JMedSci

Journal of the Medical Sciences
(Berkala Ilmu Kedokteran)

Volume 55, Number 1, 2023; 86-98
https://doi.org/10.19106/JMedSci005501202311

The effect of prophylactic negative pressure wound therapy on infection in obese women after C-section: a meta-analysis

Aris Widiyanto[1]*, Santy Irene Putri[2], Asruria Sani Fajriah[3], Yuly Peristiowati[3], Agusta Dian Ellina[3], Joko Triatmojo[1]

[1]School of Health Sciences Mamba'ul Ulum Surakarta, [2]University of Tribhuwana Tunggadewi Malang, [3]Institute of Health Sciences Strada

Submitted: 2021-08-02
Accepted : 2022-12-05

ABSTRACT

Most caesarean wounds resulted in infection. This become a huge burden on the health care system, considering the high number of women undergoing this type of surgery. Negative pressure wound therapy (NPWT) has been recommended for a wide variety of lesions including open abdominal wounds. The purpose of this study was to investigate the effect of prophylactic NPWT on infection in obese women after a C-section. This was a systematic review and meta-analysis study that used articles from online databases of EBSCO, Google Scholar, and PubMed which published until 2022. The dependent variable was infections post C-section, while the independent were NPWT and standard wound therapy. The data was analyzed by RevMan 5.3. This study showed that there is no difference in the outcome of superficial site infection (SSI), deep site infection (DSI), wound dehiscence, seroma, and hematoma between women with obesity after caesarean delivery who used NPWT and standard dressing.

ABSTRAK

Luka operasi Caesar, sebagian besar mengalami infeksi. Hal ini menjadi beban besar bagi sistem pelayanan kesehatan, mengingat tingginya jumlah wanita yang menjalani jenis operasi ini. Terapi luka tekanan negatif (TLTN) telah direkomendasikan untuk berbagai macam lesi termasuk luka perut terbuka. Tujuan dari penelitian ini adalah untuk menginvestigasi pengaruh TLTN dengan pembalut luka standar terhadap kejadian infeksi pada wanita obesitas setelah persalinan caesar. Penelitian ini merupakan review sistematis dan meta-analisis dengan pencarian artikel yang diterbitkan di database online EBSCO, Google Scholar, dan PubMed yang dipublikasikan sampai tahun 2022. Variabel tergantung adalah kejadian infeksi pasca operasi Caesar dan variable bebas adalah TLTN dan terapi luka standar. Analisis data menggunakan software RevMan versi 5.3. Hasil analisis menunjukkan tidak ada perbedaan terhadap kejadian SSI (*superficial site infection*), DSI (*deep site infection*), *wound dehiscence*, *seroma* dan *hematoma* dalam TLTN dan *standard dressing* pada wanita obesitas yang menjalani operasi Caesar.

Keywords:
prophylactic negative pressure;
wound therapy;
wound dressing;
obese women;
cesarean delivery

INTRODUCTION

Caesarean delivery rates are on average among obese women, with the risk of having an emergency caesarean delivery or elective delivery increase with the mount in body mass index (BMI).[1-6] Postoperative infection is one of a number of potential complications following caesarean section[7,8] with rates ranging from 1.2 to 5.0%, reported to occur in post-caesarean women during their hospital stay.[9-16] Postoperative wound complications such as surgical site infection (SSI), wound dehiscence (opening of closed surgical wounds), and hematoma and seroma formation are common complications of surgical

*corresponding author: widiyanto.aris99@gmail.com

procedures,[17] especially in women who are obese, diabetic, or both.[3]

Although the majority of caesarean section wound infections are superficial infections, this poses a huge burden to the health care system, given the high number of women undergoing this type of surgery.[18] Surgical site infection has been of concern because it contributes to intervention and re-treatment, increased length of hospital stays, delayed wound healing, and in some cases, death.[13,15]

Negative pressure wound therapy (NPWT) has been used since the late 1990s. It has been recommended for a wide variety of lesions including open abdominal wounds, open fractures, burns, ulcers, post-traumatic wounds, diabetic ulcers on the feet, skin grafts, sternal wounds, and postoperative cleansing in obese patients. It is also increasingly being used as a prophylactic in closed incision wounds to prevent surgical site complications, as well as being used in secondary wound healing such as chronic wounds or infected wounds.[16] Negative pressure prophylactic wound therapy consists of a closed wound management system by applying negative pressure (suction) to the wound surface. The wound is closed or packed with open cell foam or gauze dressing and sealed with an occlusive curtain. The continuous suction system is maintained by connecting the suction tube from the wound dressing to the vacuum pump and effluent collector. Standard negative pressure levels range from 50 to 125 mmHg.[19,20]

