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ORIGINAL ARTICLE

Risk Factors for Endometritis after Low Transverse Cesarean Delivery

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OBJECTIVE. To determine independent risk factors for endometritis after low transverse cesarean delivery.

STUDY DESIGN. We performed a retrospective case-control study during the period from July 1999 through June 2001 in a large tertiary care academic hospital. Endometritis was defined as fever beginning more than 24 hours or continuing for at least 24 hours after delivery plus fundal tenderness in the absence of other causes for fever. Independent risk factors for endometritis were determined by means of multivariable logistic regression. A fractional polynomial method was used to examine risk of endometritis associated with the continuous variable, duration of rupture of membranes.

RESULTS. Endometritis was identified in 124 (7.7%) of 1,605 women within 30 days after low transverse cesarean delivery. Independent risk factors for endometritis included younger age (odds ratio [OR], 0.93 [95% confidence interval {CI}, 0.90–0.97]) and anemia or perioperative blood transfusion (OR, 2.18 [CI, 1.30–3.68]). Risk of endometritis was marginally associated with a proxy for low socioeconomic status, lack of private health insurance (OR, 1.72 [CI, 0.99–3.00]); with amniotomy (OR, 1.69 [CI, 0.97–2.95]); and with longer duration of rupture of membranes.

CONCLUSION. Risk of endometritis was independently associated with younger age and anemia and was marginally associated with lack of private health insurance and amniotomy. The odds of endometritis increased approximately 1.7-fold within 1 hour after rupture of membranes, but increased duration of rupture was only marginally associated with increased risk. Knowledge of these risk factors can guide selective use of prophylactic antibiotics during labor and heighten awareness of the risk in subgroups at highest risk of infection.

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The rate of cesarean delivery has risen steadily in the United States during the past decade, exceeding 30% of deliveries in 2005.[1] Endometritis is the most common maternal infectious complication of childbirth, occurring more commonly after cesarean delivery than after vaginal delivery.[2] In a Cochrane review, the mean incidence of endometritis was 7% after elective cesarean delivery and 30% after nonelective or emergency cesarean delivery.[3]

A variety of independent risk factors for endometritis after cesarean delivery have been identified in other studies, including no prior cesarean delivery,[4] trial of labor,[2,5] rupture of membranes lasting more than 24 hours,[6] preterm[4] or postterm gestation,[7] low infant Apgar scores,[4] younger maternal age,[6] antepartum infections,[8] preeclampsia, presence of meconium in the amniotic fluid,[9] amnioinfusion,[10] postpartum anemia,[4,6,8] large number of vaginal examinations,[10] presence of internal monitors,[8,10] and manual removal of placenta.[11] Routine administration of intravenous cephalosporin plus azithromycin for antibiotic prophylaxis at the time of cord clamping has been temporally associated with significantly lower risk of endometritis compared with use of prophylactic cephalosporin alone.[5,12] The results of the study by Tita et al[5] are difficult to interpret, however, because an infection control intervention to promote aseptic technique was conducted at the same time as addition of the azithromycin prophylaxis. In a randomized placebo-controlled trial, administration of prophylactic cefazolin prior to skin incision was associated with significantly lower incidence of endometritis than was administration of cefazolin at the time of cord clamping.[13] Preoperative vaginal antisepsis with povidone-iodine was also associated with significantly decreased risk of endometritis in one randomized controlled study[8] but not in another.[14] Screening of all pregnant women for group B streptococcal infection or colonization and treatment of colonization was associated with significantly decreased risk of endometritis, compared with selective screening and treatment of only women with risk factors for colonization.[15]

The association of duration of labor and duration of rupture of membranes with the risk of endometritis is difficult to determine, as a result of the variety of methods used to

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TABLE 1. Potential Risk Factors for Endometritis after Low Transverse Cesarean Delivery for Which Data Were Collected from Medical Records

Patient characteristics
Age
Race
Marital status
Type of medical insurance (private, Medicaid, Medicare, or none)
Body mass index at hospital admission
Alcohol use during pregnancy
Tobacco use during pregnancy
Street drug use during pregnancy
Diabetes mellitus or gestational diabetes
Systemic lupus erythematosus
Group B *Streptococcus* colonization
Sexually transmitted diseases during pregnancy[a]
Use of steroids during pregnancy
Obstetrics-related risk factors
No. of previous pregnancies
No. of previous births
No. of abortions
No. of previous cesarean deliveries
No. of vaginal examinations before incision
No. of prenatal care visits
Incompetent cervix
Weight gain during pregnancy
Vaginal discharge present at admission to the hospital
Preeclampsia
Clinical and pathologic chorioamnionitis
Receipt of preoperative oxygen
Vaginal bleeding before surgery
Malpresentation
Spontaneous rupture of membranes
Amniotomy
Duration of ruptured membranes
Duration of labor
Use of internal fetal monitors
Use of Foley bulb for cervical ripening
Amnioinfusion
Presence of meconium in amniotic fluid
Minimum hemoglobin level $\leqslant$24 hours before incision
Minimum hematocrit level $\leqslant$24 hours before incision
Surgical risk factors
American Society of Anesthesiologists score
Urgency of operation[b]
Antibiotic prophylaxis agent and timing
Indication for cesarean delivery
Type of obstetric service (university teaching or private)
Duration of time between hospital admission and surgery
Type of anesthesia
Type of skin and uterine incision
Additional surgical procedure
Exteriorized uterus
Manual removal of placenta
Duration of surgery
Use of surgical drains
Use of staples for skin closure
Estimated volume of blood loss during surgery
Blood transfusion after surgical incision
Development of a subcutaneous hematoma
Minimum hemoglobin level $\leqslant$48 hours after incision

