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The impact of subcutaneous tissue suturing at cesarean section on wound complications: a meta-analysis

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Short title: Subcutaneous tissue suturing in CS

Abstract

Background: Cesarean wound complications are frequently observed in everyday practice.

Objectives: To study whether subcutaneous tissue closure following cesarean section results in decreased wound complications.

Search strategy: We systematically searched Medline (1966-2016), Scopus (2004-2016), ClinicalTrials.gov (2008-2016) and Cochrane Central Register of Controlled Trials CENTRAL (1999-2016) databases together with reference lists from included studies.

Selection criteria: Randomized and quasi-randomized trials that investigated the impact of subcutaneous tissue suturing on wound complications following cesarean section were held eligible for inclusion. Retrospective studies and prospective non-randomized studies were excluded from the present meta-analysis.

Data collection and analysis: The methodological quality of studies was assessed with the Jadad scale. Statistical meta-analysis was performed with the RevMan 5.3 software.

Main results: Ten studies were finally included in our meta-analysis, which involved 3,696 women delivered by caesarean section. Re-approximation of the subcutaneous tissue significantly reduced the odds of developing any type of wound complication (3,811 women, REM, OR 0.66, 95% CI 0.47 – 0.93). The incidence of seroma was also decreased (1,979 women, REM, OR 0.53, 95% CI 0.33 – 0.84). On the other hand, the incidence of hematoma remained unaffected by subcutaneous closure (1,663 women, REM, OR 0.74, 95% CI 0.22 – 2.42) as well as the likelihood of developing a wound infection (1,971 patients, REM, OR 0.99, 95% CI 0.70 -1.41).

Conclusions: The results of our meta-analysis suggest that subcutaneous tissue closure may benefit patients undergoing cesarean section. Current data in women with high BMI remain very limited; hence, definitive conclusions are precluded for this specific group.

Key words: cesarean: subcutaneous; wound; complications; seroma; hematoma

Tweetable abstract: Subcutaneous tissue closure may benefit patients undergoing cesarean section.

Introduction

Cesarean section (C/S) is the most common abdominal operation performed worldwide [1]. The World Health Organization (WHO) estimated that approximately 653,000 operations w ere unnecessarily performed in the U.S. at 2008 [2]. From 1996 to 2007, the cesarean section rates increased in the U.S. [3] and thereafter they seem to remain decline [4]. As every other surgical procedure, it is sometimes accompanied by surgical complications.

Wound complications are encountered in approximately 5% of women that undergo C/S and include hematomas, seromas and infection [5]. All of these, may lead to wound dehiscence. Obesity seems to have a direct effect on wound complication rates [6]. Specifically, Vermillion et al have shown that when the thickness of the subcutaneous tissue is larger than 3 cm the relative risk of developing wound infection reaches 2.8 [7]. Recently, Yamato et al suggested that the rates of wound dehiscence tend to increase as the body mass index (BMI) advances [8]. Two decades ago, Walters et al showed that the mean time of wound healing in disrupted

abdominal incision is 15 days, when the surgical debridement and drainage is successful, 67 days when the process is not successful and 23 days when the wound is re-sutured [9]. Given the high numbers of CS performed worldwide, any preventive measures which could potentially help reduce the incidence of wound complications would have a significant impact on national economic health plans.

In 2004, Anderson et al performed the latest meta-analysis concerning the impact of subcutaneous tissue closure on wound complication rates following C/S [10]. The authors included 7 randomized trials which involved 2,056 women and concluded that the risk of wound hematoma, seroma or any complication was reduced when subcutaneous tissue closure was undertaken [10]. Since then, however, several trials have been published in the field and an update of current evidence is required to reach firm conclusions.

The purpose of the present systematic review is to summarize the available data in the field and possibly provide guidance for current clinical practice.

Methods

Study design

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to design the present systematic review [11]. Eligibility criteria were predetermined by the authors. Specifically, we chose to avoid language or date restrictions during the literature search. We selected all randomized and quasi-randomized trials that reported outcomes of wound complications following subcutaneous tissue closure and controls (women that did not receive any type of preventive surgical strategy). All studies that reported outcomes in this field, regardless of the type of needle, type of suture, closure technique, type of incision (vertical or transverse), type of procedure (elective or urgent) and BMI were considered as eligible for inclusion. Clinical studies comparing subcutaneous tissue closure to subcutaneous drain or any other preventive strategy were excluded from

the present systematic review. Case reports and review articles were excluded from tabulation and analysis of results. Animal studies were also excluded.