Surgical site infections (SSI) are infections of the skin after surgery. This type of infection consist of more significant kind of infection such as superficial site infection (SSI), deep site infection (DSI), wound dehiscence, seroma, and hematoma. Superficial site infection is an infection that occurs in the area where the surgical incision was made. Deep site infection is an infection that occurs under the incision area in the muscle and tissue around the muscle. Wound dehiscence is the re-opening of a surgical wound that has been primarily sutured. Seroma is a condition that occurs when sterile serum or body fluids collect under the surface of the skin causing swelling and sometimes pain. Hematoma is an abnormal collection of blood outside the blood vessels, this condition can occur when the walls of the arteries, veins, or capillaries are damaged so that blood flows out into tissues that are not where it belongs.[21]

However, NPWT is considered relatively expensive compared to standard postoperative wound care. Therefore, it should be considered judiciously in patients who are at high risk for complications of surgical site infections or if the consequences of complications of surgical site infections are high.[21]

Studies that discusses the effectiveness of NPWT as postoperative wound therapy are still limited, so further study is needed. Therefore, this study aimed to identify the effect of negative pressure prophylactic wound therapy on the incidence of infection in obese women after caesarean delivery.

MATERIALS AND METHODS

Study design

The design of this study was a systematic review and meta-analysis.

Inclusion criteria

Search articles using the EBSCO, Google Scholar, and PubMed online databases were performed. The articles used in this review were articles published from 2016 to 2021. In the process of searching for articles, the keywords “prophylactic negative pressure”, “wound therapy”, “wound dressing”, “obese women”, and “caesarean delivery” were used.

The inclusion criteria of this study were 1) an article describing the effect of negative pressure prophylactic wound therapy versus standard wound dressings on the incidence of infection in obese women after caesarean delivery; 2) articles consists 5 kinds of dependent variables including post-operative wound complications, namely: DSI, DSI, wound dehiscence, seroma and hematoma. 3) original research papers; 4) the study design was randomized controlled trials (RCT). The exclusion criteria for this study were 1) articles in languages other than English and Indonesian; 2) review papers; 3) research data is incomplete or not available.

Study instruments

Three online databases including EBSCO, PubMed, and Google Scholar were used. The Prism diagram guided to search the articles (FIGURE 1). Articles included in this study must meet the inclusion criteria and have been reviewed using a critical appraisal in accordance with the research design of each article. The data were analyzed by the software Review Manager version 5.3.

RESULTS

Characteristics of research articles

There are a total of 899 articles searched from the online database using the keywords "prophylactic negative pressure", "wound therapy", "wound dressing", "obese women", and "caesarean delivery" by choosing the year of publication until 2022.

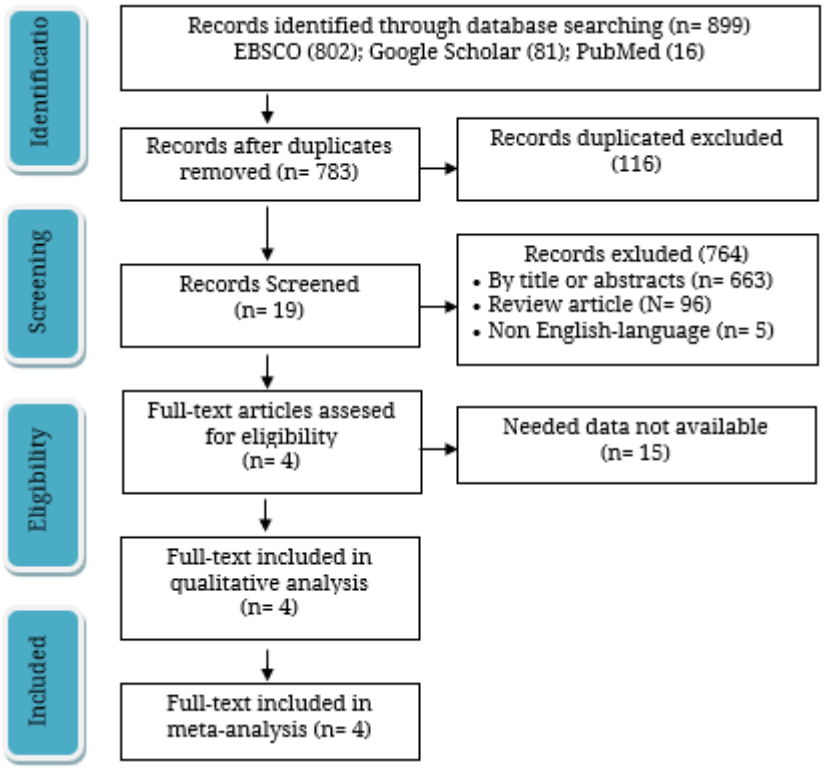


FIGURE 1. Prism diagram

A total of 4 articles that met the inclusion criteria were processed in qualitative and quantitative synthesis. The characteristics of each article included in this study are described in TABLE 1. Case and total of events extracted from each article included are summarized in TABLE 2. The numbers of cases and total in experiment group compared to the number of cases and total in control group in dichotomous data were analyzed. Furthermore, the effects with risk ratio were measured.

