REVIEW

Suture Closure of Subcutaneous Fat and Wound Disruption After Cesarean Delivery: A Meta-Analysis

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OBJECTIVE: To define the role of suture closure of the subcutaneous dead space in preventing wound complications after cesarean delivery.

DATA SOURCES: We searched MEDLINE, the Cochrane Database of Systematic Reviews, and the bibliographies of major texts and review articles.

METHODS OF STUDY SELECTION: Only studies in which patients undergoing cesarean delivery were randomly assigned to closure of the subcutaneous space or to no closure were included. Each study was required to report on at least 1 of the following outcomes: wound infection, hematoma, seroma, or separation. The studies also reported "wound disruption," a combination of these outcomes which either explicitly stated or strongly implied the need for further wound care. Six studies meeting criteria were identified.

TABULATION, INTEGRATION, AND RESULTS: Three studies included 875 patients with any subcutaneous thickness and noted a decrease in wound disruption with closure (relative risk [RR] 0.56; 95% confidence interval [CI] 0.36, 0.86). Two studies reported results from 181 patients with incision depth of 2 cm or less and noted no difference (RR 1.01; 95% CI 0.46, 2.20). Five studies reported results on 887 patients with wound thickness greater than 2 cm. Although only 1 study had a significant effect by itself, when results were combined, there was a significant decrease in wound disruption (RR 0.66; 95% CI 0.48, 0.91). This reduction seems to be largely a result of decreased wound seromas (4 studies, 852 patients, RR 0.42; 95% CI 0.24, 0.75). In women with wound thickness greater than 2 cm, subcutaneous closure resulted in a risk reduction of 6.2%, and 16.2 women would need subcutaneous closure to prevent 1 wound disruption (number needed to treat).

CONCLUSION: Suture closure of subcutaneous fat during cesarean delivery results in a 34% decrease in risk of wound disruption in women with fat thickness greater than 2 cm. (Obstet Gynecol 2004;103:974–80. © 2004 by The American College of Obstetricians and Gynecologists.)

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Throughout the world, cesarean delivery accounts for approximately 20% of all deliveries. Disruption of the skin incision is a major source of postoperative morbidity after cesarean delivery, occurring after 2.5–16% of procedures.[1] Typically reported risk factors for wound breakdown are duration of surgery, obesity, diabetes, patient age, coincident infection, and poor nutrition.[2] Fortunately, women undergoing cesarean delivery are usually young and healthy, with short hospital stays. Multiple studies have investigated various measures to prevent wound complications.

Closure of the subcutaneous tissue to prevent wound disruption has been advocated by some, stressing the importance of approximating large amounts of dead space. Many other practitioners do not routinely close this space; in fact, some argue it may increase wound disruption. Opinion has varied as to the causes of wound disruption and whether, indeed, subcutaneous closure would make a difference. There is basic science data suggesting that these sutures could increase infection risk,[3] and at least 1 major text emphatically suggests not closing this layer.[4] In the last decade randomized prospective surgical trials[5–10] have been conducted to evaluate the utility of subcutaneous wound closure at cesarean delivery and its role in preventing wound breakdown. Only 1 of these studies[9] demonstrated significantly decreased risk with closure, with others showing nonstatistically significant decreases and others no apparent effect. We performed a meta-analysis to attempt to resolve this conflict.

SOURCES

MEDLINE was searched for the period 1966 to October 2002 for studies indexed by the key word "cesarean section," and any one of "Camper fascia," "surgical wound dehiscence," "subcutaneous fat," "dead space," "subcutaneous closure," "subcutaneous approximation," "suture technique," " wound disruption," " wound separation," "seroma," or "hematoma." We manually screened reference lists from major texts, published stud-

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ies, and review articles. Only randomized, controlled trials were included in the meta-analysis.

STUDY SELECTION

Inclusion criteria were the following:

1. Patients were randomly assigned to the treatment groups.
2. There was a no-closure control group.
3. Information on blinding was clearly stated.
4. Each study included data on at least 1 of the 4 outcomes of interest (wound infection, hematoma, seroma, or separation), and these outcomes were clearly defined and reported.

Article titles were reviewed, and if the article could not unequivocally be determined to be excluded from the title alone, the abstract, and, if necessary, the entire paper were reviewed. Data from relevant studies were extracted independently by 2 of the authors, reviewed, and recorded onto data sheets. Data sheets were compared with the intention of having conflicts resolved by the third author (none occurred).