The study selection took place in three consecutive stages. The titles and/or abstracts of all electronic articles were screened to assess their eligibility. All the articles that met or were presumed to meet the criteria were retrieved as full texts. Two authors (VP and AP) tabulated the selected indices in structured forms. Any discrepancies in the methodology, retrieval of articles, and statistical analysis were resolved by consensus.

Literature search and data collection

We used the Medline (1966-2016), Scopus (2004-2016), ClinicalTrials.gov (2008-2016) and Cochrane Central Register of Controlled Trials *CENTRAL* (1999-2016) databases in our primary search along with the reference lists of electronically retrieved full-text papers. The date of our last search was set at 31 of August 2016. Search strategies and results are shown in Figure 1.

Our search strategy included the in Pubmed was based on the search details (cesarean[All Fields] AND subcutaneous[All Fields]). The PRISMA flow diagram schematically presents the stages of article selection (Figure 1).

Quality assessment

The methodological quality of included randomized and quasi-randomized trials was evaluated with the modified Jadad scale using the following criteria: description of the studies as randomized along with details of randomization, description of the studies as double blind, details of double blinding procedure, information on withdrawals, and allocation concealment (Figure 2) [12].

Statistical analysis

Statistical meta-analysis was performed with the RevMan 5.3 software (*Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2011*). Confidence intervals were set at 95%. We aimed to choose between the random effects model (REM) and the fixed effects model (FEM) based on the results of the I^2 test. However due to due to the significant heterogeneity in the methodological characteristics of included studies, pooled odds ratios (OR) and 95% confidence interval (CI) for all primary and secondary outcomes were calculated, using the DerSimonian-Laird REM (Table 1) [13]. For the same reason publication bias was not tested due to the small number of studies and their gross heterogeneity (significant confounders that may influence the methodological integrity of these tests) [14].

Subgroup analysis

We aimed to perform subgroup analysis according to the BMI of enrolled patients. However, this was not possible due to the limited amount of available data.

Sensitivity analysis

All analyses were also performed with the fixed effects model. Results were reported only when they significantly changed the odds of developing a wound complication. Furthermore, we conducted sensitivity analysis by omitting one study at a time and by selecting only randomized trials in the field (thus excluding quasi-RCTs). This way, we evaluated whether selected studies significantly influenced the outcomes of the meta-analysis. Subcutaneous tissue depth has been previously linked to wound complications. In this context we chose to also perform sensitivity analysis of reported outcomes among cases with a tissue depth of >2 cm.

We also aimed to perform sensitivity analysis according to the type of needle, type of suture, closure technique, type of incision (vertical or transverse) and type of procedure (elective or urgent); however, lack of stratification of participants according to these variables precluded such analysis.

Definitions

The selected wound complication in the present meta-analysis included wound dehiscence, formation of seroma, hematoma, wound infection and aggregated wound disruption (all or most of the aforementioned complications). The latter index was extracted from studies included and when data were missing it was constructed by aggregating the aforementioned parameters.

Results

Excluded studies

One study was excluded from the present systematic review because it did not report the outcomes of interest [15]. Another study was excluded because it compared antibacterial vicryl to standard vicryl for subcutaneous tissue re-approximation in obese women [16]. Another study was excluded because it compared subcutaneous closure to closure and drain [17]. A fourth study investigated the impact of the type of needle (blunt vs sharp) on wound complications [18]. Another study was excluded because it was not relevant to the field [19]. The final study was not relevant with the field as it compared different types of suture materials for subcuticular skin closure [20]

Ongoing studies

One study is still ongoing in the field. The last update in Clinicaltrials.gov is provided at March 2016, however, it still has not recruited participants [21]. The primary outcome of this study is surgical site infection and the secondary outcomes include wound seroma, postoperative pain at 24 hours, postoperative fever and cosmetic outcome.

Included studies

Ten studies were finally included in our meta-analysis, which involved 3,696 women delivered by caesarean section [22-31]. Of them, 1,849 underwent subcutaneous tissue closure through running or interrupted sutures, while in the remaining 1,847 women the subcutaneous tissue was not closed. Esmer et al presented their outcomes according to two separated follow-up examination intervals, evaluating the patients on the first and fourth postoperative week (Esmer (1) and Esmer (2)) [22]. One study was identified as a quasi-RCT because researchers randomized patients based on an alternating-month basis [30]. Two more studies did not report the randomization method [27, 28]. We constructed two structured forms, which briefly present the methodological characteristics of included studies (Table 1) and the characteristics of enrolled patients (Table 2).