TABLE 1. Summary of characteristics from articles included

Authors (years)	Location	Design study	Age [mean (y)]	Intervention	Control	Total sample	Study period	Outcome
Gillespie *et al.*,[23]	Queensland, Australia	RCT	Cases: 31 Control: 31	Closed incisional NPWT	Standard wound dressing	Cases: 1017; Control: 1018	October 2015 - November 2019	SSI, DSI, wound dehiscence, seroma, hematoma
Hyldig *et al.*,[22]	Denmark	RCT	Cases: 32 Control: 32	Incisional NPWT	Standard wound dressing	Cases: 432; Control: 444	2013-2016	Wound dehiscence
Tuuli *et al.*,[24]	USA	RCT	Cases: 30.2 Control: 30.5	Prophylactic NPWT	Standard wound dressing	Cases: 816; Control: 808	February 8, 2017 - November 13, 2019	SSI, DSI, Seroma, Hematoma
Wihbey *et al.*,[25]	USA	RCT	Cases: 31 Control: 30	Vacuum-assisted closure dressing	Standard wound dressing	Cases: 80; Control: 86	January 5, 2015 - January 7, 2017	SSI, DSI, Wound dehiscence, Seroma, Hematoma

NPWT: negative pressure wound therapy; SSI: superficial site infection; DSI: deep site infection

TABLE 2. Data extraction for analysis from each article

Dependent variable	References	Experiment		Control	
		Cases	Total	Cases	Total
DSI	Gillespie *et al.*,[23]	70	75	93	99
	Tuuli *et al.*,[24]	18	806	16	802
	Wihbey *et al.*,[25]	12	80	8	81
DSI	Gillespie *et al.*,[23]	4	75	6	99
	Tuuli *et al.*,[24]	2	806	2	802
	Wihbey *et al.*,[25]	1	80	4	81
Wound dehiscence	Gillespie *et al.*,[23]	108	1017	103	1018
	Hyldig *et al.*,[22]	62	432	69	444
	Wihbey *et al.*,[25]	14	80	13	81
Seroma	Gillespie *et al.*,[23]	27	1017	26	1018
	Tuuli *et al.*,[24]	5	806	6	802
	Wihbey *et al.*,[25]	7	80	6	81
Hematoma	Gillespie *et al.*,[23]	11	1017	6	1018
	Tuuli *et al.*,[24]	4	806	8	802
	Wihbey *et al.*,[26]	2	80	4	81

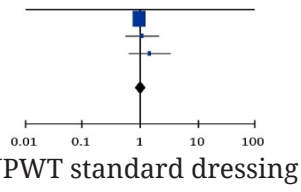
Effect of NPWT on SSI

The results of the meta-analysis showed that subjects using NPWT and those using standard wound care had almost the same risk of developing SSI (RR = 1.05; 95% CI = 0.91-1.22; p = 0.48). The heterogeneity in this analysis is low, so the authors use fixed effects to determine the results of the analysis (TABLE 3).

The author considers that there is no publication bias in the results of the analysis as indicated by the presence of a circle touching the center line and the positions of the circles in the symmetrical funnel plot (FIGURE 2).

TABLE 3. Forest plot of the SSI

Study or subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight (%)	Risk ratio [M-H fixed (95%CI)]
Gillespie *et al.*,[23]	70	75	93	99	77	0.99 (0.92-1.07)
Tuuli *et al.*,[24]	18	806	16	802	15.4	1.12 (0.57-2.18)
Wihbey *et al.*,[25]	12	80	8	81	7.6	1.52 (0.66-3.52)
Total (95%CI)		961		982	100	1.05 (0.91-1.22)
Total events	100		117			



Heterogenity Chi^2 : 2.87; df: 2 (p=0.24); I^2: 30%; Test for overall effect Z: 0.71 (p=0.48)

