgical site infection of the included 10 studies of NPWT vs. control wound care ($Z = 1.62$, $p = 0.11$). A substantial heterogeneity was noted ($Tau^2 = 0.23$; $Chi^2 = 16.65$, $p = 0.05$; $I^2 = 46\%$). However, the subgroup analysis found a significant reduction of OR in the subgroup patients with colorectal cancer surgical wounds [90 participants in the NPWT group vs. 96 participants in the control group, 0.19, 95% confidence interval (CI): 0.08–0.45, $Z = 3.73$, $p = 0.0002$]. A low heterogeneity was noted ($Tau^2 = 0.00$; $Chi^2 = 0.43$, $p = 0.93$; $I^2 = 0\%$) (Figure 3). However, the results should be interpreted with caution. No significant findings of OR of surgical site infection in patients with other subgroups of cancer surgical wounds, such as pancreatic cancer category (200 participants in the NPWT group vs. 210 participants in the control group) or gynecological cancer category (334 participants in the NPWT group vs. 392 participants in the control group).

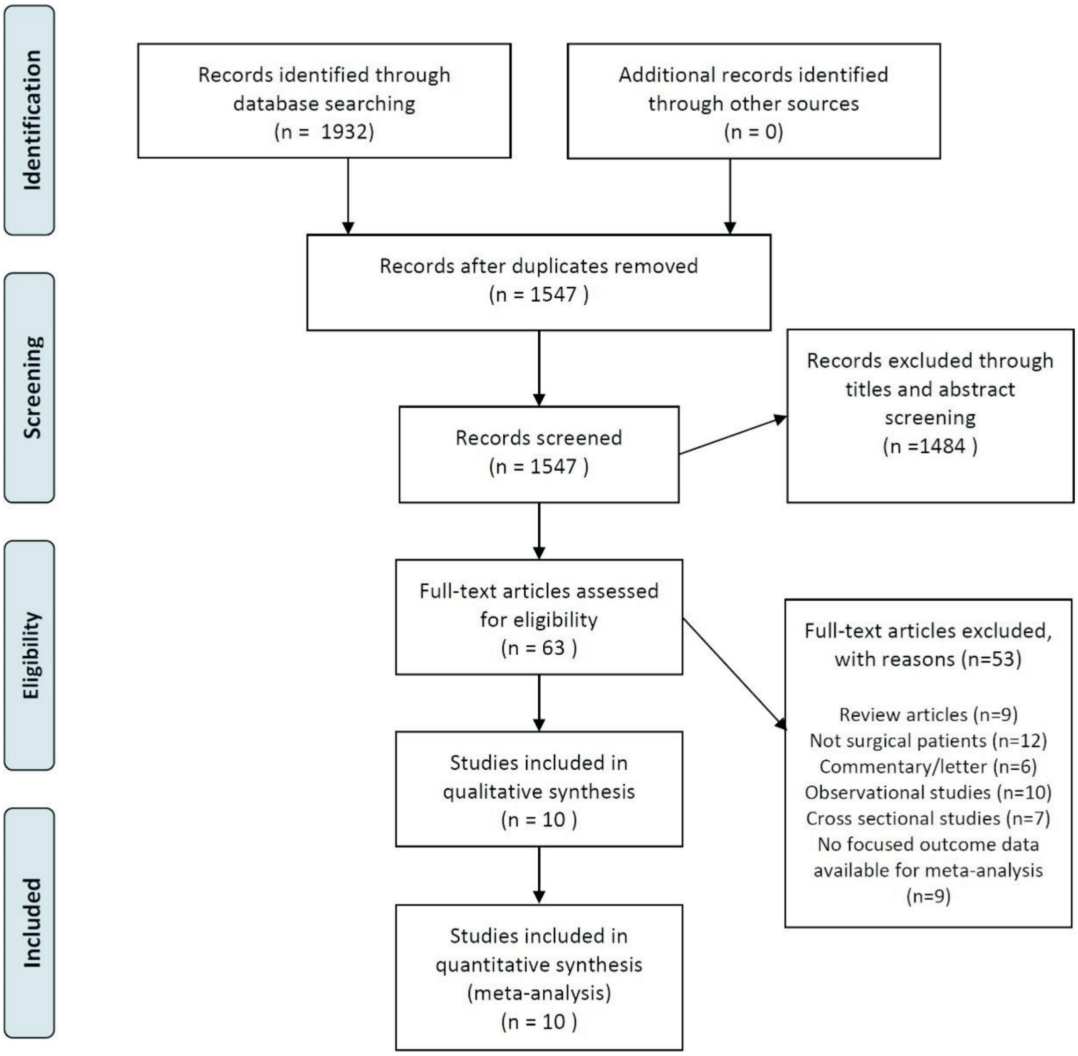

Figure 1. The study selection flowchart under PRISMA criteria. The selection, exclusion, qualitative, and quantitative analysis of included randomized controlled trials (RCTs).

Table 1
Summary of included studies.

	Subjects (NPWT vs. control)	NPWT administration	Cancer types and surgery	Outcome
Andrianello 2021	32 (mean age: 69) vs. 40 (mean age: 64) Follow up 30 days	Pressurenot mentioned Intermittent mode for 3-7 days	Ampullary cancer Cystic Distal bile duct cancer Duodenal cancer Neuroendocrine tumor Pancreatic ductal adenocarcinoma Surgery: Pancreaticoduodenectomy Total pancreatectomy	Surgical site infection, seroma
De Rooij 2021	50 (mean age: 65.4) vs. 111 (mean age: 65.1) Follow up 90 days	Pressure: -80 mmHg Continuous mode for 4 days	Breast cancer Surgery: Mastectomy with sentinel node Mastectomy with axillary lymph node dissection	Surgical site infection, seroma, and hospital readmission
Kacmaz 2022	24 (mean age: 67.4) vs. 26 (mean age: 64.5) Follow up 30 days	Pressure: -80 mmHg Continuous mode for 7 days	Colorectal cancer Surgery: Stoma closure Hemicolectomy Low anterior resection Sigmoid colectomy Transverse colectomy, Miles	Surgical site infection, seroma