Outcomes

Our meta-analysis showed that re-approximation of the subcutaneous tissue significantly reduced the odds of developing any type of wound complication (3,811 women, REM, OR 0.66, 95% CI 0.47 – 0.93, Figure 3). The incidence of seroma was also limited (1,979 women, REM, OR 0.53, 95% CI 0.33 – 0.84, Figure S1). On the other hand, the incidence of hematoma remained unaffected by subcutaneous closure (1,663 women, REM, OR 0.74, 95% CI 0.22 – 2.42, Figure S2).

Given the fact that sutures are foreign material, we investigated their impact on developing an infection. According to the results of the present meta-analysis there seem to be no difference between the two groups in terms of wound infection (1,971 patients, REM, OR 0.99, 95% CI 0.70 -1.41, Figure S3).

Sensitivity analysis

The transition from the fixed effects model to the random effects model did not influence the statistical significance of the primary analysis. Moreover, the outcomes were not changed in the case of individual study exclusion. Furthermore, when we excluded the

quasi-RCT from the present analysis we observed that the significant effect of wound closure onaggregated wound disruption was not affected (1,979 women, REM, OR 0.53, 95% CI 0.33 – 0.84, outcomes from 8 studies [22, 23, 25-29, 31]).The remaining indices were not analyzed in the included quasi-RCT; hence no sensitivity analysis was needed.

Finally, the re-assessment of all indices by analyzing only studies that reported outcome on patients with a SC of >2 cm revealed significantly improved outcomes in the case of aggregated wound disruption (297 women, REM, OR 0.47, 95% CI 0.26, 0.85, outcomes from 2 studies [27, 29]), similar results in the case of wound infection (52 patients, REM, OR 2.08, 95% CI 0.18, 24.51, outcomes from one study [27]) and statistically improved results in the case of wound seroma (297 women, REM, OR 0.31, 95% CI 0.13, 0.73, outcomes from 2 studies [27, 29]). There were no cases with reported wound haematoma.

Discussion

Main findings

Elective cesarean section has gained significant ground in the field of obstetrics lasting recent years. Despite the fact that several efforts have been made to reduce its prevalence, it stills remain the most common elective abdominal operation; thus, even minimal complications, such as wound disruption, pose a significant burden for healthcare systems. In this context, efforts should aim to reduce the impact of wound complications. A recent meta-analysis on ten RCTs found that the implementation of wound drainage does not benefit women [32]. The findings of our meta-analysis indicate a promising beneficial effect of subcutaneous tissue closure following cesarean section as they show that the incidence of wound complications is significantly reduced after implementing this technique in the general population. This effect is ,however, mainly influenced by the significant reduction in the incidence of wound seroma, as neither wound hematoma nor wound infection seem to be affected by the introduction of subcutaneous suturing.

More than 10 years ago, two meta-analyses were published on this subject [10, 33]. The first one in 2004 by Anderson et al included seven studies with 2,056 women [10]. However, one of the studies included did not have a control group (204 women were stratified in two groups according to the needle of the suture (blunt vs sharp) [18]. The second meta-analysis by Chelmow et al included only five studies that included 887 patients [33]. Taking these in mind, our meta-analysis enhances current knowledge by increasing the number of enrolled parturient by at least 80%.

Sutures have been previously linked with wound infections, as they are foreign materials that can be easily colonized by bacteria. Modern sutures contain anti-bacterial barriers that prohibit their colonization; thus, limiting the risk of infection and/or abscess formation [34]. In the present meta-analysis, we did not find increased incidence of surgical site infection in patients with subcutaneous tissue closure. However, this observation is partly limited by the fact that each study used different types of sutures (Table 1). On the other hand, this heterogeneity provides information that represents a pragmatic approach of current clinical practice as the type of suture is mainly determined by the individual surgeon or hospital practice.

Several other factors may also influence wound complications including closure technique (multilayer or single layer), type of incision (vertical or transverse), type of procedure (elective or urgent) and BMI. However, none of the included studies investigated the impact of these parameters specifically on wound complications.