Summary relative risks (RRs) and Q tests for heterogeneity were calculated with MetaAnalyst .99 software (Lau J. MetaAnalyst, version .99. Boston, MA: Tufts-New England Medical Center; 1999). Tests for heterogeneity were not statistically significant, justifying the use of the fixed-effect Mantel–Haenszel RR as the summary measure throughout our analysis. Sensitivity analysis was performed excluding each individual study and recalculating the summary RR and confidence interval (CI). Summary group mean incidences of adverse outcomes were calculated, weighted by the sample size. An α value of .05 was chosen for statistical significance. Ninety-five percent CIs were reported throughout.

RESULTS

A total of 431 papers was identified in the initial literature search. All but 19 could be excluded by reviewing the title. Of the 19 abstracts reviewed, 6 studies appeared to meet the criteria for inclusion in our meta-analysis. After review of the 6 papers, it was determined that all met criteria for inclusion. The excluded papers could easily be seen to be on other subjects or to be retrospective reviews based on the content of the title and abstract. Review of the Cochrane Library of Systematic Reviews, major texts, review articles, and the bibliographies of the 6 papers did not yield any further papers.

Characteristics of the 6 studies are presented in Table 1. Five of the studies were done in the United States. All were done in training institutions. Both running and interrupted sutures were used, and suture material varied as well but was usually plain gut or a rapidly absorbable suture such as polyglycolic acid. Several studies were not clear when interrupted or running suture was used, and all included scant detail on issues like spacing of sutures. Only a single study[7] commented on the use of irrigation or electrocautery during wound closure. In general, wound thickness was measured after fascia closure, with a sterile ruler at the midpoint of the incision. For Pfannenstiel incisions, the measurement was made along the superior aspect of the skin incision. All studies appeared to have achieved effective randomization. The studies used similar, but not identical, definitions for the various wound complications (Table 2). In addition to reporting one of the individual outcomes required for study selection, each study also defined and reported an outcome of "wound disruption," a combination of the individual outcomes. The definition of this outcome either explicitly stated or implied the need for further wound care. Table 3 shows the various study sizes and wound complication rates for each study. In the absence of subcutaneous closure, the baseline incidences of complications were seroma 8.5% (95% CI 6.0%, 11.5%), hematoma 1.6% (95% CI 0.7%, 3.3%), wound infection 7.1% (95% CI 5.1%, 9.5%), and wound disruption 14.3% (95% CI 12.0%, 16.9%).

Many clinicians believe subcutaneous dead space closure is only efficacious in heavier patients, and study design reflected this. Likely because of this bias, only 3 articles[6–8] included patients with any thickness subcutaneous tissue in their study. Combining these 3 studies, which included 875 patients, a significant reduction in wound complications was noted (RR 0.56; 95% CI 0.36, 0.86; test for heterogeneity $Q = 1.35$, $P = .51$). However, examination of the 2 studies[6,7] that separately reported outcomes in patients with subcutaneous thickness of 2 cm or less (Figure 1) did not suggest any effect in these patients (181 patients, RR 1.01; 95% CI 0.46, 2.20; test for heterogeneity $Q = 0.14$, $P = .71$). Five studies[5–7,9,10] reported outcomes in 887 patients with wound thickness greater than 2 cm (Figure 2), of which only one[9] showed a statistically significant protective effect on its own. Combining results from these studies noted a strongly significant reduction in wound disruption (RR 0.66; 95% CI 0.48, 0.91; test for heterogeneity $Q = 5.28$, $P = .26$).

We also examined individual wound complications in an effort to determine whether the overall risk reductions stemmed from prevention of specific types of wound complications. There was no evidence of an effect on hematomas or wound infections. For hematomas (Figure 3A), summarizing results from 4 studies[5,6,9,10] with 852 subjects showed an RR of 1.03 (95% CI 0.38, 2.76; test for heterogeneity $Q = 2.89$, $P = .41$).