Kuncewitch 2019	36 (mean age: 64.75) vs. 37 (mean age: 61.5) Follow up 30 days	Pressure: -125 mmHg Continuous mode for 4 days	Pancreatic Cancer Surgery: Laparotomy	Surgical site infection, seroma, and hospital readmission
Leitao 2021	254 (mean age: 56.25) vs. 251 (mean age: 58) Follow up 30 days	Pressure: -125 mmHg Continuous mode for 7 days	Ovarian cancer Fallopian tube cancer Peritoneal cancer Uterine cancer Cervical cancer Surgery: Laparotomy	Surgical site infection, seroma
Luo 2021	30 (mean age: 62.89) vs. 30 (mean age: 63.85) Follow up 30 days	Pressure: -125 to -150 mmHg Continuous mode for 7 days	Esophageal Cancer Surgery: Esophageal cancer surgery	Surgical site infection
Pieszko 2023	30 vs. 30 Follow up 1 year	Pressure: -125 mmHg Continuous mode for 7 days	Breast cancer Surgery: immediate breast reconstruction	Surgical site infection
Shen 2017	132 (mean age: 57.25) vs. 133 (mean age: 58.75) Follow up 30 days	Pressure: -125 mmHg Continuous mode for 4 days	Gastrointestinal cancer Pancreatic cancer Peritoneal cancer Surgery: Bowel resection Colorectal resection Pancreaticoduodenectomy Distal pancreatectomy Total pancreatectomy Cytoreduction	Surgical site infection, seroma, and hospital readmission
Wierdak 2021	35 (mean age: 61.6) vs. 36 (mean age: 62.4) Follow up 30 days	Not mentioned	Colorectal cancer Surgery: Ileostomy reversal Hemicolectomy Colectomy Anterior resection of rectum Intersphincter resection Transanal total mesorectum excision	Surgical site infection, seroma
Yang 2020	11 (mean age: 73.18) vs. 13 (mean age: 69.85) Follow up 30 days	Not mentioned	Colorectal cancer Surgery: Abdominoperineal resection	Surgical site infection

3.3.2. The impacts of NPWT on patients with cancer surgical wounds: seroma

In the random effects model, the authors failed to find significant OR of seroma of the included 7 studies of NPWT vs. control wound care (Z = 0.88, p = 0.38). A substantial heterogeneity was noted ($Tau^2 = 0.30$; $Chi^2 = 10.51$, p = 0.10; $I^2 = 43\%$).