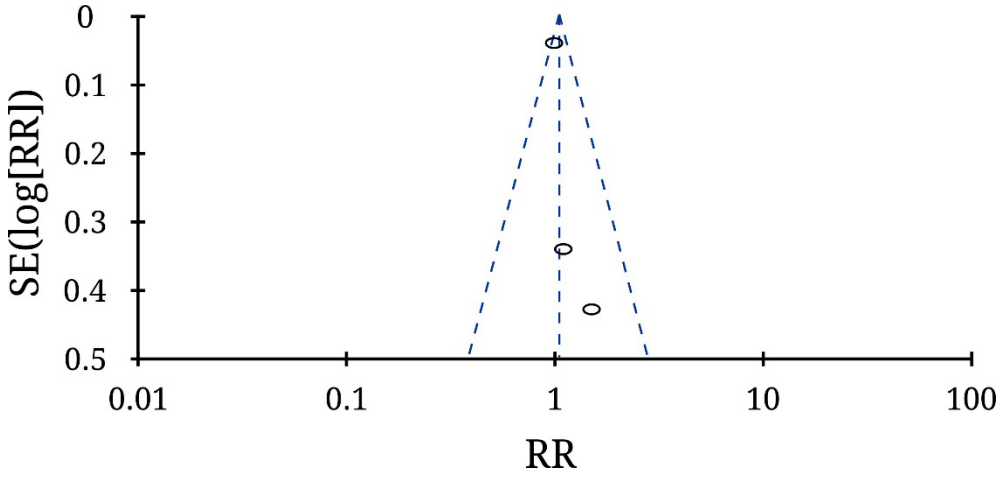


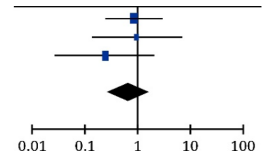
FIGURE 2. Funnel plot of SSI

Effect of NPWT on DSI

The results of the meta-analysis showed that subjects using NPWT had a lower risk of DSI than those using standard wound care. However, it was not significantly different (RR = 0.68; 95% CI = 0.27-1.68; p = 0.40). No difference between subjects using NPWT with those using standard wound care was reported (TABLE 4). The author considers that there is a publication bias in the results of the analysis, which is indicated by the asymmetrical position of the circle (FIGURE 3).

TABLE 4. Forest plot of the DSI

Study or subgroup	Experimental		Control		Weight (%)	Risk ratio [M-H fixed (95%CI)]
	Events	Total	Events	Total		
Gillespie *et al.*,[23]	4	75	6	99	46.4	0.88 (0.26-3.01)
Tuuli *et al.*,[24]	2	806	2	802	18.0	1.00 (0.14-7.05)
Wihbey *et al.*,[24]	1	80	4	81	35.6	0.25 (0.03-2.22)
Total (95%CI)		961		982	100%	0.68 (0.27-1.68)
Total events	7		12			



Heterogenity Chi^2 : 1.11; df: 2 (p=0.57); I^2: 0%; Test for overall effect Z: 0.84 (p=0.40)

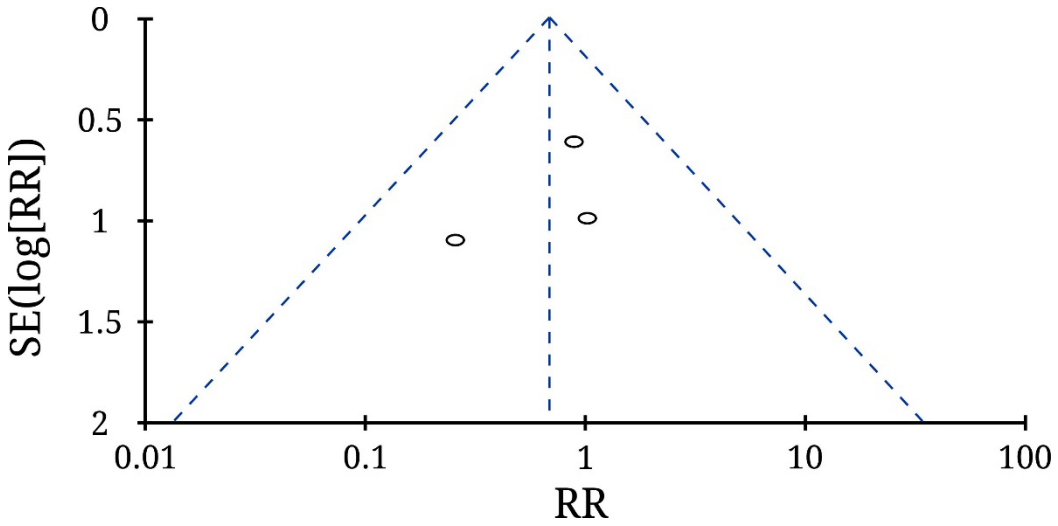


FIGURE 3. Funnel plot of DSI

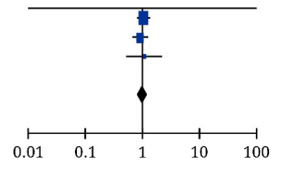
Effect of NPWT on wound dehiscence

The results of the meta-analysis showed that subjects using NPWT and those using standard wound care had almost the same risk of developing wound dehiscence (RR = 1.01; 95% CI = 0.83-1.22; p = 0.95). The heterogeneity in this analysis is low, so the authors use fixed effects to determine the results of the analysis (TABLE 5).

The author considers that there is no publication bias in the analysis results, which is indicated by the presence of a circle touching the center line and the positions of the circles in the symmetrical funnel plot (FIGURE 4).

TABLE 5. Forest plot of the wound dehiscence

Study or subgroup	Experimental		Control		Weight	Risk ratio
	Events	Total	Events	Total	(%)	[M-H fixed (95%CI)]
Gillespie *et al.*,[23]	108	1017	103	1018	56	1.05 (0.81-1.36)
Tuuli *et al.*,[24]	62	432	69	444	37	0.92 (0.67-1.27)
Wihbey *et al.*,[25]	14	80	13	81	7	1.09 (0.55-2.17)
Total (95%CI)		1529		1534	100%	1.01 (0.83-1.22)
Total events	184		185			



Heterogenity Chi^2 : 0.44; df: 2 (p=0.80); I^2: 0%; Test for overall effect Z: 0.06 (p=0.95)