TABLE 1. (*Continued*)

Patient characteristics
Minimum hematocrit level ⩽48 hours after incision
Maximum perioperative serum glucose level from 24 hours before through 120 hours after incision
Gestational age at delivery
Infant birth weight(s)

[a] Gonorrhea, *Chlamydia* infection, bacterial vaginosis, *Trichomonas* infection, *Herpes simplex* virus infection, or human immunodeficiency virus infection.

[b] Cesarean deliveries were classified as elective, urgent, or emergent by use of standardized criteria by the operative team. Elective procedures were planned procedures. True emergent procedures were classified as emergent, and patients did not undergo a full surgical preparation.

categorize duration and the primarily univariate statistical methods used in the older literature. More recently, one study showed that rupture of membranes of greater than 16 hours' duration was independently associated with increased risk of endometritis after all deliveries in which premature rupture of membranes occurred.[16] In that study, duration of ruptured membranes was categorized in 2-hour intervals and compared with a reference duration of less than 8 hours, and the risk of endometritis was not specifically reported for patients who underwent cesarean delivery. Seaward et al[17] reported that duration of labor of greater than 3 hours and cesarean delivery independently increased the risk of postpartum fever.

We performed a case-control study of endometritis after low transverse cesarean delivery (LTCD) to determine clinically relevant independent risk factors associated with increased risk of endometritis and to determine the effect of increased duration of rupture of membranes, increased duration of labor, and number of vaginal examinations on the risk of endometritis. This knowledge is essential to develop targeted strategies to reduce the incidence of infection after cesarean delivery.

METHODS

We performed a retrospective nested case-control study at Barnes-Jewish Hospital, a 1,250-bed academic tertiary care hospital. Approval for this study was obtained from the Washington University Human Research Protection Office. Women who underwent LTCD during the period from July 1, 1999, through June 30, 2001, were identified on the basis of *International Classification of Diseases, 9th Edition, Clinical Modification (ICD-9-CM)* procedure code 74.1. We focused on LTCD because low transverse uterine incisions are the preferred type of incision, used for the vast majority of cesarean deliveries performed in the United States.

Demographic, pharmacy, and laboratory data were obtained from the Barnes-Jewish Hospital Medical Informatics database. Data on potential risk factors were collected from the medical records of each patient's surgical hospitalization, including all notes by physicians, nurses, and/or operative staff concerning the hospitalization (Table 1).

Potential cases of endometritis were identified on the basis of the presence in the medical record of *ICD-9-CM* diagnosis codes for endometritis (670.02, 670.04) during the original surgical hospitalization or during an inpatient or emergency department rehospitalization within 30 days of surgery and/or the receipt of antibiotics for a prolonged duration beyond a prophylactic course after surgery, as described elsewhere.[18,19] Endometritis was defined as fever (temperature of 38°C or higher) beginning more than 24 hours or continuing at least 24 hours after delivery plus fundal tenderness, with no other recognized cause for fever.[20] Control patients were selected by means of a random-number generator from among the patients who underwent LTCD during the study period and did not receive a diagnosis of either endometritis or surgical site infection. The control patients have been described elsewhere in a study of risk factors for surgical site infection after LTCD.[21] Medical records were reviewed for all case patients and control patients to determine whether they met the endometritis case definition within 30 days after LTCD.

Statistical Analysis

Univariate and multivariable logistic regression models were used to identify independent risk factors for endometritis. Continuous variables were compared by means of the Mann-Whitney *U* test. A multivariable logistic regression model was performed by means of backward selection, including all variables with *P* less than .15 in the univariate analysis or a priori clinical importance. All continuous variables with *P* less than .15 were evaluated by means of a fractional polynomial approach to preserve the continuous nature of covariates suspected to have a nonlinear relationship with endometritis.[22] To determine the final multivariable model, we used the SAS macro of Meier-Hirmer to determine the appropriate transformation of each continuous covariate.[23] Since covariate values of zero preclude logarithm and negative power transformations, continuous covariates with values of 0 were transformed by adding 1. Odds ratios are presented for relevant exposure categories, by using the mean of each category as the reference point and 95% confidence intervals calculated as described by Royston and Sauerbrei.[24] After identification of the main effects, clinically relevant interactions between dichotomous variables were tested, with *P* less than .05 the criterion