We also aimed to evaluate the effect of subcutaneous tissue closure in obese women that undergo C/S. Obesity has been already linked to surgical wound complications following a C/S [35]. Unfortunately, to date, only two studies investigated the impact of subcutaneous tissue closure in obese women, comparing them with controls (women with no closure) [27, 29]; hence, current data in the field remain extremely limited to draw definitive conclusions.

Strengths and limitations of our study

The findings of our study are based on a meticulous review of the literature. No language or date restriction were applied, therefore, the possibility of potential article losses is small. We included all randomized and quasi-randomized clinical trials in the field, thus, partly, reducing the risk of selection bias.

On the other hand, certain factors seem to limit our findings. Firstly, the available evidence is drawn from moderate quality studies (Figure 2). Secondly, the heterogeneity of included studies in terms of study and patient characteristics (Tables 1 and 2) partially limits the findings of our meta-analysis.Furthermore, power analysis was not available in several studies, while one study provided a power calculation which was based on an aesthetic scar assessment scale, rather than wound complications [23]

Interpretation

Based on the results of the present meta-analysis we believe that subcutaneous tissue closure should be practiced in patients undergoing cesarean section, as the technique results in reduced wound complications. Unfortunately, current evidence in obese women is very limited to draw any conclusions for this very important group of patients. In this context we strongly believe that future randomized trials should be focused in this particular population of women to investigate whether subcutaneous re-approximation offers any advantage or, alternatively, results in increased complications.

Conclusion

Subcutaneous tissue closure following cesarean section results in decreased wound complications and this should be taken into consideration in current clinical practice. The available data are limited, however, in obese women; hence further studies are needed for this specific group.

Disclosure of conflicts of interest: The authors report that they have no conflicts of interest to disclose. The ICMJE disclosure forms are available as online supporting information.

Contribution to authorship: VP and SD conceived the idea. VP and AP ran the electronic search. VP and DP performed the meta-analysis. All authors contributed to manuscript writing and approve the final draft.

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References

1. Pfuntner A, Wier L, Stocks C. Most Frequent Procedures Performed in U.S. Hospitals, 2010: Statistical Brief #149. 2013 Feb. In: Healthcare Cost and Utilization Project (HCUP) Statistical Briefs [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2006 Feb-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK132428/.

2. Gibbons L, Belizan JM, Lauer JA, Betran AP, Merialdi M, Althabe F. The Global Numbers and Costs of Additionally Needed and Unnecessary Caesarean Sections Performed per Year: Overuse as a Barrier to Universal Coverage. WHO World Health Report (2010) Background Paper, 30. http://www.who.int/healthsystems/topics/financing/healthreport/30C-sectioncosts.pdf.

3. Menacker F, Hamilton BE. Recent trends in cesarean delivery in the United States. NCHS data brief. 2010 Mar(35):1-8.

4. Hamilton BE, Martin JA, Osterman MJ. Births: Preliminary Data for 2015. National vital statistics reports : from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System. 2016 Jun;65(3):1-15.

5. Hager RM, Daltveit AK, Hofoss D, Nilsen ST, Kolaas T, Oian P, et al. Complications of cesarean deliveries: rates and risk factors. American journal of obstetrics and gynecology. 2004 Feb;190(2):428-34.

6. Conner SN, Verticchio JC, Tuuli MG, Odibo AO, Macones GA, Cahill AG. Maternal obesity and risk of postcesarean wound complications. American journal of perinatology. 2014 Apr;31(4):299-304.

7. Vermillion ST, Lamoutte C, Soper DE, Verdeja A. Wound infection after cesarean: effect of subcutaneous tissue thickness. Obstetrics and gynecology. 2000 Jun;95(6 Pt 1):923-6.

8. Yamasato K, Yoshino K, Chang AL, Caughey AB, Tsai PJ. Cesarean delivery complications in women with morbid obesity. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstet. 2016 May 23:1-4.

9. Walters MD, Dombroski RA, Davidson SA, Mandel PC, Gibbs RS. Reclosure of disrupted abdominal incisions. Obstetrics and gynecology. 1990 Oct;76(4):597-602.

10. Anderson ER, Gates S. Techniques and materials for closure of the abdominal wall in caesarean section. The Cochrane database of systematic reviews. 2004(4):CD004663.

11. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol. 2009 Oct;62(10):e1-34.

12. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? Controlled clinical trials. 1996 Feb;17(1):1-12.

13. DerSimonian R, Kacker R. Random-effects model for meta-analysis of clinical trials: an update. Contemporary clinical trials. 2007 Feb;28(2):105-14.