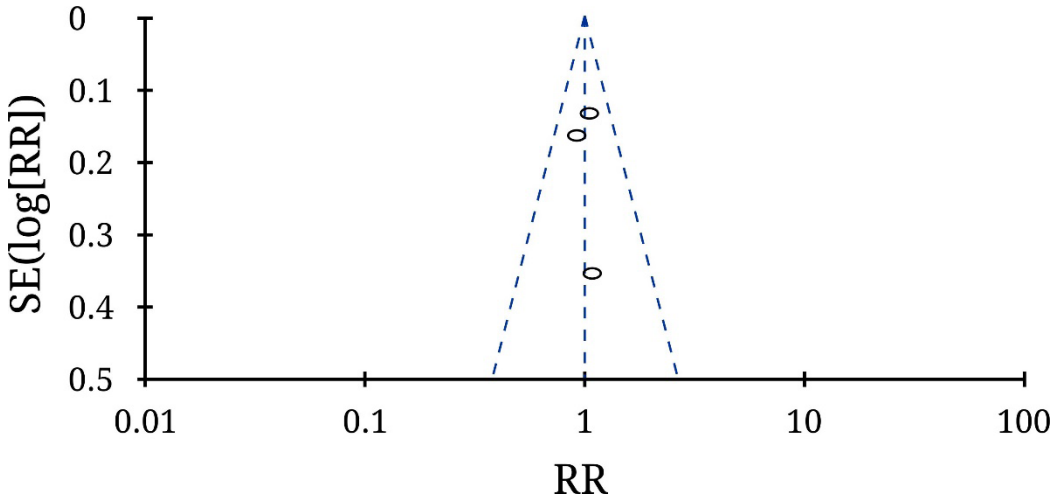


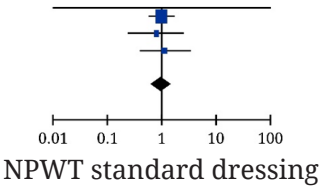
FIGURE 4. Funnel plot of wound dehiscence

Effect of NPWT on seroma

The results of the meta-analysis showed that subjects using NPWT and those using standard wound care had almost the same risk of developing seroma (RR = 1.03; 95% CI = 0.66-1.60; p = 0.90). The heterogeneity in this analysis is low, so the authors use fixed effects to determine the results of the analysis (TABLE 6). The author considers that there is no publication bias in the analysis results, which is indicated by the presence of a circle touching the center line and the positions of the circles on a symmetrical funnel plot (FIGURE 5).

TABLE 6. Forest plot of seroma

Study or subgroup	Experimental		Control		Weight	Risk ratio
	Events	Total	Events	Total	(%)	[M-H fixed (95%CI)]
Gillespie *et al.*,[23]	27	1017	26	1018	68.5	1.04 (0.61-1.77)
Tuuli *et al.*,[24]	5	806	6	802	15.8	0.83 (0.25-2.71)
Wihbey *et al.*,[25]	7	80	6	81	15.7	1.18 (0.42-3.36)
Total (95%CI)		1903		1901	100	1.03 (0.66-1.60)
Total events	39		38			



Heterogenity Chi² : 0.22; df: 2 (p=0.91); I²: 0%; Test for overall effect Z: 0.13 (p=0.90)

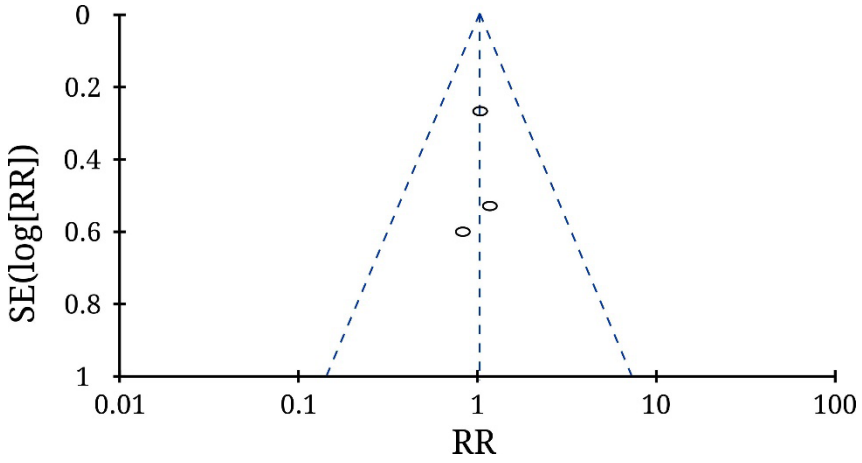


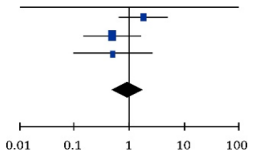
FIGURE 5. Funnel plot of seroma

Effect of NPWT on hematoma

The results of the meta-analysis showed that subjects using NPWT and those using standard wound care had almost the same risk of developing hematoma (RR = 0.95; 95% CI = 0.49-1.83; p = 0.87). The heterogeneity in this analysis is low, so the authors use fixed effects to determine the results of the analysis (TABLE 7). The author considers that there is a publication bias in the analysis results as indicated by the asymmetrical position of the circle (FIGURE 6).

