The association of skin incision placement during cesarean delivery with wound complications in obese women: a systematic review and meta-analysis

Rebekah J. Mccurdy , Laura A. Felder , Gabriele Saccone , Rodney K. Edwards , Loralei L. Thornburg , Caroline Marrs , Shayna N. Conner , Robert Strauss & Vincenzo Berghella

Taylor & Francis
Taylor & Francis Group

Check for updates

ORIGINAL ARTICLE

The association of skin incision placement during cesarean delivery with wound complications in obese women: a systematic review and meta-analysis

Rebekah J. Mccurdy[a,b], Laura A. Felder[b], Gabriele Saccone[c], Rodney K. Edwards[d], Loralei L. Thornburg[e] (iD), Caroline Marrs[f], Shayna N. Conner[g], Robert Strauss[h] and Vincenzo Berghella[a,b] (iD)

[a]Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine, Thomas Jefferson University Hospital, Philadelphia, PA, USA; [b]Department of Obstetrics and Gynecology, Thomas Jefferson University Hospital, Philadelphia, PA, USA; [c]Department of Neuroscience, Reproductive Science and Dentistry, School of Medicine, University of Naples Federico II, Naples, Italy; [d]Department of Obstetrics and Gynecology, University of Oklahoma College of Medicine, Oklahoma City, OK, USA; [e]Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine, University of Rochester Medical Center, Rochester, NY, USA; [f]Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine, The University of Texas Medical Branch, Galveston, TX, USA; [g]Division of Maternal Fetal Medicine, Washington University School of Medicine, Saint Louis, MO, USA; [h]Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine, University of North Carolina, Chapel Hill, NC, USA

ABSTRACT

Objective: To determine the risk of wound complications by skin incision type in obese women undergoing cesarean delivery.

Data sources: Electronic databases (MEDLINE, Scopus, and Ovid) were searched from their inception through August 2018.

Methods of study selection: We included all randomized controlled trials and cohort studies reporting the placement of skin incision during cesarean section in obese women, defined as those with BMI ≥ 30 kg/m^2. Studies were included if they compared one placement of skin incision with a different one as comparison group. The primary outcome was incidence of wound complications, while secondary outcomes included wound infection, hematoma, seroma, post-partum hemorrhage, and endometritis. Demographics and outcomes for each individual study identified were reported as part of the review. Meta-analysis was performed using the random effects model of DerSimonian and Laird, to produce summary treatment effects in terms of mean difference (MD) or relative risk (RR) with 95% confidence interval (CI). Sub-group analyses (vertical versus Pfannenstiel) were also reported.

Tabulation, integration and results: Seventeen studies (including 3 RCTs; 8960 participants among the 15 non-overlapping studies) were included in the systematic review. Vertical incisions were associated with a relative risk of 2.07 (95% CI 1.61–2.67) for wound complications compared to transverse incisions, however significant possible confounders were present. Studies were mildly-moderately heterogeneous (I^2 44.81%, 95% CI 0.00–71.85%) with varying definitions of obesity and wound complications. High transverse incisions (3 studies, 218 participants) trend toward a lower risk of wound complications compared to low transverse incisions (RR 0.338, 95% CI 0.114–1.004).

Conclusions: Vertical incisions may be associated with an increased risk for wound complications compared to transverse incisions for cesarean delivery in obese women. Randomized controlled trials are needed to evaluate optimal cesarean skin incisions for these women.

Introduction

More than one-third of US reproductive-aged women are obese, defined by the World Health Organization (WHO) and the National Academy of Medicine as a body mass index (BMI) greater than or equal to 30 kg/m^2 [1,2]. Obesity is a known risk factor for multiple adverse pregnancy outcomes affecting both mother and fetus [3–6].

Surgery in obese gravidas may be challenging as visibility is limited and retraction of subcutaneous tissues may be difficult. Obese patients experience increased intraoperative complications, such as increased operating time, increased blood loss,

difficulty obtaining adequate neuraxial anesthesia, and increased conversion to general anesthesia [7]. Obese women also experience more postoperative complications including fascial dehiscence, seromas, hematomas, wound infections including cellulitis and abscess, endometritis, and deep vein thrombosis [3,8–17]. Obese patients have an increased need for cesarean delivery (OR 2.05, 95% CI 1.86–2.27) compared to normal weight women [6,18]. The need to limit complications in this patient population is therefore an increasingly important aspect of prenatal and intrapartum care.

The risk for wound complications increases proportional to BMI and is independently associated even when accounting for gestational and pregestational diabetes [8,9]. Vermillion et al. found that it was subcutaneous tissue thickness rather than BMI that was associated with wound complication in obese women undergoing cesarean delivery [10]. This suggests that incision placement may play an important role in determining postoperative outcomes. Presumably the subcutaneous tissue depth is limited by making an incision beneath the pannus. However, this leaves the incision in a skin fold that may be difficult to keep clean and dry, which could ultimately increase the risk of wound infection. Incisions going through extensive subcutaneous layers may experience increased operating times and potentially increased blood loss from more extensive dissection. Further, vertical incisions are associated with increased risk for non-lower segment surgery, including increased use of classical uterine incisions, which increases operative risk and has implications for future pregnancy [11]. Objective evidence upon which to guide incision placement during cesarean delivery in obese patients is limited. This study aims to evaluate the relationship between cesarean delivery skin incision placement in obese patients and postoperative wound complications.

Sources and study selection

Search strategy

This was a systematic review and meta-analysis. Electronic databases (MEDLINE, Scopus, and Ovid as well as ClinicalTrials.gov) were searched from their inception through August 2018. Search terms included "incision", "cesarean", "caesarean", "pregnancy", "obesity", "overweight", "infection", and "wound complication". No restrictions for language or geographic location were applied. In addition, the reference lists of all identified articles were examined to identify studies not captured by electronic searches.

The electronic search and the eligibility of the studies were independently assessed by two authors (RM, LF). Differences were resolved via discussion with a third reviewer (VB).

Study selection

We included all randomized controlled trials and cohort studies reporting the placement of skin incision during cesarean delivery in obese women, defined as those with BMI $\geq 30\,kg/m^2$. Studies were included if they compared one placement of skin incision with a different one as the comparison group.

Case series, studies without a comparison group, as well as studies not reporting the placement of skin incision, BMI, or the primary outcome (wound complications) were also excluded. Only manuscripts with at least ten cases were included in order to minimize publication bias.