14. Souza JP, Pileggi C, Cecatti JG. Assessment of funnel plot asymmetry and publication bias in reproductive health meta-analyses: an analytic survey. Reproductive health. 2007;4:3.

15. Gaertner I, Burkhardt T, Beinder E. Scar appearance of different skin and subcutaneous tissue closure techniques in caesarean section: a randomized study. European journal of obstetrics, gynecology, and reproductive biology. 2008 May;138(1):29-33.

16. Veisi F, Zangeneh M, Malekkhosravi S, Rezavand N, Hemiari K, Rezaei M. Subcutaneous vicryl suture covering efficacy on wound complications after cesarean section. (J Kermanshah Univ Med Sci. 2016;15(3).

17. Ramsey PS, White AM, Guinn DA, Lu GC, Ramin SM, Davies JK, et al. Subcutaneous tissue reapproximation, alone or in combination with drain, in obese women undergoing cesarean delivery. Obstetrics and gynecology. 2005 May;105(5 Pt 1):967-73.

18. Stafford MK, Pitman MC, Nanthakumaran N, Smith JR. Blunt-tipped versus sharp-tipped needles: wound morbidity. Journal of obstetrics and gynaecology : the journal of the Institute of Obstetrics and Gynaecology. 1998 Jan;18(1):18-9.

19. Tuuli MG, Stout MJ, Martin S, Rampersad RM, Cahill AG, Macones GA. Comparison of suture materials for subcuticular skin closure at cesarean delivery. American journal of obstetrics and gynecology.

20. Tuuli MG, Stout MJ, Martin S, Rampersad RM, Cahill AG, Macones GA. Comparison of suture materials for subcuticular skin closure at cesarean delivery. American journal of obstetrics and gynecology. 2016 Oct;215(4):490 e1-5.

21. Abdelrahman RM. Closure Versus Non Closure of Subcutaneous Tissue After Cesarean Section in Diabetic Patients. NCT02664285. 2016.

22. Corbacioglu Esmer A, Goksedef PC, Akca A, Akbayir O, Dagdeviren H, Turan GY, et al. Role of subcutaneous closure in preventing wound complications after cesarean delivery with Pfannenstiel incision: a randomized clinical trial. The journal of obstetrics and gynaecology research. 2014 Mar;40(3):728-35.

23. Husslein H, Gutschi M, Leipold H, Herbst C, Franz M, Worda C. Suture Closure versus Non-Closure of Subcutaneous Fat and Cosmetic Outcome after Cesarean Section: A Randomized Controlled Trial. PloS one. 2014;9(12):e114730.

24. Huppelschoten AG, van Ginderen JC, van den Broek KC, Bouwma AE, Oosterbaan HP. Different ways of subcutaneous tissue and skin closure at cesarean section: a randomized clinical trial on the long-term cosmetic outcome. Acta obstetricia et gynecologica Scandinavica. 2013 Aug;92(8):916-24.

25. Chelmow D, Huang E, Strohbehn K. Closure of the subcutaneous dead space and wound disruption after Cesarean delivery. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstet. 2002 Jun;11(6):403-8.

26. Magann EF, Chauhan SP, Rodts-Palenik S, Bufkin L, Martin JN, Jr., Morrison JC. Subcutaneous stitch closure versus subcutaneous drain to prevent wound disruption after cesarean delivery: a randomized clinical trial. American journal of obstetrics and gynecology. 2002 Jun;186(6):1119-23.

27. Allaire AD, Fisch J, McMahon MJ. Subcutaneous drain vs. suture in obese women undergoing cesarean delivery. A prospective, randomized trial. The Journal of reproductive medicine. 2000 Apr;45(4):327-31.

28. Cetin A, Cetin M. Superficial wound disruption after cesarean delivery: effect of the depth and closure of subcutaneous tissue. International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics. 1997 Apr;57(1):17-21.

29. Naumann RW, Hauth JC, Owen J, Hodgkins PM, Lincoln T. Subcutaneous tissue approximation in relation to wound disruption after cesarean delivery in obese women. Obstetrics and gynecology. 1995 Mar;85(3):412-6.

30. Bohman VR, Gilstrap Iii LC, Ramin SM, Little BB, Santos-Ramos R, Goldaber KG, et al. Subcutaneous tissue: to suture or not to suture at cesarean section. Infectious diseases in obstetrics and gynecology. 1994;1(6):259-64.