Table 1. Study Characteristics

Study	Study period	Location	Population	Exclusions	Suture material
Del Valle et al[8]	1/1991–1/1992	University of New Mexico, Albuquerque, NM	Resident service	None	Absorbable, 3–0, interrupted or running
Naumann et al[9]	10/1991–4/1993	University of Alabama, Birmingham, AL	Resident service	Subcutaneous tissue < 2 cm	Polyglycolic 3–0, running
Cetin and Cetin[6]	2/1995–5/1996	Cumhuriyet University Hospital, Sivas, Turkey	Resident service	Antibiotic use 2 wks prior, required cardiac antibiotic prophylaxis	Absorbable, 3–0, interrupted or running
Allaire et al[5]	11/1995–3/1997	Grady Memorial Hospital, Atlanta, GA	Resident service	Emergent delivery, subcutaneous tissue < 2 cm	Absorbable 3–0, running
Chelmow et al[7]	9/1995–6/1997	Tufts-New England Medical Center, Boston, MA	Faculty and resident service	Drain placement or delayed primary closure planned preoperatively	Absorbable 3–0, running
Magann et al[10]	1/1998–3/2001	University of Mississippi Medical Center, Jackson, MS	University hospital, residents involved in surgery	Subcutaneous thickness < 2 cm, emergent delivery	Polyglycolic 3–0, running

Blank spaces indicate data not provided in study.
* Maternal weight is presented as body mass index (kg/m^2) in this study.

For wound infections (Figure 3B), summarizing results from 5 studies[5–7,9,10] with 1,130 subjects yielded an RR of 0.98 (95% CI 0.65, 1.49; test for heterogeneity Q= 1.28, P = .86). There was, however, a strongly significant reduction in seroma formation (Figure 3C) when results from the 4 studies with this outcome[5,6,9,10] were combined (852 subjects, RR 0.42; 95% CI 0.24, 0.75; test for heterogeneity Q= 1.56, P = .67).

Sensitivity analysis performed by removing any single study from any of the above analyses did not markedly change the RRs or 95% CIs. Baseline incidence of wound disruption in patients with subcutaneous thickness greater than 2 cm was 18.1%. The summary RR of wound disruption was 0.66 with subcutaneous closure, yielding a risk reduction of 6.2%, and 16.2 women with subcutaneous thickness greater than 2 cm would need subcutaneous closure to prevent 1 wound disruption (number needed to treat).

CONCLUSIONS

Wound infections occur after 2.5–16% of all cesarean deliveries.[1] Given the large number of cesarean deliveries, this constitutes substantial morbidity and cost. With current trends away from vaginal birth after cesarean delivery and toward elective cesarean delivery, the cesarean birth rate is likely to climb still further and wound complications become even more significant. Many strategies have been studied to decrease wound infection rates, including antibiotic prophylaxis[11,12] and wound drainage. Wound drainage in particular has shown conflicting results in cesarean delivery patients, with 1 study[5] showing a decreased risk of wound complications with drainage compared with either subcutaneous dead space closure or standard closure, a second study[13] showing no benefit, and yet a third study[14] showing a nonstatistically significant, higher risk of infection.

Theoretically, by suturing the fat tissue and closing the subcutaneous dead space, the formation of hematomas and seromas could be prevented, thereby preventing wound disruption. Alternately, by including an additional foreign body, a nidus for wound infection formation may be created, increasing wound infection. Possibly, both mechanisms could occur simultaneously. A review of practice guidelines and textbooks revealed no clear statement on subcutaneous closure with cesarean delivery. At present, usual practice depends on individual provider preference.

Previously, it was thought that there was not adequate evidence to guide clinical practice regarding subcutaneous space closure. Using meta-analysis techniques to summarize the 6 available studies, we were able to clarify a number of questions. Specifically, we chose wound disruption as our main outcome of interest, because hematoma, seroma, and infection resulting in wound

Age (y)		Length of surgery (min)		Maternal weight (kg)	
Suture	No suture	Suture	No suture	Suture	No suture
26.3	25.0	63.6	60.9	31.3*	30.3*
24.9	25.6	56.2	56.5	95.6	100.6
28.2	25.0	31.6	32.2	70.4	71.1
26.6	23.4	78.0	62.9	99.5	88.0
30.0	30.0	. . .	. . .	85.8	84.4
25.7	25.8	46.8	45.1	105.2	106.5

breakdown are all of clinical significance and concern to the patient. Further, because the subgroup of hematomas and seromas that lead to wound breakdown may have subclinical infection, all 3 may be related. Additionally, the subgroup analyses of separate wound complications (hematomas, seromas, and wound infections) were helpful and important in suggesting that the decrease in wound seromas is most clearly associated with the prevention of wound disruption. Our research also sheds some evidence in favor of the accepted surgical dogma that subcutaneous closure is only warranted in heavier patients. The protective effect (34% decrease in wound disruption risk) was confined to the subgroup of patients with subcutaneous depth greater than 2 cm.