3.3.3. The impacts of NPWT on patients with cancer surgical wounds: hospital readmission

In the random effects model, the authors failed to find significant OR of hospital readmission of the included 3 studies of NPWT vs. control wound care (Z = 0.41, p = 0.68). A low heterogeneity was noted ($Tau^2 = 0.05$; $Chi^2 = 2.29$, p = 0.32; $I^2 = 13\%$).

3.4. Certainty of evidence

The risk of bias in individual studies was not substantial enough to adversely affect the overall body of evidence. Although the evidence exhibited low imprecision and indirectness, it was characterized by high inconsistency. The publication bias was moderate. Ac-

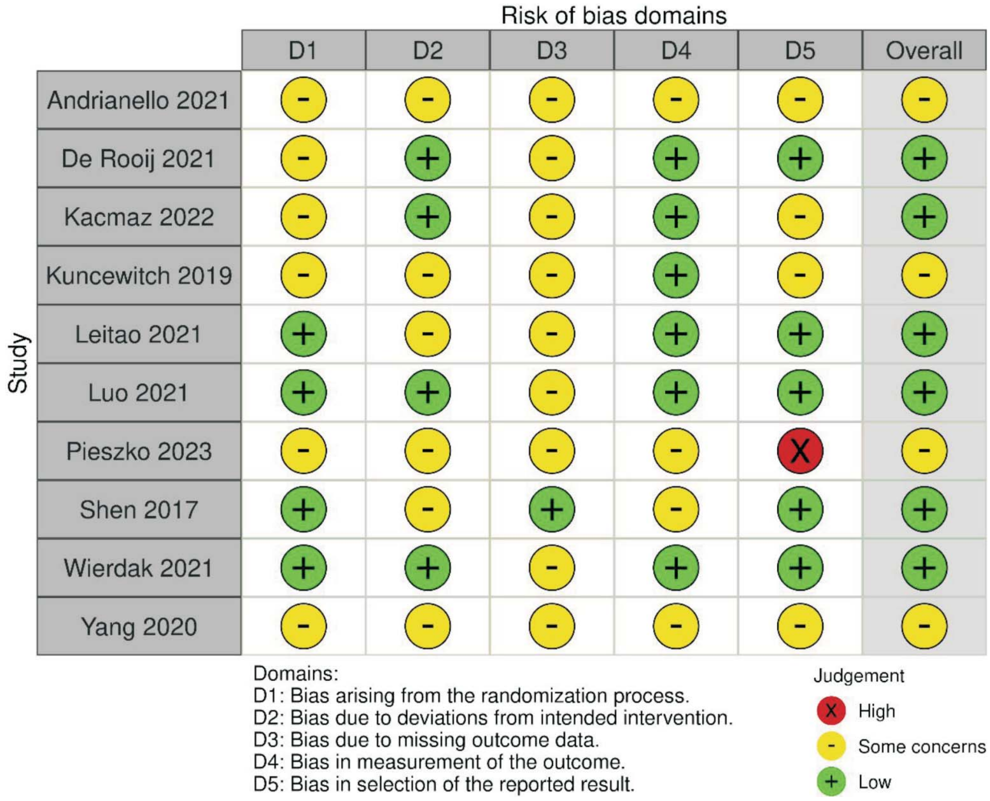

Figure 2. Risk of bias assessment. The risk of bias assessment version 2 (ROB v2) was used to report the assessment of bias risk.