Data extraction

The primary outcome was incidence of wound complications as defined by the individual study authors. Secondary outcomes were wound infection, hematoma, seroma, incisional separation, and readmission to the hospital for wound concern. Other secondary outcomes were endometritis, operative time, and blood loss greater than 1000 ml or requiring a blood transfusion. Wound infection was defined as wound cellulitis or abscess requiring antibiotic therapy. Patient satisfaction and perceived cosmesis were additional planned secondary outcomes. We defined placement of skin incisions, according to direction (vertical vs transverse), above or below the umbilicus, and above versus below the pannus. We identified eight different potential placements of skin incision:

- Vertical supra-umbilical supra-pannus
- Vertical infra-umbilical supra-pannus
- Vertical infra-umbilical infra-pannus (in crease)
- Transverse supra-umbilical supra-pannus
- Transverse infra-umbilical supra-pannus
- Transverse infra-umbilical infra-pannus (in crease)
- Vertical otherwise undefined
- Horizontal otherwise undefined

Therefore we had the potential for several analyses according to placement of skin incision (Supplemental Table 1). Where the term Pfannenstiel is used, this refers to a transverse infra-umbilical infra-pannus incision. All authors were contacted to confirm that use of

the term "Pfannenstiel" accurately depicted this placement. Additional data not initially supplied in the published manuscript was obtained from the authors whenever possible. Data coding was completed by two reviewers (LF and RM) with discussion with a third reviewer (VB) if any difference between the first two reviewers.

Two authors (RM, LF) independently assessed inclusion criteria, study selection, and data abstraction. Disagreements were resolved by discussion with a third reviewer (VB). Data from each eligible study were abstracted without modification of original data onto custom-made data collection forms. Information on potential confounders (maternal BMI, diabetes, closure of subcutaneous layer, suture vs staples for skin closure, perioperative antibiotics, diagnosis of chorioamnionitis, and presence of drains) and adjusted risk estimates were collected when available. All authors were contacted for missing data.

In the course of this review, one study referenced in the review and meta-analysis (Marrs 2014) was removed by the editorial board of the publishing journal secondary to an error made in statistical analysis (variable coding was erroneously switched between the two incision types compared). After discussion with the primary author as well as review of the reasons for removal from the editors of the journal, it was confirmed that the error was in the statistical analysis (the magnitude of risk calculated was correct, however it was attributed to the incorrect group) and not in the underlying "raw" data. Thus the "raw" data is included in this review in an effort to be as comprehensive as possible with the evidence currently available.

Assessment of risk of bias

The risk of bias of the included studies was assessed using the Methodological Index for Non-Randomized Studies (MINORS) criterion [19]. Eight domains are included to aid in the evaluation of risk of bias: (1) Aim, (2) Rate (inclusion of consecutive patients and response rate), (3) Data (prospective versus retrospective collection of data), (4) Bias (unbiased assessment of study end points, (5) Blind (if participants and researchers were blinded), (6) Time (follow-up time appropriate), (7) Loss (loss to follow-up), (8) Size (calculation of the study size). The items were scored 0 if not reported, 1 when reported but inadequate, and 2 when reported and adequate. The global ideal score was 16 for non-comparative studies and 24 for comparative studies. We considered low risk of bias when

studies fulfilled all MINORS criteria and high risk of bias otherwise. Consensus was reached by the two reviewers (RM/LF) when there was a difference of opinion on an item. If no consensus was reached, the independent opinion of a third reviewer (VB) was considered decisive.

Data synthesis

The data analysis was completed independently by two authors (RM, GS) using MedCalc v 18.2.1 (MedCalc Software, Acacialaan 22, B-8400 Ostend, Belgium). The completed analyses were then compared, and any difference was resolved by discussion with a third reviewer (VB). Potential publication biases were assessed visually with inspection of funnel plots. Thornburg's dataset included the data from Wall's study, and Marr's 2014 dataset included the data from Smid's study (this was confirmed via contact with the individual authors), thus the review presents all seventeen studies identified, but the meta-analysis includes only the fifteen non-overlapping studies. Differences between risk factors for wound complications by incision type were analyzed by Fisher's exact test (two-tailed analysis). A 2×2 table was assessed for relative risk; for continuous outcomes, means ± standard deviation were extracted and imported to MedCalc. Frequencies and percentages of risk factors for wound complications were reported individually for studies as well as composites. Meta-analysis was performed using the random effects model of DerSimonian and Laird, to produce summary treatment effects in terms of mean difference (MD) or relative risk (RR) with 95% confidence interval (CI). I-squared (Higgins I^2) greater than 30% was used to identify heterogeneity. p Value $<.05$ was considered statistically significant.

The study was designed and conducted according to the Meta-analysis and Systematic Reviews of Observational Studies (MOOSE) guidelines [20]. This systematic review was deemed exempt from institutional review board (IRB) by the Thomas Jefferson University IRB because of the nature of the research design. Before data extraction, the review was registered with the PROSPERO International Prospective Register of Systematic Reviews (CRD73635).

Results

Study selection and characteristics

Seventeen studies were identified which utilized at least two different incision types for cesarean and stratified outcomes by incision type in obese women
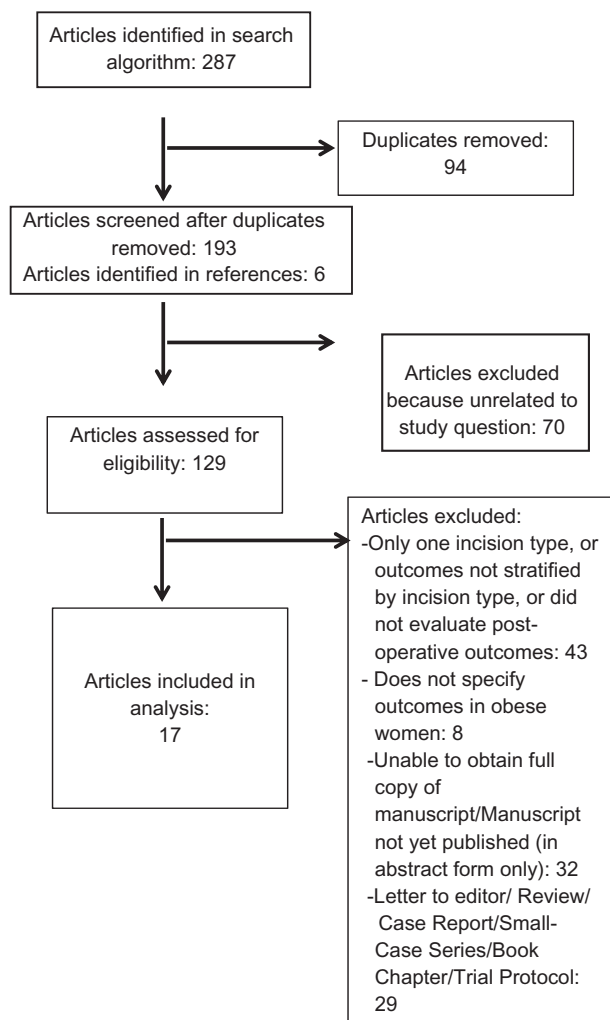
Figure 1. Study selection flow diagram (in accordance with PRISMA 2009 flow diagram) [47].