TABLE 7. Forest plot of hematoma

Study or subgroup	Experimental		Control		Weight	Risk ratio
	Events	Total	Events	Total	(%)	[M-H fixed (95%CI)]
Gillespie *et al.*,[23]	11	1017	6	1018	33.3	1.84 (0.68-4.94)
Tuuli *et al.*,[24]	4	806	8	802	44.6	0.50 (0.15-1.65)
Wihbey *et al.*,[25]	2	80	4	81	22.1	0.51 (0.10-2.69)
Total (95%CI)		1903		1901	100	0.95 (0.49-1.83)
Total events	17		18			



Heterogenity Chi^2 : 3.37; df: 2 (p=0.19); I^2: 41%; Test for overall effect Z: 0.17 (p=0.87)

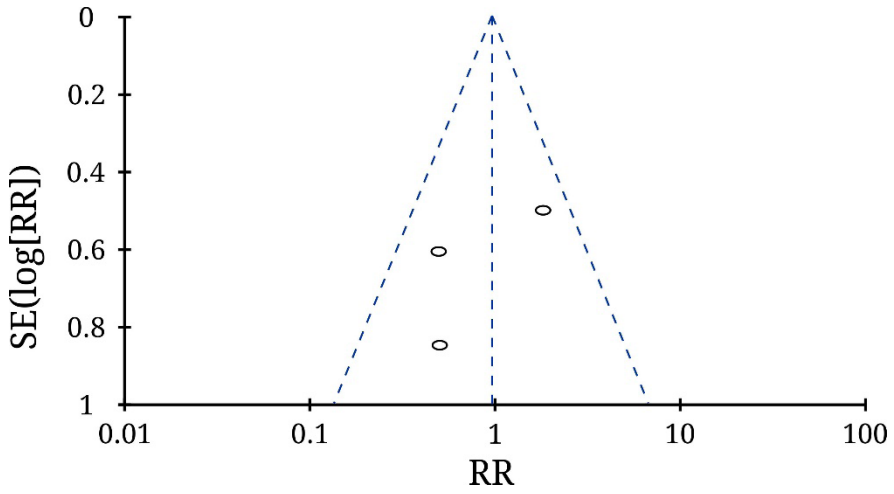


FIGURE 6. Funnel plot of hematoma

DISCUSSION

This study describes the comparison of the benefits of NPWT with standard wound care in obese mothers who gave birth by caesarean section. Previous studies reported that NPWT reduces bacterial contamination, edema, and exudate, as well as increases microvascular blood flow, and promotes granulation tissue by inducing mechanical stress that promotes cell growth.[26-29]

A total of 4 articles which met the inclusion criteria were analyzed. Five criteria of infection that occur in mothers who use NPWT and standard wound therapy including SSI, DSI, wound dehiscence, seroma, and hematoma were compared. Among 5 criteria for infection and wound complications analyzed, only DSI showed a moderate strength of measurement inclined towards benefits. The reduction of risk 32% lower on the incidence of DSI in the NPWT group compared to the standard dressing group was observed. However, it was not significantly different (RR = 0.68; 95% CI = 0.27-1.68; p = 0.40). Meanwhile, 4 other types of infection showed an inconsiderable value of risk ratio, which stated that there is no difference between the intervention and control group in terms of decreasing the SSI, wound dehiscence, seroma, and hematoma. The reduction in the incidence of DSI in the NPWT group may be explained by an increase in microvascular blood flow

during therapy, which leads to a decrease in the hypoxic response, thereby enhancing the oxidative bacterial killing mechanism in adipose tissue.[30,31]

As for the insignificant results in other complications, it may be due to the relatively small number of patients involving in the study, therefore further study is needed. Likewise, the limitations of each of the studies analyzed in this review and meta-analysis study. The results of this study are in accordance with the results of a study by Costa *et al*.,[32] which reported that there is no difference in patients using NPWT who underwent major trauma-related surgery for lower extremity fractures in reducing surgical site infection. Previous systematic review studies and meta-analyses also reported similar results, that there is insufficient evidence to support the use of NPWT among obese women for the prevention of caesarean wound complications.[33,34]

CONCLUSION

In conclusion, there is no difference in the benefits of NPWT with standard wound care to reduce SSI, DSI, wound dehiscence, seroma, and hematoma in obese women after caesarean section.

ACKNOWLEDGEMENTS

We would like to thanks the online database provider of EBSCO, Google Scholar, and PubMed for supporting the articles.