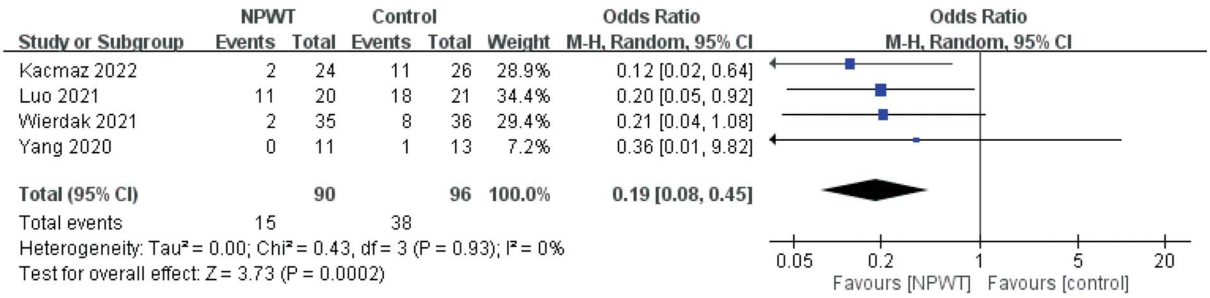

Figure 3. The forest plot for the odds ratio (OR) of surgical site infection in the subgroup patients with colorectal cancer surgical wounds [negative pressure wound therapy (NPWT) vs. control wound care]. NPWT was with a lower OR of surgical site infection when compared to the control wound care in the subgroup patients with colorectal cancer surgical wounds.

cording to the GRADE assessment, the overall quality of evidence was deemed low.

4. Discussion

The findings from this meta-analysis indicate that NPWT may not significantly reduce the risk of surgical site infection, seroma, or hospital readmission across various cancer patient populations with surgical wounds. This suggests a lack of beneficial effects of NPWT in the pooled data from diverse cancer categories, including gynecological cancer, pancreatic cancer, and colorectal cancer. Notably, however, a subgroup analysis revealed a significant reduction in the risk of surgical site infection among colorectal cancer patients (90 participants in the NPWT group vs. 96 in the control group). It is important to approach these results with caution. The low heterogeneity observed in the colorectal cancer subgroup analysis (Tau^2 = 0%, Chi^2 = 0.43, p = 0.93, I^2 = 0%) indicates that these significant findings are less likely to be influenced by issues related to heterogeneity. Nonetheless, the limited number of RCTs included in this pooled analysis raises questions about the clinical relevance of the significant benefits of NPWT in reducing surgical site infection risk for colorectal cancer patients.

The observed reduction in the risk of surgical site infection, alongside low heterogeneity in colorectal cancer patients, may be attributed to the relatively homogenous nature of surgical techniques and wound presentations in this patient group. Despite these positive findings, most results from the current meta-analysis indicate an overall lack of significant impact of NPWT on postoperative surgical site infections, seromas, and hospital readmissions, with the exception of colorectal cancer patients.

The authors needed to announce the following limitations in the current meta-analysis. First, the different kinds of cancer patients, cancer surgery, and cancer surgical wounds in the included RCTs might bias the current results. The authors aimed to pool the synthesis effects of different kinds of cancer patients after different kinds of surgery. The authors found the significant reduction of the risk of surgical site infection and low heterogeneity in the colorectal cancer patients with surgical wounds. Therefore, the specific individual analysis for the different kinds of cancer and surgery should be warranted in the future. Second, the different ages of patients in the included RCTs might influence the meta-analysis results. Third, the significant heterogeneity may bias the negative results of the risk of surgical site infection, seroma, and hospital readmission. It might be related to the diversity of operating surgeons, using materials, operating room setting, underlying categories of cancer and underlying ages of patients in the included studies. Fourth, the statistical methods for the heterogeneity I^2 estimates need to be interpreted with caution due to that the current meta-analysis only enrolled a limited number of RCTs and might be biased, especially for the pooled analysis of subgroup analysis of colorectal cancer patients. Sixth, the limited number of RCTs, the limited sample size (624 subjects with NPWT vs. 698 subjects with control wound care), the variation of cancer stages, underlying cancer categories needing surgery, and gender in the included RCTs might influence the meta-analysis results. However, subgroup analysis in this perspective seemed difficult due to the significant heterogeneity from these biased issues in patients with cancer surgical wounds. Seventh, the language bias is also relevant due to the fact that only English-language articles were included in the current meta-analysis.

5. Conclusion

The results suggested that NPWT might just provide additional benefits to the colorectal cancer patients with surgical wounds, such as a lower risk of surgical site infection. No significant benefits of NPWT have been found in the outcome of surgical site infection, seroma, and hospital readmission of patients with cancer surgical wounds. Further evaluations with adequate sample size and number of studies of NPWT vs. control RCTs in the colorectal cancer are warranted to confirm the effects of lowering the risk of surgical site infection.

Conflict of interest statement

The authors have no conflicts of interest relevant to this article.

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