(Prisma Flow Diagram, Figure 1). Two studies overlapped (included a subgroup of the same patients) with two other included studies, leaving fifteen non-overlapping studies for meta-analysis ($n = 8960$). All studies were either retrospective cohorts or secondary analyses of observational cohorts (Table 1), with the exception of two recently published randomized controlled trials. All studies were based in the United States, except for one study in France and one in Egypt.

Incision types included both vertical and transverse types not otherwise specified (Table 1). Three meta-analysis comparisons were possible: all vertical versus all transverse incisions; and all vertical versus transverse infra-umbilical infra-pannus (Pfannenstiel) and high-transverse versus low-transverse incisions. Specifics regarding the incision placement were variably reported and not clearly defined according to bone, pannus, or umbilical landmarks in the studies, even after contacting authors.

Obesity was likewise variably defined. All utilized body mass index (BMI), but the criteria for inclusion ranged from >30 to $>50\,\mathrm{kg/m^2}$ and some utilized pre-pregnancy BMI (2 studies) while others used pre-delivery BMI (12 studies) and others did not specify when BMI was measured (3 studies). In almost every study, those receiving vertical incisions had a higher BMI than those receiving transverse incisions (Table 2) and this is reflected in the meta-analysis (vertical incision mean BMI of 48.6 versus transverse incision mean BMI of 45.5, $p < .0001$).

Several risk factors for complications were not similar between vertical incisions and transverse incisions (Table 2). Women with vertical incisions had a higher incidence of overall diabetes (and pregestational diabetes, but not gestational diabetes) and had lower rates of surgical prophylactic antibiotics, which are risk factors for wound complications. On the other hand, women with vertical incisions were more likely to have the subcutaneous layer closed (which has been associated with a lower incidence of wound complications) [21]. The incidence of chorioamnionitis and skin closure with staples was similar in the two groups, and, while the incidence of subcutaneous drain was higher in the vertical incision group, this has not been shown to be a risk factor for wound complications [22,23]. Meta-regression and an adjusted meta-analysis was not able to be performed as we did not have access to individual patient data.

Risk of bias in included studies

Publication bias, assessed with visual inspection of funnel plot, did not reveal asymmetry. All studies contained elements of bias as assessed by the MINORs criteria (Supplemental Table 1) and were thus considered high risk for bias. Included studies demonstrated low-medium heterogeneity for overall wound complication outcome (I^2 44.81%).

Synthesis of results

The meta-analysis reveals that all types of vertical incision were more likely to have wound complications when compared to all types of transverse incisions (14.1 vs. 7.8%; RR 2.07, 95% CI 1.61, 2.67, Figure 2, Tables 3 and 4). In addition, all types of vertical incisions were more likely to have wound infections, endometritis, postpartum hemorrhage, and wound separation ($p < .01$ for each respectively, Table 4). Transverse incisions were not associated with a lower incidence of hematoma and seroma ($p > .05$ for both,

Table 1. Characteristics of studies included in review.

	Site	Study design	Total study number (N)	Incision types	Pannus	Definition of obesity	Exclusion criteria	Primary outcome
Wall et al., 2003 [33]	USA	Retrospective cohort	239	Vertical (above and below umbilicus); Unspecified transverse	NR	Pre-pregnancy BMI >35 kg/m²	• Periumbilical transverse incision • Incomplete medical record • Repeat cesarean	Wound complication before discharge requiring wound exploration
Tixier et al., 2009 [32]	France	Retrospective cohort	18	Subumbilical transverse (low transverse) incision; Supraumbilical (high transverse) transverse incision	Described as voluminous for all included patients	BMI ≥40 kg/m²	• Those without a "voluminous pannus"	Post-operative complications
Alanis et al., 2010 [34]	USA	Retrospective cohort	194	Vertical were midline/paramedian, above/below umbilicus; Transverse (Pfannenstiel except one supra-pannus infra-umbilical)	NR	Pre-delivery BMI ≥50 kg/m²	• Maternal death	Wound complications (wound disruption, cellulitis, NOT superficial wound opening)
Bell et al., 2011 [35]	USA	Retrospective cohort	424	Vertical (above or below umbilicus); Transverse (Pfannenstiel)	Transverse mostly infra-pannus	BMI >35 kg/ m² at delivery	• None	Prevalence of vertical uterine incision
McLean et al., 2011 [36]	USA	Secondary analysis of observational cohort	242	Vertical: Transverse (Pfannenstiel)	NR	BMI ≥30 kg/m²	• Incomplete record	Partial or complete wound separation
Thornburg et al., 2012 [37]	USA	Retrospective cohort	623	Vertical; Low transverse	All transverse incisions infra-pannus	Pre-pregnancy BMI >35 kg/m²	• Prior CD • Other type of skin incision • Incomplete record	Wound complication (wound separation, wound infection)
Brocato et al., 2013 [11]	USA	Retrospective cohort	135	Supra-umbilical vertical; Pfannenstiel	NR	BMI >40 kg/m²	• Multiple gestations – Incomplete records	Occurrence of classical hysterotomy
Conner et al., 2014 [8]	USA	Retrospective cohort	2444	Midline vertical; Pfannenstiel	NR	BMI ≥30 kg/m² on admission	• Incomplete record	Would complication (seroma, hematoma, separation, dehiscence, or infection) within 6 weeks
Marrs et al., 2014 [38]	USA	Secondary analysis of cohort	3200	Vertical; Transverse	NR	BMI ≥40 kg/m² at delivery	• Stillbirth • Unknown skin incision • Prior cesarean section • <24 weeks gestation	Composite wound complication (infection, seroma, hematoma, evisceration, fascial dehiscence)
Ahmadzia et al., 2015 [39]	USA	Retrospective Cohort Study	335	Vertical; Pfannenstiel	NR	>290 lbs at delivery	• Multiple gestations • Vaginal deliveries • Penicillin or cephalosporin allergy • HIV • Suspected chorioamnionitis • Antibiotic type not recorded (for prophylaxis)	Surgical site infections (including superfision, deep, and organ space, including endometritis infections)
Smid et al., 2015 [40]	USA	Secondary cohort analysis	2411	Vertical: Pfannenstiel	NR	BMI >45 kg/m² at delivery	• Age <15 or >45 • Incomplete record	Composite of wound complication (infection, endometritis, wound opening, seroma or hematoma, and

(continued)

Table 1. Continued.