31. Del Valle GO, Combs P, Qualls C, Curet LB. Does closure of Camper fascia reduce the incidence of post-cesarean superficial wound disruption? Obstetrics and gynecology. 1992 Dec;80(6):1013-6.

32. Gates S, Anderson ER. Wound drainage for caesarean section. The Cochrane database of systematic reviews. 2013(12):CD004549.

33. Chelmow D, Rodriguez EJ, Sabatini MM. Suture closure of subcutaneous fat and wound disruption after cesarean delivery: a meta-analysis. Obstetrics and gynecology. 2004 May;103(5 Pt 1):974-80.

34. Wu X, Kubilay NZ, Ren J, Allegranzi B, Bischoff P, Zayed B, et al. Antimicrobial-coated sutures to decrease surgical site infections: a systematic review and meta-analysis. European journal of clinical microbiology & infectious diseases : official publication of the European Society of Clinical Microbiology. 2016 Sep 2.

35. 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 : an international journal of obstetrics and gynaecology. 2012 Oct;119(11):1324-33.

Figure legends

Figure 1. The search plot presents the main methodological steps of data collection.

Figure 2. JADAD score for the evaluation of enrolled randomized and quasi-randomized trials.

Figure 3. Any type of wound complications. The overall effect was statistically significant and favored subcutaneous tissue closure (p=.02).

Figure S1. Seroma formation. The overall effect was statistically significant (p=.008).

Figure S2. Haematoma formation. The overall effect was not significant (p=.61).

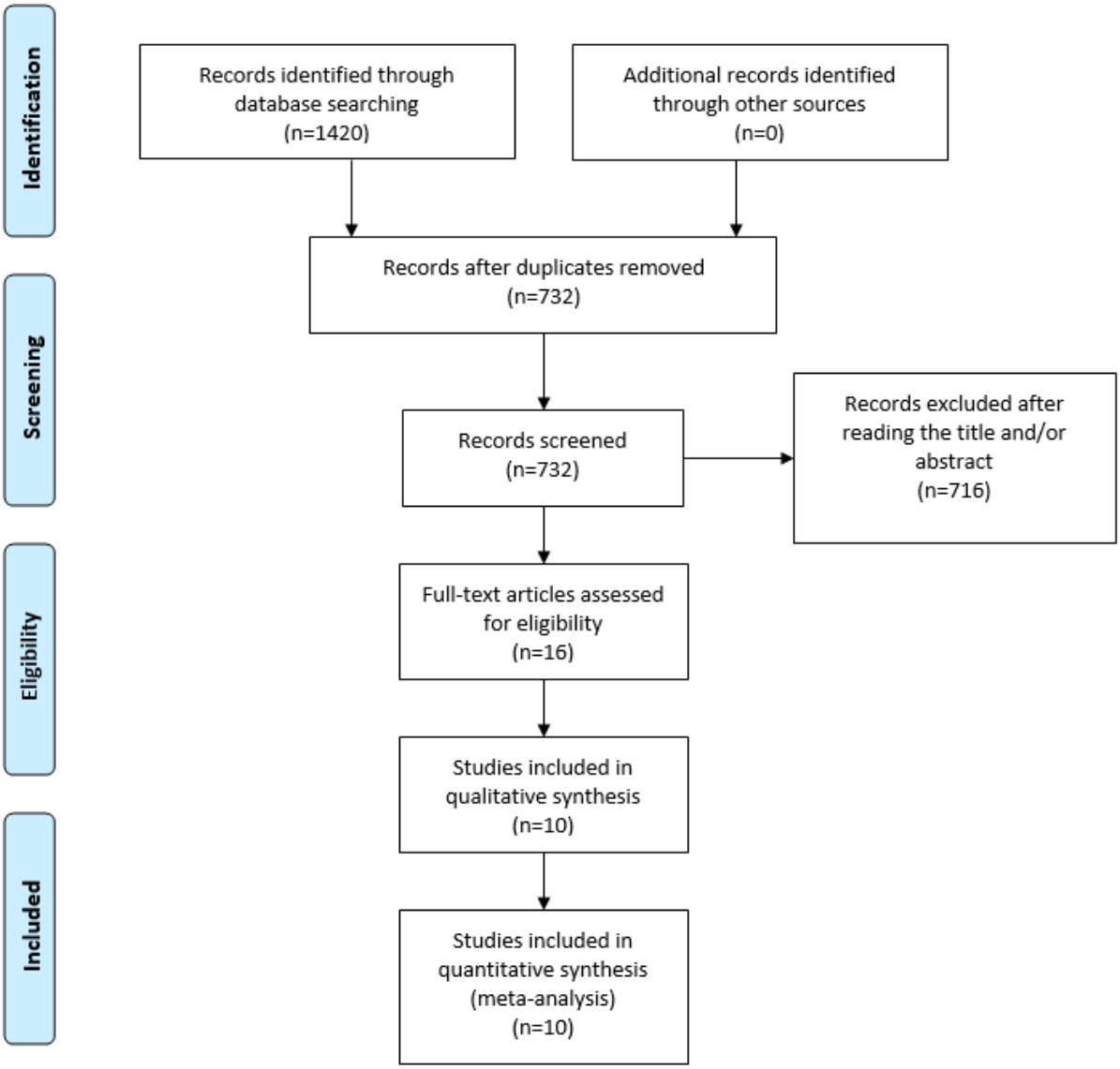
Figure S3. Risk of infection. The overall effects was similar among groups (p=.96).