The individual studies showed a range of RRs for wound disruption with subcutaneous closure. Given the lack of heterogeneity, it appears that the studies do not conflict, but rather show consistent effects previously unclear because of the lack of power of the individual relatively small studies. These consistent effects became clear once the studies were examined in combination. Also of note, the 2 larger studies[7,10] did not show reductions in risk in heavier women. Nonetheless, in our

Table 2. Summary of Individual Study Outcomes and Definitions

Study	Outcome	Definition of outcome
Del Valle et al[8]	Seroma	Serous fluid collection in absence of infection
	Hematoma	Subcutaneous blood in absence of infection
	Wound infection	Erythema, induration, and pus in wound
	Wound disruption	Spontaneous or iatrogenic separation of wound edges requiring drainage, packing, and healing by secondary intention
Naumann et al[9]	Seroma	Draining serosanguinous fluid and not meeting criteria for wound infection
	Hematoma	Not defined
	Wound infection	Drained purulent material; or incision required opening and 2 or more classical signs: erythema, tenderness, induration, or fever
	Wound complication	Disruption $\geq$ 1 cm in the incision
Cetin and Cetin[6]	Seroma/Hematoma	Presence of serous fluid collection or subcutaneous blood without signs of infection
	Wound infection	Drained purulent material or incision required opening and showed 2 or more signs of infection: erythema, tenderness, induration, or fever
	Wound disruption	Spontaneous or iatrogenic separation of wound edges $>$ 1 cm (all of the above)
Allaire et al[5]	Seroma/Hematoma	Presence of serous fluid or blood collection in the absence of infection
	Wound infection	Displayed 2 or more of the following characteristics: drainage of purulent material, erythema, tenderness, induration, or fever
	Wound separation	Disruption $>$ 1 cm in incision that required packing and healing by secondary intention
Chelmow et al[7]	Wound collection	Significant amount (few milliliters) of bloody or clear fluid (not purulent) drained from the incision either spontaneously or by probing
	Wound infection	Purulent material drained or the incision needed to be opened and any 2 of the following were present: fever, warmth, erythema, or induration
	Wound separation	Skin separated enough to admit a sterile cotton-tipped swab easily
Magann et al[10]	Seroma	Collection of serous fluid in the wound without evidence of infection
	Hematoma	Demonstrable blood clot between the rectus fascia and skin
	Wound infection	Wound with induration and erythema that contained purulent discharge
	Wound disruption	Hematoma, seroma, or infection that required that the incision be opened, evacuated, and/or irrigated and débrided

Table 3. Summary of Study Size and Outcomes

Study	Study size		Wound disruption		Seroma		Hematoma		Wound infection	
	Closure	No closure	Closure (%)	No closure (%)	Closure (%)	No closure (%)	Closure (%)	No closure (%)	Closure (%)	No closure (%)
Del Valle et al[8]	222	216	6 (2.7)	16 (7.4)	. . .	. . .	. . .	. . .	. . .	. . .
Naumann et al[9]	117	128	17 (14.5)	34 (26.6)	6 (5.1)	22 (17.2)	4 (3.4)	2 (1.6)	7 (6.0)	10 (7.8)
Cetin and Cetin[6]*	A: 35	33	4 (11.4)	3 (9.1)	2 (5.7)	1 (3.0)	0 (0.0)	1 (3.0)	2 (5.7)	1 (3.0)
	B: 47	44	5 (10.6)	12 (27.3)	3 (6.4)	6 (13.6)	1 (2.1)	3 (6.8)	1 (2.1)	3 (6.8)
Allaire et al[5]	26	26	5 (19.2)	11 (42.3)	2 (7.7)	3 (11.5)	0 (0.0)	0 (0.0)	2 (7.7)	1 (3.8)
Chelmow et al[7]	162	165	14 (8.6)	21 (12.7)	. . .†	. . .†	. . .†	. . .†	11 (8.1)	13 (9.1)
Magann et al[10]	191	205	20 (10.5)	20 (9.8)	2 (1.0)	5 (2.4)	2 (1.0)	1 (0.5)	16 (8.4)	14(6.9)

Blank spaces indicate data not provided in study.
* Group A < 2 cm; group B ≥ 2 cm.
† Article presented aggregated seromas and hematomas 2 (1.5%) versus 7 (4.9%).