	Site	Study design	Total study number (N)	Incision types	Pannus	Exclusion criteria	Definition of obesity	Primary outcome
Sutton et al., 2016 [41]	USA	Retrospective cohort	421	Vertical; Transverse	All transverse incisions infra-pannus	• <34 weeks gestational age • Multiple gestations • Periumbilical transverse incision • Known fetal anomalies • Planned hysterectomy	BMI ≥40 mg/kg^2 at delivery	Wound complication (cellulitis, abscess, hematoma, seroma, dehiscence) within 6 weeks
Walton et al., 2017 [42]	USA	Retrospective cohort	128	High Transverse; Low Transverse	High Transverse Suprapannus; Low Transverse Infrapannus	• Ages <18 or >45 • Gestational age <23 weeks • Incomplete records including postpartum records	BMI ≥40 mg/kg^2 at delivery	Wound complication (infection, seroma, hematoma, dehiscence)
Marrs et al., 2018 [43]	USA	RCT	91	Vertical; Pfannenstiel	Vertical incision was Infrapannus or suprapannus at the discretion of the surgeon	• Rupture of membranes >18 hours • Clinical chorioamnionitis • Vaginal delivery • Private practice patients • Inmates • Other clinical trial enrollees • Those with indication for incision in a specific location • Ages < 18 or >50 years • Gestational age < 24 weeks	BMI ≥40 mg/kg^2 at delivery	Wound complication composite (surgical site infection, cellulitis, seroma/hematoma, or separation up to 6 weeks postpartum)
Wihbey et al., 2018 [44]	USA	RCT (Secondary Analysis)	166	Vertical; Pfannenstiel	NR	• <18 years of age • Non-English speakers • Allergy to silver or adhesives products • Skin incisions that would not fit the negative pressure device	BMI ≥35 mg/kg^2 at delivery	Superficial Surgical Site Infections
Looby et al., 2018 [45]	USA	Retrospective Cohort	467	Vertical; Pfannenstiel	NR	• Missing data on chart abstraction	BMI ≥40 mg/kg^2 at delivery	Surgical Site Infections
El Sayed et al., 2018 [46]	Egypt	RCT	72	Transverse Supraumbilical; Pfannenstiel	Pfannenstiel incisions were infrapannus; comparison group included transverse suprapannus, supraumbilical incisions	• Not scheduled for cesarean • Gestational age <36 weeks • Hemoglobin <10 g/dL • Medication usage (including cortisone and anti-coagulants)	BMI ≥40 mg/kg^2 at delivery	Surgical Site Infection (assessed after 7 days)

NR: Not recorded; lbs: pounds.

Table 2. Risk factors for postoperative complications.

Study	BMI (kg/m²)	Maternal diabetes	Subcutaneous layer closed	Perioperative Antibiotics	Chorioamnionitis	Skin closed with staples	Subcutaneous drains
Wall et al., 2003** [33]	V 44.1±6.0 T 41.2±4.8	V 5/26 (19.2%) T 38/213 (17.8%)	V 9/26 (34.6%) T 12/213 (5.6%)	V 24/26 (92.3%) T 187/213 (87.8%)	V 1/26 (3.8%) T 33/213 (15.5%)	NS	V 5/26 (19.2%) T 5/213 (2.3%)
Tixier et al., 2009 [32]	NR	NR	NR	NR	NR	NR	NR
Alanis et al., 2010 [34]	V 56.1* T 52.8*	V 41/104 (39.4%) T 17/90 (18.9%)	V 71/104 (68.3%) T 34/90 (38.7%)	V 58/104 (55.8%) T 65/90 (72.2%)	V 6/104 (5.8%) T 5/90 (5.6%)	V 74/104 (71.2%) T 26/90 (28.9%)	V 57/104 (54.8%) T 10/90 (11.1%)
Bell et al., 2011 [35]	V 48.2±9.1 T 41.7±6.7	NR	NR	NR	NR	NR	NR
McLean et al., 2011 [36]	V 43* T 36*	Pre-gestational V 8/25 (32.0%) T 23/213 (10.8%) Gestational V 5/25 (20.0%) T 25/213 (11.7%)	V 11/25 (44.0%) T 33/213 (15.5%)	V 21/25 (84.0%) T 163/213 (76.5%)	NR	V 25/25 (100.0%) T 197/213 (92.5%)	V 12/25 (48.0%) T 15/213 (7.0%)
Thornburg et al., 2012 [37]	V NR T NR	V 6/35 (17.1%) T 49/588 (8.3%)	V 16/35 (45.7%) T 169/588 (28.7%)	V 35/35 (100.0%) T 588/588 (100.0%)	V 2/35 (5.7%) T 86/588 (14.6%)	NS	V 9/35 (25.7%) T 22/588 (3.7%)
Brocato et al., 2013 [11]	V 64±10 T 56±6	V 21/43 (48.8%) T 8/90 (8.9%)	NR	V 43/43 (100.0%) T 90/90 (100.0%)	NR	NR	V 18/43 (41.9%) T 9/90 (10.0%)
Conner et al., 2014 [8]	V NR T NR	V 9/73 (12.3%) T 89/1643 (5.0%)	NS	V 53/73 (72.6%) T 1326/1643 (79.8%)	NR	NR	NR
Marrs et al., 2014 [38]	V 47.2±6.4 T 45.3±5.2	Pre-gestational V 44/597 (7.4%) T 124/ 2603 (4.8%) Gestational V 78/597 (13.1%) T 344/2603 (13.2%)	NR	V 473/597 (79.2%) T 2564/2603 (98.5%)	V 75/597 (12.6%) T 243/2603 (9.3%)	NR	NR
Ahmadzia et al., 2015 [39]	NR	NR	NR	NR	NR	NR	NR
Smid et al., 2015** [40]	NR	NS	NR	NS	NR	NR	NR
Sutton et al., 2016 [41]	V 54.5±12.1 T 47.6±6.2	Pre- gestational V 22/57 (38.6%) T 53/364 (14.6%) Gestational V 13/57 (22.8%) T 50/364 (13.7%)	NR	NR	V 3/57 (5.3%) T 32/364 (8.8%)	V 54/57 (94.7%) T 219/364 (60.2%)	NR
Walton et al., 2017 [42]	HT 49.9±9.0 T 49.8±7.6	HT 15/32 T 45/96	NR	NR	NR	NR	NR
Marrs et al., 2018 [43]	V48±6 T 50±8	Pre-gestational V 6/41 T 13/50 Gestational V 7/41 T 11/50	V 37/38*** T 38/39	V 41/41 T 49/50	NR***	V 13/41 T 13/50	V 0/41 T 0/50
Wihbey et al., 2018 [44]	NR	NR	NR	NR	NR	NR	NR

Table 2. Continued.