REFERENCES

1. Sebire NJ, Jolly M, Harris JP, Wadsworth J, Joffe M, Beard RW, *et al*. Maternal obesity and pregnancy outcome: a study of 287,213 pregnancies in London. Int J Obes Relat Metab Disord 2001; 25(8):1175-82. https://doi.org/10.1038/sj.ijo.0801670
2. Poobalan AS, Aucott LS, Gurung T, Smith WC, Bhattacharya S. Obesity as an independent risk factor for elective and emergency caesarean delivery in nulliparous women--systematic review and meta-analysis of cohort studies. Obes Rev 2009; 10(1):28-35. https://doi.org/10.1111/j.1467-789X.2008.00537.x
3. Heslehurst N, Simpson H, Ells LJ, Rankin J, Wilkinson J, Lang R, *et al*. The impact of maternal BMI status on pregnancy outcomes with immediate short-term obstetric resource implications: a meta-analysis. Obes Rev 2008; 9(6):635-83. https://doi.org/10.1111/j.1467-789X.2008.00511.x
4. Denison FC, Price J, Graham C, Wild S, Liston WA. Maternal obesity, length of gestation, risk of postdates pregnancy and spontaneous onset of labour at term. BJOG 2008; 115(6):720-5. https://doi.org/10.1111/j.1471-0528.2008.01694.x
5. Denison FC, Norwood P, Bhattacharya S, Duffy A, Mahmood T, Morris C, *et al*. Association between maternal body mass index during pregnancy, short-term morbidity, and increased health service costs: a population-based study. BJOG 2014; 121(1):72-81; discussion 82. https://doi.org/10.1111/1471-0528.12443
6. Voinchet V, Magalon G. [Vacuum assisted closure. Wound healing by negative pressure. Ann Chir Plast Esthet 1996; 41(5):583-9.
7. Liu S, Liston RM, Joseph KS, Heaman M, Sauve R, Kramer MS, *et al*. Maternal mortality and severe morbidity associated with low-risk planned cesarean delivery versus planned vaginal delivery at term. CMAJ 2007; 176(4):455-60. https://doi.org/10.1503/cmaj.060870.
8. Bodner K, Wierrani F, Grünberger W, Bodner-Adler B. Influence of the mode of delivery on maternal and

neonatal outcomes: a comparison between elective cesarean section and planned vaginal delivery in a low-risk obstetric population. Arch Gynecol Obstet 2011; 283(6):1193-8. https://doi.org/10.1007/s00404-010-1525-y
9. Johnson A, Young D, Reilly J. Caesarean section surgical site infection surveillance. J Hosp Infect 2006; 64(1):30-5. https://doi.org/10.1016/j.jhin.2006.03.020
10. Vincent A, Ayzac L, Girard R, Caillat-Vallet E, Chapuis C, Depaix F, *et al*. Downward trends in surgical site and urinary tract infections after cesarean delivery in a French surveillance network, 1997-2003. Infect Control Hosp Epidemiol 2008; 29(3):227-33. https://doi.org/10.1086/527512
11. Ward VP, Charlett A, Fagan J, Crawshaw SC. Enhanced surgical site infection surveillance following caesarean section: experience of a multicentre collaborative post-discharge system. J Hosp Infect 2008; 70(2):166-73. https://doi.org/10.1016/j.jhin.2008.06.002
12. Szilágyi E, Füzi M, Böröcz K, Kurcz A, Tóth Á, Nagy K. Risk factors and outcomes for bloodstream infections with extended-spectrum β-lactamase-producing Klebsiella pneumoniae; Findings of the nosocomial surveillance system in Hungary. Acta Microbiol Immunol Hung 2009; 56(3):251-62. https://doi.org/10.1556/AMicr.56.2009.3.5
13. Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, *et al*. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. JAMA Surg 2017; 152(8):784-91. https://doi.org/10.1001/jamasurg.2017.0904
14. Dias M, Dick A, Reynolds RM, Lahti-Pulkkinen M, Denison FC. Predictors of surgical site skin infection and clinical outcome at caesarean section in the very severely obese: A retrospective cohort study. PLoS One 2019; 14(6):e0216157. https://doi.org/10.1371/journal.pone.0216157
15. Ramírez-Wong FM, Atencio-Espinoza T, Rosenthal VD, Ramirez E, Torres-Zegarra SL, Díaz Tavera ZR, *et al*. Surgical Site Infections Rates in More Than 13,000 Surgical Procedures in Three Cities in Peru: Findings of the International Nosocomial Infection Control Consortium. Surg Infect (Larchmt) 2015; 16(5):572-6. https://doi.org/10.1089/sur.2014.201
16. Norman G, Goh EL, Dumville JC, Shi C, Liu Z, Chiverton L, *et al*. Negative pressure wound therapy for surgical wounds healing by primary closure. Cochrane database Syst Rev 2020; 5(5):CD009261. https://doi.org/10.1002/14651858.CD009261
17. Smyth ETM, McIlvenny G, Enstone JE, Emmerson AM, Humphreys H, Fitzpatrick F, *et al*. Four country healthcare associated infection prevalence survey 2006: overview of the results. J Hosp Infect 2008; 69(3):230-48. https://doi.org/10.1016/j.jhin.2008.04.020
18. Wloch C, Wilson J, Lamagni T, Harrington P, Charlett A, Sheridan E. Risk factors for surgical site infection following caesarean section in England: results from a multicentre cohort study. BJOG 2012; 119(11):1324-33. https://doi.org/10.1111/j.1471-0528.2012.03452.x
19. Ubbink DT, Westerbos SJ, Nelson EA, Vermeulen H. A systematic review of topical negative pressure therapy for acute and chronic wounds. Br J Surg 2008; 95(6):685-92. https://doi.org/10.1002/bjs.6238
20. Vikatmaa P, Juutilainen V, Kuukasjärvi P, Malmivaara A.