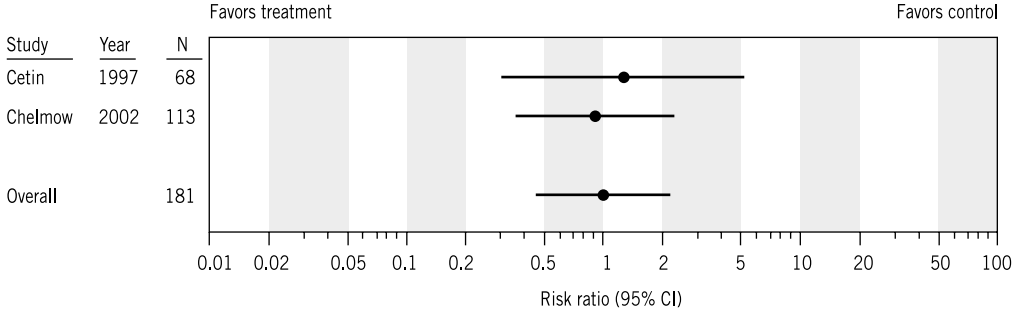

Figure 1. Summary of studies reporting wound disruption in patients with subcutaneous tissue depth less than or equal to 2 cm. *Solid circles* represent relative risks from individual studies. The *solid lines* represent the 95% confidence intervals (CI). Summary relative risk is presented at the bottom. A Mantel–Haenzel fixed-effects model was used. "Overall" includes all studies. N = number of subjects in each study.
Chelmow. Subcutaneous Fat Closure. Obstet Gynecol 2004.

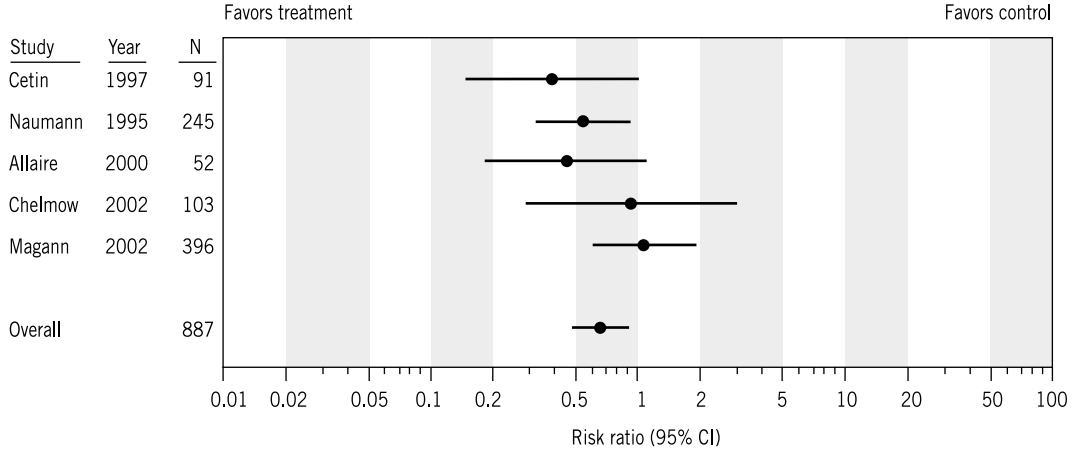

Figure 2. Summary of studies reporting wound disruption in patients with subcutaneous tissue depth greater than 2 cm. *Solid circles* represent relative risks from individual studies. The *solid lines* represent the 95% confidence intervals (CI). Summary relative risk is presented at the bottom. A Mantel–Haenzel fixed-effects model was used. "Overall" includes all studies. N = the number of subjects in each study.
Chelmow. Subcutaneous Fat Closure. Obstet Gynecol 2004.