Study	BMI (kg/m²)	Maternal diabetes	Subcutaneous layer closed	Perioperative Antibiotics	Chorioamnionitis	Skin closed with staples	Subcutaneous drains
Looby et al., 2018 [45]	V 45.7±4.8 T 45.3±4.6	V 4/35 T 11/249	NR	NR	V 1/35 T 4/249	V 30/35 T 227/249	NR
El Sayed et al., 2018 [46]	HT 47.2±3.3 T 45.9±3.1	HT 9/36 T 5/36	NR	NR	NR	NR	NR
Total	Comparison #1: Summary data for the 6 studies with means and SD listed for V vs T. V: 48.6±8.3, n=814 T: 45.5±5.9, n=3739 p<.0001 Comparison #2: Summary Data for the 2 studies with means and SD listed for HT vs. T. HT: 48.5±6.7, n=68 T: 48.7±6.9, n=102 p=.852	Diabetes overall V 264/1010 (26.1%) T 867/6022 (14.4%) HT 24/68 (35.3%) p<.001 Pre-gestational V 80/720 (11.1%) T 213/3230 (6.6) p<.0001 Gestational V 103/720 (14.3%) T 430/3230 (13.1%) p=.480	V 135/202 (66.8%) T 274/930 (29.5%) p<.001	V 724/918 (78.9%) T 4845/5277 (91.8) p<.001	V 87/828 (10.5%) T 370/3894 (9.5%) p=.374	V 196/262 (74.8%) T 682/966 (70.6%) p=.181	V 96/248 (38.7%) T 56/1032 (5.4%) p<.001

NS: Not stratified by incision type; NR: Not recorded.
*These studies were not included in the statistical analysis because standard deviations were not included.
**These studies are not included in the meta-analysis of data as both of these studies' datasets are included in other studies in this review.
***This particular RCT recommended closure if subcutaneous thickness was ≥3 cm. This study also listed chorioamnionitis as an exclusion criteria.

Table 4) when compared to vertical incisions. Furthermore, operative time was 22.5 min longer for all types of vertical incisions when compared to all types of transverse incisions (81.1 vs. 58.6 min, $p = .002$, Table 4).

When comparing all types of vertical incisions specifically to transverse infra-umbilical infra-pannus

incisions, vertical incisions were more likely to have wound complications (RR 1.99, 95% CI 1.43, 2.77, $p < .001$, Table 5, Figure 3). In addition, wound infection, postpartum hemorrhage, and wound separation were increased in all types of vertical incisions when compared to transverse infra-umbilical infra-pannus incision ($p < .05$, Table 5).

Only one study compared vertical supra-umbilical supra-pannus incisions to transverse infra-umbilical infra-pannus incisions [11]. Overall wound complications occurred in 8/43 (18.5%) subjects in the vertical group and 7/90 (7.8%) in the transverse group (χ^2, $p = .065$). Endometritis occurred in 2/43 (4.7%) in the vertical group and 2/90 (2.2%) in the transverse group (χ^2, $p = .384$). Postpartum hemorrhage occurred in 14/43 (32.6%) in the vertical group and 11/90 (12.2%) in the transverse group (χ^2, $p = .012$). A cesarean was completed in a mean of 97 ± 38 min in the vertical group and 68 ± 30 min in the transverse group ($p < .001$).
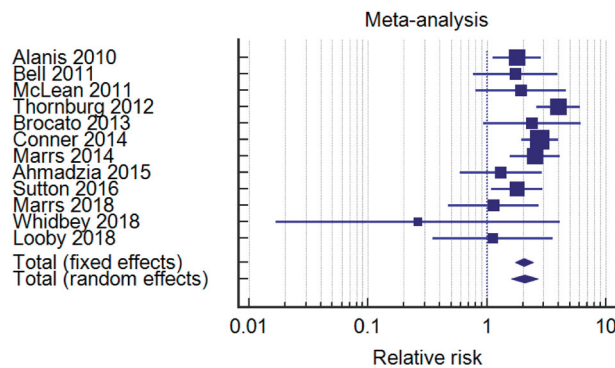
Figure 2. Forest Plot of overall wound complications (as defined by authors) for all vertical incisiosn versus all transverse incisions.

Table 3. Postoperative complication outcomes.

	Wound complications	Wound infection	Endometritis	PPH*	Operative time (mins)	Hematoma	Seroma	Wound separation	Hospital readmission
Wall et al., 2003** [33]	V 9/26 T 20/213	V 5/26 T 15/213	V 4/26 T 31/213	NR	V 74 ± 19.2 T 68 ± 22.0	NR	NR	NR	NR
Tixier et al., 2009 [32]	HT 0/5 LT 0/13	HT 0/5 LT 0/13	NR	NR	NR	NR	NR	NR	NR
Alanis et al., 2010 [34]	V 39/104 T 19/90	NS	NR	V 46/104 T 23/90	V 71 T 58.5	NR	NR	NR	NR
Bell et al., 2011 [35]	V 6/41 T 29/341	NR	NR	V 4/41 T 6/383	V 79 T 72	NR	NR	NR	NR
McLean et al., 2011 [36]	V 5/25 T 22/213	V 2/25 T 28/213	V 0/25 T 14/213	V 0/25 T 4/213	V 65.6 T 50.6	NR	V 1/25 T 12/213	V 5/25 T 22/ 213	V 0/25 T 5/213
Thornburg et al., 2012 [37]	V 16/35 T 68/588	V 10/35 T 42/588	V 4/35 T 54/588	V 9/35 T 90/588	NR	V 0/35 T 9/588	V 4/35 T 3/588	V 8/35 T 27/588	NR
Brocato et al., 2013 [11]	V 8/43 T 7/90	NR	V 2/43 T 2/90	V 14/43 T 11/90	V 97 ± 38 T 68 ± 30	NR	NR	NR	NR
Conner et al., 2014 [8]	V 24/73 T 194/1643	V 18/73 T 169/1643	V 0/73 T 19/1643	V 3/73 T 51/1643	V 80.6 ± 32.3 T 57.2 ± 21.6	V 3/73 T 13/1643	V 2/73 T 6/1643	V 1/73 T 6/1643	NR
Marrs et al., 2014 [38]	V 25/597 T 43/2603	V 17/597 T 31/2603	V 82/597 T 253/2603	V 19/597 T 48/2603	NR	V 2/597 T 9/2603	V 11/597 T 12/2603	V 6/597 T 8/2603	NR
Ahmadzia et al., 2015 [39]	V 6/36 T 38/298	V 6/36 T 38/298	NR	NR	NR	NR	NR	NR	NR
Smid et al., 2015** [40]	V 113/669 T 224/1742	V 80/669 T 155/1742	V 67/669 T 133/1742	NR	NR	V 13/669*** T 14/ 1742		NR	V 25/669 T 62/ 1742
Sutton et al., 2016 [41]	V 15/57 T 54/364	V 15/57 T 51/364	NR	V 4/57 T 7/364	V 73 T 55	V 3/57 T 9/364	V 3/57 T 17/364	V 2/57 T 5/364	V 10/57 T 39/ 364
Walton et al., 2017 [42]	HT 5/32 LT 26/96	NR	HT 1/32 LT 8/96	NR	NR	NR	NR	NR	NR
Marrs et al., 2018 [43]	V 8/38 T 8/43	V 3/38 T 3/43	NR	V 3/38 T 7/43	V 69 ± 21 T 68 ± 32	V 0/38*** T 2/43		V 3/38 T 5/43	V 1/41 T 2/50
Wihbey et al., 2018 [44]	V 0/14 T 19/152	V 0/14 T 19/152	NR	NR	NR	NR	NR	NR	NR
Looby et al., 2018 [45]	V 3/35 T 19/249	V 3/35 T 19/249	NR	NR	V 75.6 ± 29.8 T 63.1 ± 18.9	NR	NR	NR	V 0/35 T 12/249
El Sayed et al., 2018 [46]	HT 4/36 LT 21/36	NR	NR	NR	HT 88.5 ± 7.7 LT 91.0 ± 9.2	NR	NR	NR	NR

NS: Not stratified by incision type; NR: Not recorded; NA: Not available.
*Postpartum hemorrhage as defined by the authors.
**These studies are not included in the meta-analysis of data as both of these studies' datasets are included in other studies in this review.
***This study combined both seroma and hematoma as an outcome.