Negative pressure wound therapy: a systematic review on effectiveness and safety. Eur J Vasc Endovasc Surg 2008; 36(4):438-48. https://doi.org/0.1016/j.ejvs.2008.06.010
21. Medicine JH. Surgical Site Infections. Health. 2021.
22. Hyldig N, Vinter CA, Kruse M, Mogensen O, Bille C, Sorensen JA, *et al*. Prophylactic incisional negative pressure wound therapy reduces the risk of surgical site infection after caesarean section in obese women: a pragmatic randomised clinical trial. BJOG 2019; 126(5):628-35. https://doi.org/10.1111/1471-0528.15413
23. Gillespie BM, Webster J, Ellwood D, Thalib L, Whitty JA, Mahomed K, *et al*. Closed incision negative pressure wound therapy versus standard dressings in obese women undergoing caesarean section: multicentre parallel group randomised controlled trial. BMJ 2021; 373:n893. https://doi.org/10.1136/bmj.n893
24. Tuuli MG, Liu J, Tita ATN, Longo S, Trudell A, Carter EB, *et al*. Effect of prophylactic negative pressure wound therapy vs standard wound dressing on surgical-site infection in obese women after cesarean delivery: A randomized clinical trial. JAMA 2020; 324(12):1180-9. https://doi.org/10.1001/jama.2020.13361
25. Wihbey KA, Joyce EM, Spalding ZT, Jones HJ, MacKenzie TA, Evans RH, *et al*. Prophylactic Negative Pressure Wound Therapy and Wound Complication after Cesarean Delivery in Women with Class II or III Obesity: A Randomized Controlled Trial. Obstet Gynecol 2018; 132(2):377-84. https://doi.org/10.1097/AOG.0000000000002744
26. Gouttefangeas C, Eberle M, Ruck P, Stark M, Müller JE, Becker HD, *et al*. Functional T lymphocytes infiltrate implanted polyvinyl alcohol foams during surgical wound closure therapy. Clin Exp Immunol 2001; 124(3):398-405. https://doi.org/10.1046/j.1365-2249.2001.01547.x
27. Chen SZ, Li J, Li XY, Xu LS. Effects of vacuum-assisted closure on wound microcirculation: An experimental study. Asian J Surg 2005; 28(3):211-7. https://doi.org/10.1016/S1015-9584(09)60346-8
28. Malmsjö M, Gustafsson L, Lindstedt S, Gesslein B, Ingemansson R. The effects of variable, intermittent, and continuous negative pressure wound therapy, using foam or gauze, on wound contraction, granulation tissue formation, and ingrowth into the wound filler. Eplasty 2012; 12:e5.
29. Xia CY, Yu AX, Qi B, Zhou M, Li ZH, Wang WY. Analysis of blood flow and local expression of angiogenesis-associated growth factors in infected wounds treated with negative pressure wound therapy. Mol Med Rep 2014; 9(5):1749-54. https://doi.org/10.3892/mmr.2014.1997
30. Greif R, Akça O, Horn EP, Kurz A, Sessler DI. Supplemental perioperative oxygen to reduce the incidence of surgical-wound infection. N Engl J Med 2000; 342(3):161-7. https://doi.org/10.1056/NEJM200001203420303
31. Allen DB, Maguire JJ, Mahdavian M, Wicke C, Marcocci L, Scheuenstuhl H, *et al*. Wound hypoxia and acidosis limit neutrophil bacterial killing mechanisms. Arch Surg 1997; 132(9):991-6. https://doi.org/10.1001/archsurg.1997.01430330057009
32. Costa ML, Achten J, Knight R, Bruce J, Dutton SJ, Madan J, *et al.* Effect of incisional negative pressure wound therapy vs standard wound dressing on deep surgical site infection after surgery for lower limb fractures associated with major trauma: The

WHIST Randomized Clinical Trial. JAMA 2020; 323(6):519-26. https://doi.org/10.1001/jama.2020.0059

33. Smid MC, Dotters-Katz SK, Grace M, Wright ST, Villers MS, Hardy-Fairbanks A, *et al*. Prophylactic negative pressure wound therapy for obese women after cesarean delivery: a systematic review and meta-analysis. Obstet Gynecol 2017; 130(5):969-78. https://doi.org/10.1097/AOG.0000000000002259
34. Widiyanto A, Putri SI, Fajriah AS, Rejo R, Nurhayati I, Yuniarti T, *et al*. The implementation of family nursing care to patients with chronic diseases: a systematic review. STRADA: Jurnal Ilmiah Kesehatan 2021; 10(1):1225-33. https://doi.org/10.30994/sjik.v10i1.753