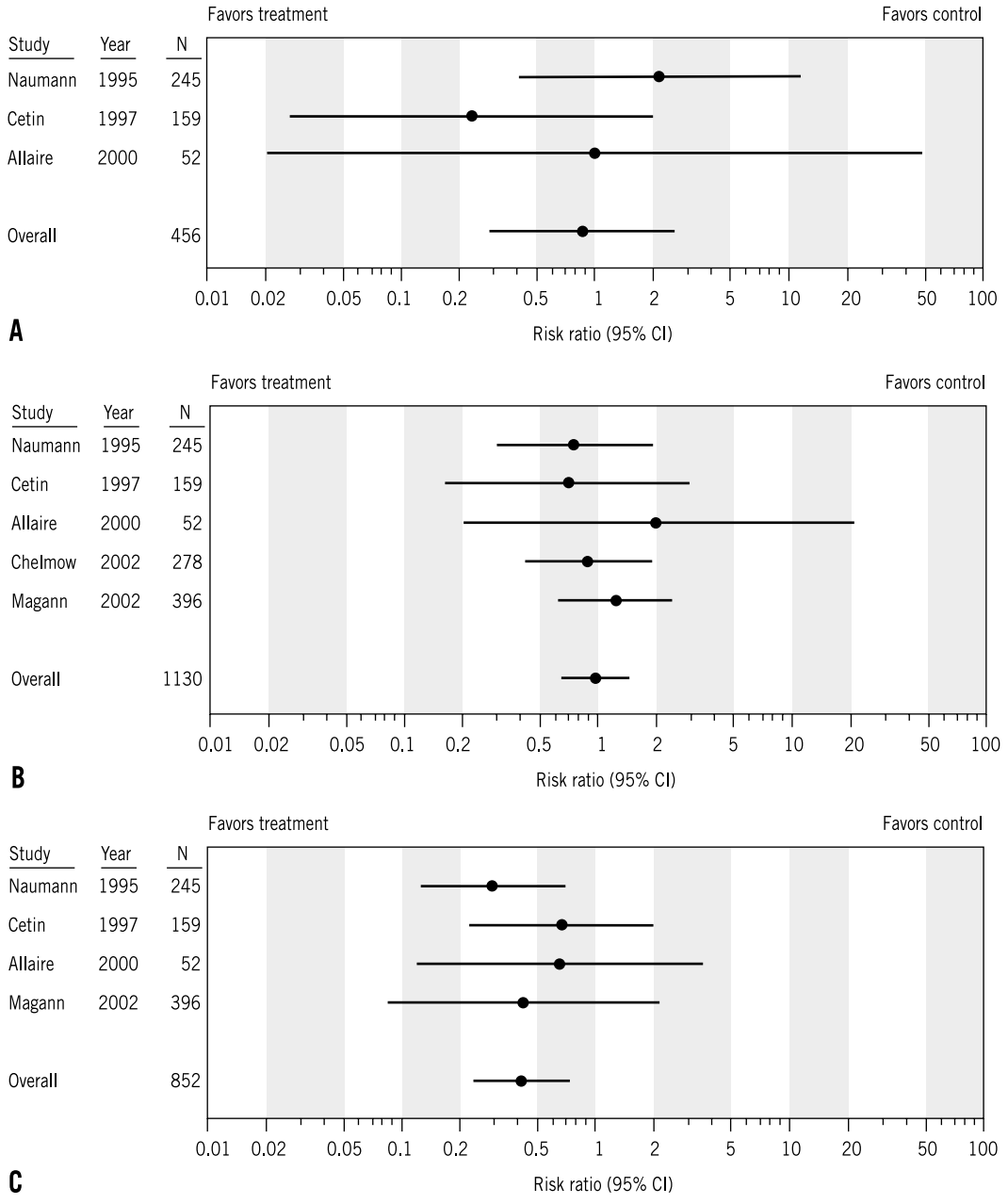

Figure 3. Summary of studies reporting separate types of wound complications. A) Hematomas, B) wound Infection, and C) seromas. *Solid circles* represent relative risks from individual studies. The *solid lines* represent the 95% confidence intervals (CI). Summary relative risk is presented at the bottom. A Mantel–Haenzel fixed-effects model was used. "Overall" includes all studies. N = the number of subjects in each study.

Chelmow. Subcutaneous Fat Closure. Obstet Gynecol 2004.

sensitivity analysis, including these 2 larger studies and excluding the only one with a statistically significant result[9] only minimally changed the summary RR.

The results of our meta-analysis strongly suggest that subcutaneous wound closure should be performed in all cesarean-delivery patients with wound thickness greater than 2 cm. Because the various individual studies presented scant data on suture material, primary versus repeat procedure, and incision type, further study is necessary to determine the optimal suture material and whether this effect is uniform over all incision types and for primary and repeat procedures. Because the bulk of

the procedures in these studies were done through Pfannenstiel incisions, subcutaneous dead space closure should be performed with Pfannenstiel incisions. Many practitioners and several of the studies used rapidly absorbable suture (3–0 plain), and this seems to be a reasonable choice.

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