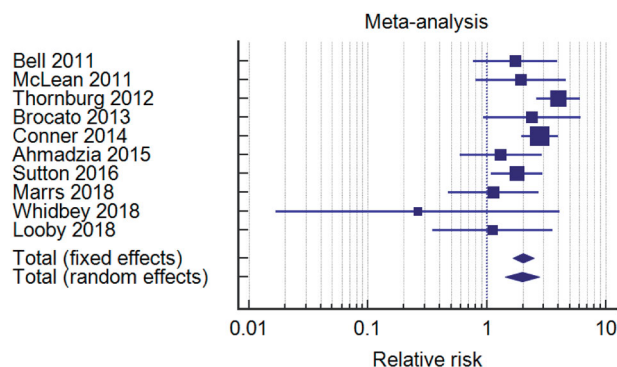**Table 4.** Outcomes for all vertical incisions versus all transverse incisions.

Outcome	Number of studies	Vertical (%)	Transverse (%)	Relative risk (random effects)	95% Confidence interval for relative risk	p Value	I^2	95% Confidence interval for I^2	Q Statistic (sig level)
Overall wound complication	12	155/1098 (14.1%)	520/6674 (7.8%)	2.071	1.607–2.671	<.001	44.81	0.00–71.85	19.93 (0.0463)
Wound infection	9	74/910 (8.1%)	400/6153 (6.5%)	1.906	1.339–2.712	<.001	45.04	0.00–74.56	14.55 (0.0684)
Endometritis	5	88/773 (11.4%)	342/5137 (6.7%)	1.388	1.111–1.735	.004	0.00%	0.00–58.84	1.90 (0.7537)
Postpartum Hemorrhage	9	102/1013 (10.1%)	247/6017 (4.1%)	1.874	1.367–2.570	<.001	28.29	0.00–66.67	11.16 (0.1930)
Hematoma	5	8/800 (0.01%)	42/5241 (0.08%)	1.747	0.675–4.520	.250	34.79	0.00–75.48	6.13 (0.1894)
Seroma	6	21/825 (2.5%)	52/5454 (1.0%)	2.843	0.921–8.781	.069	71.53	33.96–87.73	17.56 (0.0035)
Wound separation	6	25/825 (3.0%)	73/5454 (1.3%)	2.602	1.448–4.676	.001	36.78	0.00–74.80	7.91 (0.1613)
Hospital readmission	4	11/158 (7.0%)	58/876 (6.6%)	1.379	0.767–2.482	.283	0.00	0.00–83.62	2.36 (0.5004)
Operative time	4	$N = 189$ 81.10 ± 32.6	$N = 2025$ 58.63 ± 22.2	Standard mean difference 0.667	Standard error 0.212 (95% CI 0.252–1.083)	.002	83.09	56.87–93.37	17.74 (0.0005)

NA: Not Applicable; *summary data for the 2 studies with means AND standard deviations listed.
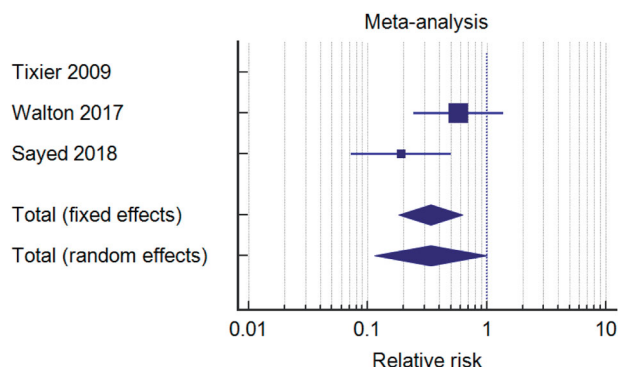
Table 5. Outcomes for all vertical incisions vs all low transverse incisions.

Outcome	Number of studies	Vertical (%)	Low transverse (%)	Relative risk (random effects)	95% Confidence interval for relative risk	p Value	I^2	95% Confidence interval for I^2	Q Statistic (sig level)
Overall wound complication	10	91/397 (22.9%)	458/3981 (11.5%)	1.991	1.430–2.772	<.001	53.07	3.94–77.07	19.18 (0.0237)
Wound infection	8	57/313 (18.2%)	369/3550 (10.4%)	1.763	1.150–2.704	.009	52.38	0.00–78.61	14.70 (0.0400)
Endometritis	4	6/176 (3.4%)	89/2534 (3.5%)	1.135	0.517–2.490	.753	0.00	0.00–77.41	1.71 (0.6338)
Postpartum hemorrhage	7	37/312 (11.6%)	176/3324 (5.3%)	1.983	1.159–3.395	.013	44.90	0.00–76.81	10.89 (0.0918)
Hematoma	4	6/203 (3.0%)	33/2638 (1.3%)	1.994	0.616–6.456	.249	40.59	0.00–79.90	5.05 (0.1682)
Seroma	5	10/228 (4.4%)	40/2851 (1.4%)	2.399	0.481–11.958	.286	77.47	45.59–90.67	17.75 (0.0014)
Wound separation	5	19/228 (8.3%)	65/2851 (2.3%)	2.392	1.129–5.064	.023	49.92	0.00–81.64	7.99 (0.0921)
Hospital readmission	4	11/158 (7.0%)	58/876 (6.6%)	1.379	0.767–2.482	.283	0.00	0.00–83.62	2.36 (0.5004)
Operative time	3	$N = 151$ 84.11 ± 34.3	$N = 1982$ 58.43 ± 21.9	Standard mean difference 0.873	Standard error 0.137 (95% CI 0.605–1.141)	<.001	52.91	0.00–86.49	4.25 (0.1196)

NA: Not Applicable.

Figure 3. Forest Plot of overall wound complications (as defined by authors) for all vertical incisions versus all low transverse incisions.

Figure 4. Forest Plot of overall wound complications (as defined by authors) for all high transverse incisions versus all low transverse incisions.

Three studies evaluated high transverse incisions versus low transverse incisions, with overall wound complications trending toward a decrease in the high transverse incision group, although not reaching statistical significance (Table 6, Figure 4, RR 0.338, 95% CI 0.114–1.004, $p = .051$). Additional meta-analysis among these three studies for secondary outcomes was not possible as only one study reported additional outcomes other than wound complications.

Additional planned subgroup analyses (as noted in methods) could not be performed secondary to a lack of identifiable studies. Patient satisfaction and wound cosmesis were not well described in the included studies.