Table 1. Study characteristics (closure vs non-closure)				
Year; Author	***Type of study***	***Inclusion criteria***	***Exclusion criteria***	***Groups definition-Type of suture***
2014; Esmer	RCT	N/A	Preoperative diagnosis of amnionitis; steroid or antibiotic therapy; coagulopathy; placement of drain	Interrupted 2-0 polyglactin 910 (Vicryl) vs closure of skin only
2014; Husslein	RCT	Age 18 to 45 years; Caucasian origin and literate in German language	Infection; HELLP or preeclampsia; keloids; previous transverse suprapubic scars; medical disorders that affect wound healing	3-5 interrupted, Polysorb 3–0 sutures vs closure of skin only
2013; Huppelschoten	RCT	Women ≥ 18 years old and literate in Dutch language.	Emergency cesarean section due to lack of obtain (written) informed consent.	3 interrupted Vicryl 1.0 sutures vs closure of skin only
2002; Chelmow	RCT	N/A	N/A	3-0 plain gut running suture vs closure of skin only
2002; Magann	RCT	N/A	Emergency cesarean; refusal to participate in the study	3-0 polyglycolic running suture vs closure of skin only
2000; Allaire	RCT	Women required cesarean delivery; and had at least 2 cm of subcutaneous fat	Emergency cesarean; possible delay of delivery due to consent process	Single horizontal running suture 3.0 Vicryl vs closure of skin with staples
1997; Cetin	RCT	All patients undergoing cesarean delivery	Antibiotics within the preceding 2 weeks	3-0 Synthetic delayed absorbable

				suture materials vs closure of skin only
1995; Nauman	RCT	Women required cesarean delivery; and had at least 2 cm of subcutaneous fat	Patients with at least 2 cm of subcutaneous fat	3-0 polyglycolic acid running suture vs closure of skin only
1994; Bohman	qRCT	N/A	Incomplete data; or laparotomy performed for indications other than cesarean section	0 polydioxanone suture vs closure of skin only
1992; Del Valle	RCT	N/A	N/A	Multiple interrupted sutures or a continuous absorbable suture usually 3-0 plain vs closure of skin only

Table 2. Patient characteristics (closure vs non closure)									
Year; Author	***Patients***	***Age (years)***	***BMI***	***Maternal DM***	***Previous CS***	***Emergency CS***	***Length of surgery***	***Gestational age***	***Tissue thickness***
2014; Esmer	176 vs 185	28.4 ± 5.4 vs 28.3 ± 5.3	N/A	16/176 vs 8 /185	115/176 vs 120/185	79/176 vs 85/185	32.6 ± 7.4 vs 32.8 ± 7.7	N/A	25.5 ± 10.7 vs 23.4 ± 7.9
2014; Husslein	47 vs 44	28 (18–43) vs 30 (17–40)	26.6 (19.6–39.7) vs 28.6 (17.4–39.2)	0/47 vs 0/47	26/47 vs 20/47	1/47 vs 4/44	N/A	N/A	N/A
2013; Huppelschoten	110 vs 108	32 (21–42) vs 31 (21–45)	29.4 (21.6–44.9) vs 29.9 (17.1–42.9)	N/A	25/110 vs 21/108	0/110 vs 0/108	N/A	275 (239–296) vs 274 (229–295)	N/A
2002; Chelmow	162 vs 165	30.2 (6.2) vs 30.0 (6.0)	N/A	N/A	106/162 vs 111/165	N/A	N/A	37.7 (3.9) vs 37.8 (3.3)	2.3 (1.1) vs 2.3 (1.1)
2002; Magann	191 vs 205	25.7 ± 6.2 vs 25.8 ± 5.7	39.4 ± 8.6 vs 39.8 ± 7.2	14/191 vs 16/205	92/191 vs 96/205	0/191 vs 0/205	46.5 ± 15.8vs 45.1 ± 18.2	N/A	3.7 ± 1.6 vs 3.4 ± 1.4
2000; Allaire	26 vs 26	26.6±7.3 vs 23.4±5.1	N/A	4/26 vs 0/26	13/26 vs 14/24	0/26 vs 0/24	78.0±40.3 vs 62.9±190	N/A	3.3±1.1 vs 3.1±1.0