Table 6. Outcomes for all high transverse vs. all low transverse Incisions.

Outcome	Number of studies	High transverse (%)	Low transverse (%)	Relative risk (random effects)	95% Confidence interval for relative risk	p Value	I^2	95% Confidence interval for I^2	Q Statistic (sig level)
Overall wound complication	3	9/73 (12.3%)	47/145 (32.4%)	0.338	0.114–1.004	.051	64.42	0.00–91.88	2.81 (0.0936)
Wound infection*	1	0/5 (0.0%)	0/13 (0.0%)	–	–	–	–	–	–
Endometritis*	1	1/32 (3.1%)	8/96 (8.3%)	–	–	–	–	–	–
Postpartum Hemorrhage*	0	–	–	–	–	–	–	–	–
Hematoma*	0	–	–	–	–	–	–	–	–
Seroma*	0	–	–	–	–	–	–	–	–
Wound separation*	0	–	–	–	–	–	–	–	–
Hospital readmission*	0	–	–	–	–	–	–	–	–
Operative Time	1	88.5 ± 7.7	91.0 ± 9.2	NA	NA	NA	NA	NA	NA

NA: Not Applicable, *Meta-analysis not completed as only one study or fewer reported data for this sub-group analysis.

Discussion

Main findings

All types of vertical incisions were associated with an increased risk for wound complications when compared to all types of transverse incisions. However, there are also increased risk factors (increased BMI, increased diabetes incidence, less likely to have pre-operative antibiotics) for wound complications among those who received vertical incisions in the included studies.

Strengths and limitations

This is the first systematic review detailing the types of incisions studied in obese women and comparing them in a meta-analysis and provides the impetus for additional randomized controlled trials. Authors were contacted for additional data and methodology was applied as appropriate for cohort studies. However, a significant limitation is the observational nature of most of the included studies. Surgeon preference dictated incision choice in these studies and on review of the included studies, those receiving vertical incisions had increased risk for wound complications based on underlying risk factors. Conversely, vertical incisions were more likely to close subcutaneous tissue (which has been associated with a lower risk of seroma formation) than were transverse incisions, however the subcutaneous thickness was not recorded and it may be that the transverse incisions did not have a subcutaneous thickness that would have prompted closure. This meta-analysis did not control for these risk factors in evaluating outcomes as we did not have access to individual patient data. This study was also unable to address the location of the hysterotomy, which may have implications to both pain, operative complications and healing.

Comparison with existing literature

Existing literature presents mixed opinions on which incision is preferred for an obese woman undergoing a cesarean delivery. One publication surveying obstetrician preferences for incision choice in obese women with a BMI $>40 \, \text{kg/m}^2$ noted that in a non-emergency cesarean, 84% preferred a low transverse incision (67% with taping pannus, 17% without taping pannus) [24]. Whether or not taping the pannus influences wound complication rates has not been adequately studied.

Conclusion

An ideal surgical approach and methodology remains inadequately characterized for obese women undergoing cesarean section. The majority of studies compare outcomes between low transverse skin incision and a midline vertical skin incision. A low transverse skin incision is typically associated with less postoperative pain but visualization may be hindered by this approach [25,26]. Additionally, wound healing may be compromised by increased tension of the pannus on the wound, however this may be true for vertical incisions (albeit in a different direction). Similarly, the moist environment beneath the pannus coupled with difficulty keeping the area clean may increase the rate of wound infections. Conversely, vertical skin incisions, while allowing for greater visualization, are typically associated with more postoperative pain.

Studies have failed to show reductions in wound complications when placing surgical drains and while there are limited data to support the use of negative pressure wound devices their efficacy and cost-effectiveness remain controversial [27–30].

Historically, skin closure with nonabsorbable staples (compared to suture) was thought to decrease the risk of postoperative wound complications, but a recent meta-analysis of twelve randomized controlled studies showed wound complications were 51% less common

when absorbable suture was used (compared to staples), with five of these studies further stratifying results by BMI and yielding similar outcomes in obese women (49% reduction in wound complications) [12]. Closure of the subcutaneous space when greater than 2 cm is one method that has been shown to decrease wound complications in the postoperative period [31].

Furthermore, there was a paucity of literature regarding supraumbilical incisions, and theoretically there is decreased subcutaneous tissue in this region compared to infraumbilical incisions in obese women. Additional studies regarding supraumbilical (higher vertical or transverse) incisions would be informative [11,32].

In summary, in this meta-analysis, vertical skin incisions were associated with an increased risk of wound complications for obese women undergoing a cesarean delivery when compared to transverse skin incisions, however significant confounders existed. Randomized controlled trials evaluating different types of skin incisions in obese women undergoing cesarean delivery are desperately needed.

Acknowledgment

Disclosure statement

ORCID

Loralei L. Thornburg http://orcid.org/0000-0003-3967-1568
Vincenzo Berghella http://orcid.org/0000-0003-2854-0239

References

[1] World Health Organization. Obesity: preventing and managing the global epidemic. World Health Organization; 2000 [cited 2020 Jun 26]. Available from: who.int/nutrition/publications/obesity/WHO_TRS_894/en/

[2] Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the united states, 2011–2012. JAMA. 2014;311(8):806–814.

[3] Catalano PM, Koutrouvelis GO. Obesity in pregnancy. Obstet Gynecol. 2015;126:e112–e126.

[4] American College of Obstetricians and Gynecologists. ACOG committee opinion no. 549: obesity in pregnancy. Obstet Gynecol. 2013;121:213–217.

[5] Ayres-de-Campos D. Obesity and the challenges of caesarean delivery: prevention and management of wound complications. Best Pract Res Clin Obstet Gynaecol. 2015;29(3):406–414.

[6] Chu S, Kim S, Schmid C, et al. Maternal obesity and risk of cesarean delivery: a meta-analysis. Obes Rev. 2007;8(5):385–394.

[7] Hood DD, Dewan DM. Anesthetic and obstetric outcome in morbidly obese parturients. Anesthesiology. 1993;79(6):1210–1218.

[8] Conner SN, Verticchio JC, Tuuli MG, et al. Maternal obesity and risk of postcesarean wound complications. Amer J Perinatol. 2013;31(4):299–304.

[9] Schneid-Kofman N, Sheiner E, Levy A, et al. Risk factors for wound infection following cesarean deliveries. Int J Gynecol Obstet. 2005;90(1):10–15.

[10] Vermillion ST, Lamoutte C, Soper DE, et al. Wound infection after cesarean: effect of subcutaneous tissue thickness. Obstet Gynecol. 2000;95(6 Pt 1):923–926.

[11] Brocato BE, Thorpe EM, Gomez LM, et al. The effect of cesarean delivery skin incision approach in morbidly obese women on the rate of classical hysterotomy. J Preg. 2013;2013:1–3.

[12] Mackeen AD, Schuster M, Berghella V. Suture versus staples for skin closure after cesarean: a metaanalysis. Am J Obstet Gynecol. 2015;212(5):621.e1.

[13] Owen J, Andrews WW. Wound complications after cesarean sections. Clin Obstet Gynecol. 1994;37(4):842–855.

[14] Robinson HE, O'Connell CM, Joseph KS, et al. Maternal outcomes in pregnancies complicated by obesity. Obstet Gynecol. 2005;106:1357–1364.

[15] Tipton AM, Cohen SA, Chelmow D. Wound infection in the obese pregnant woman. Semin Perinatol. 2011;35(6):345–349.

[16] Tran TS, Jamulitrat S, Chongsuvivatwong V, et al. Risk factors for postcesarean surgical site infection1. Obstet Gynecol. 2000;95:367–371.

[17] Yamasato K, Yoshino K, Chang AL, et al. Cesarean delivery complications in women with morbid obesity. J Matern Fetal Neonatal Med. 2016;29(23):3885–3888.

[18] Poobalan AS, Aucott LS, Gurung T, et al. 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.

[19] Slim K, Nini E, Forestier D, et al. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg. 2003;73(9):712–716.

[20] Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-Analysis of Observational Studies in Epidemiology (MOOSE) group. JAMA. 2000;283(15):2008–2012.

[21] Chelmow D, Rodriguez EJ, Sabatini MM. Suture closure of subcutaneous fat and wound disruption after cesarean delivery: a meta-analysis. Obstet Gynecol. 2004;103(5 Pt 1):974–980.

[22] Hellums EK, Lin MG, Ramsey PS. Prophylactic subcutaneous drainage for prevention of wound complications after cesarean delivery-a metaanalysis. Am J Obstet Gynecol. 2007;197(3):229–235.

[23] Dahlke JD, Mendez-Figueroa H, Rouse DJ, et al. Evidence-based surgery for cesarean delivery: an updated systematic review. Am J Obstet Gynecol. 2013;209(4):294–306.

[24] Smid MC, Smiley SG, Schulkin J, et al. Stuebe AM. The problem of the pannus: physician preference survey and a review of the literature on cesarean skin incision in morbidly obese women. Am J Perinatol. 2016; 33(5):463–472.

[25] Habib AS, Wahl K, Gu J, Adenosine Study Group, et al. Comparison of postoperative pain outcomes after vertical or Pfannenstiel incision for major gynecologic surgery. Curr Med Res Opin. 2009;25(6): 1529–1534.

[26] Kisielinski K, Conze J, Murken AH, et al. The Pfannenstiel or so called "bikini cut": still effective more than 100 years after first description. Hernia. 2004;8(3):177–181.

[27] Al-Inany H, Youssef G, Abd ElMaguid A, et al. Value of subcutaneous drainage system in obese females undergoing cesarean section using pfannenstiel incision. Gynecol Obstet Invest. 2002;53(2):75–78.

[28] Tuffaha HW, Gillespie BM, Chaboyer W, et al. Cost-utility analysis of negative pressure wound therapy in high-risk cesarean section wounds. J Surg Res. 2015; 195(2):612–622.

[29] Mark KS, Alger L, Terplan M. Incisional negative pressure therapy to prevent wound complications following cesarean section in morbidly obese women: a pilot study. Surg Innov. 2014;21(4):345–349.

[30] Smid MC, Dotters-Katz SK, Grace M, et al. Prophylactic negative pressure wound therapy for obese women after cesarean delivery: a systematic review and meta-analysis. Obstet Gynecol. 2017;130(5):969–978.

[31] Naumann RW, Hauth JC, Owen J, et al. Subcutaneous tissue approximation in relation to wound disruption after cesarean delivery in obese women. Obstet Gynecol. 1995;85(3):412–416.

[32] Tixier H, Thouvenot S, Coulange L, et al. Cesarean section in morbidly obese women: supra or subumbilical transverse incision? Acta Obstet Gynecol Scand. 2009; 88(9):1049–1052.

[33] Wall PD, Deucy EE, Glantz JC, et al. Vertical skin incisions and wound complications in the obese parturient. Obstet Gynecol. 2003;102:952–956.

[34] Alanis MC, Villers MS, Law TL, et al. Complications of cesarean delivery in the massively obese parturient. Am J Obstet Gynecol. 2010;203(3):271.e1–e7.

[35] Bell J, Bell S, Vahratian A, et al. Abdominal surgical incisions and perioperative morbidity among morbidly obese women undergoing cesarean delivery. Eur J Obstet Gynecol Reprod Biol. 2011;154(1):16–19.

[36] McLean M, Hines R, Polinkovsky M, et al. Type of skin incision and wound complications in the obese parturient. Amer J Perinatol. 2012;29(04):301–306.

[37] Thornburg LL, Linder MA, Durie DE, Walker B, et al. Risk factors for wound complications in morbidly obese women undergoing primary cesarean delivery. J Matern Fetal Neonatal Med. 2012;25(9):1544–1548.

[38] Marrs CC, Moussa HN, Sibai BM, et al. REMOVED: The relationship between primary cesarean delivery skin incision type and wound complications in women with morbid obesity. Am J Obstet Gynecol. 2014; 210(4):319–319.e4.

[39] Ahmadzia HK, Patel EM, Joshi D, et al. Obstetric surgical site infections: 2 grams compared with 3 grams of cefazolin in morbidly obese women. Obstet Gynecol. 2015;126(4):708–715.

[40] Smid MC, Kearney MS, Stamilio DM. Extreme obesity and postcesarean wound complications in the maternal-fetal medicine unit cesarean registry. Amer J Perinatol. 2015;32(14):1336–1341.

[41] Sutton AL, Sanders LB, Subramaniam A, et al. Abdominal incision selection for cesarean delivery of women with class III obesity. Amer J Perinatol. 2015; 33(06):547–551.

[42] Walton RB, Shnaekel KL, Ounpraseuth ST, et al. High transverse skin incisions may reduce wound complications in obese women having cesarean sections: a pilot study. J Matern Fetal Neonatal Med. 2019;32(5): 781–785.

[43] Marrs C, Blackwell S, Hester A, et al. Pfannenstiel versus vertical skin incision for cesarean delivery in women with Class III Obesity: a randomized trial. Am J Perinatol. 2019;36(1):97–104.

[44] Wihbey KA, Joyce EM, Spalding ZT, 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):377–384.

[45] Looby MA, Vogel RI, Bangdiwala A, et al. Prophylactic negative pressure wound therapy in Obese Patients Following Cesarean Delivery. Surg Innov. 2018;25(1): 43–49.

[46] El Sayed HM, El Mekkawi SF, El Kotb AM, et al. Transverse supraumbilical versus Pfannenstiel incision for cesarean section in morbidly obese women "A randomized controlled trial. The Egyptian Journal of Hospital Medicine. 2018; 72(7):4780–4785.

[47] Moher D, Shamseer L, Clarke M, PRISMA-P Group, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015;4:1.