1996; Cetin	Group A	35 vs 33	28.2 ± 3.7 vs 25.0 ±3.5	N/A	1/35 vs 1/35	7/35 vs 6/33	N/A	31.6±7.2 vs 32.2 ± 7.7	39.1 ± 1.1 vs 38.9 ± 1.3	1.5 ± 0.3 vs 1.6 ± 0.2
	Group B	47 vs 44	27.0 ± 5.3 vs 28.0 ± 5.6	N/A	2/47 vs 2/44	9/47 vs 8/44	N/A	34.3 ± 6.4 vs 33.5 ± 6.7	38.8 ± 1.6 vs 38.8 ± 1.4	3.4 ± 0.9 vs 3.3 ± 1.0
1995; Nauman		117 vs 128	24.9 ± 5.8 vs 25.6 ± 5.6	36.4 + 7.6 vs 37.7 ± 9.3	30/117 vs 13/128	39/117 vs 41/128	N/A	56.2 ± 22.2 vs 56.5 + 20.5		4.0 + 1.4 vs 4.4 ± 2.0
1994; Bohman		716 vs 693	25 ± 6 vs 25 ± 6	N/A	34/716 vs 21/693	326/716 vs 300/693	N/A	48 ± 18 vs 49 ± 19	N/A	N/A
1992; Del valle		222 vs 216	26.3 ±0.4 vs 25.8±0.4	31.3±0.4 vs 30.3±0.4	N/A	34/222 vs 36/216	N/A	63.6±1.3 vs 60.9±1.3	38.2±0.2 vs 38.1 ±0.3	N/A



	2014; Esmer	2014; Husslein	2013; Huppelschoten	2002; Chelmow	2002; Magann	2000; Allaire	1997; Cetin	1995; Nauman	1994; Bohman	1992; Del Valle
Was the study described as random?	+	+	+	+	+	+	+	+	+	+
Was the randomization scheme described and appropriate?	+	+	+	+	+	−	−	+	−	+
Was the study described as double-blind?	−	−	−	−	−	−	−	−	−	−
Was the method of double blinding appropriate?	−	−	−	−	−	−	−	−	−	−
Was there a description of dropouts and withdrawals?	+	+	+	+	+	+	+	+	+	−

Study or Subgroup	Subcutaneous suture Events	Total	No suture Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
1992; Del valle	6	222	16	216	7.8%	0.35 [0.13, 0.90]
1994; Bohman	40	716	59	693	15.5%	0.64 [0.42, 0.96]
1995; Nauman	17	117	34	128	11.7%	0.47 [0.25, 0.90]
1997; Cetin	9	82	15	77	8.5%	0.51 [0.21, 1.24]
2000; Allaire	4	26	7	26	4.8%	0.49 [0.12, 1.95]
2002; Chelmow	14	162	21	165	10.7%	0.65 [0.32, 1.32]
2002; Magann	20	191	20	205	11.6%	1.08 [0.56, 2.08]
2014; Esmer (1)	29	176	20	185	12.3%	1.63 [0.88, 3.00]
2014; Esmer (2)	22	165	24	165	12.1%	0.90 [0.48, 1.69]
2014; Husslein	3	47	15	47	5.1%	0.15 [0.04, 0.54]
Total (95% CI)		**1904**		**1907**	**100.0%**	**0.66 [0.47, 0.93]**
Total events	164		231			

Heterogeneity: $Tau^2 = 0.15$; $Chi^2 = 19.62$, df = 9 (P = 0.02); $I^2 = 54\%$
Test for overall effect: Z = 2.40 (P = 0.02)