TABLE 2. Univariate Comparisons of Continuous Risk Factors in Case Patients with Endometritis and Control Patients without Endometritis after Low Transverse Cesarean Delivery

Risk factor	Median value (range)		P[a]
	Case patients (n = 124)	Control patients (n = 310)	
Demographic variables			
Age, years	21.2 (13.4–44.2)	26.5 (14.5–42.9)	<.001
Body mass index[b]	33.1 (21.1–66.1)	31.8 (16.7–64.8)	.138
Obstetrics-related variables			
No. of prenatal visits[c]	10 (0–30)	10 (0–50)	.356
No. of vaginal examinations	4 (0–14)	1 (0–14)	<.001
Duration of labor, minutes[d]	672 (24–2,204)	540 (27–3,841)	.168
Duration of rupture of membranes, minutes[e]	695 (22–131,118)	554 (8–68,610)	.309
Duration of operation, minutes[f]	52 (25–146)	55 (17–168)	.949
Gestational age, weeks[b]	39.3 (26.4–42.6)	38.9 (25.7–43.3)	.056
Preoperative variables			
Hemoglobin level, g/dL[g]	11.3 (4.3–14.2)	11.3 (8.0–15.2)	.223
Hematocrit level, g/dL[g]	33.3 (12.0–41.5)	33.4 (23.3–46.10	.546
Postoperative variables			
Estimated blood loss, mL	800 (300–3,000)	800 (300–4,000)	.303
Hemoglobin level, g/dL[h]	8.8 (3.4–12.8)	9.7 (4.4–12.8)	<.001
Hematocrit level, g/dL[h]	26.1 (9.5–38.0)	28.3 (14.0–38.0)	<.001

[a] Comparison with Mann-Whitney U test.
[b] Data missing for 1 patient.
[c] Data missing for 10 patients. Number of prenatal visits counted from the prenatal record, or if missing, number of prenatal visits recorded on the birth certificate.
[d] Excluding 176 patients without labor.
[e] Excluding 170 patients without rupture of membranes.
[f] Data missing for 72 patients.
[g] Data missing for 47 patients.
[h] Data missing for 5 patients.

for inclusion in the model. Model fit was assessed by means of the C statistic. All tests were 2-tailed, and P less than .05 was considered to indicate a significant difference. Analyses were performed with SAS, version 9.1 (SAS Institute), and SPSS, version 14.0 (SPSS).

RESULTS

At Barnes-Jewish Hospital, 1,759 patients underwent cesarean delivery during the period from July 1, 1999, through June 30, 2001. Among the 1,605 patients (91.2%) with low transverse uterine incision, 124 (7.7%) of the 1,605 were identified as having endometritis within 30 days after operation. We randomly selected 310 control patients without endometritis or surgical site infection for comparison. One hundred seven (24.7%) of 434 women underwent elective cesarean deliveries, 254 (58.5%) women underwent urgent cesarean deliveries, and 73 (16.8%) women underwent emergent cesarean deliveries. The majority of patients (310 [71.4%]) underwent a primary cesarean delivery.

The univariate results of risk factors for endometritis are presented in Tables 2 and 3. Women with endometritis were more likely to be younger, nonwhite, or unmarried and to have Medicare, Medicaid, or no health insurance (ie, lacked private health insurance). Younger age was also associated with fewer prenatal visits (P = .005, 1-way ANOVA), as was lack of private health insurance (P < .001, 1-way ANOVA). Younger age was also associated with slightly higher gestational age at delivery (P = .015, Spearman ρ test). Patients with *Neisseria gonorrhoeae* or *Chlamydia* infection during pregnancy and with higher American Society of Anesthesiologists physical status classification were also more likely to develop endometritis. For the mother, obstetrics-related factors associated with an increased risk of endometritis included preeclampsia, clinical chorioamnionitis, labor (spontaneous or induced), amnioinfusion (transcervical infusion of saline into the uterus to dilute meconium-stained fluid or relieve cord compression due to low amniotic fluid volume), use of internal fetal monitors, increased number of vaginal examinations, and spontaneous or artificial rupture of membranes (amniotomy). Surgical factors associated with a decreased risk of endometritis included elective surgery, manual removal of the placenta, and bilateral tubal ligation. Manual removal of the placenta (compared with cord traction) was significantly associated with the type of attending physician; physicians in private practice were significantly less likely to remove the placenta manually than were university faculty members (P < .001, χ^2 test).

There were no statistically significant differences in pre-

operative hemoglobin or hematocrit values between case patients with endometritis and control patients; however, case patients with endometritis had significantly lower postoperative hemoglobin and hematocrit values. Estimated blood loss during surgery was not related to risk of endometritis, but perioperative blood transfusion (with both leukocyte-depleted and non–leukocyte-depleted blood products) was associated with increased risk of endometritis.

Patients with premature rupture of membranes were significantly more likely to develop endometritis than patients whose membranes ruptured at or after the onset of labor or at delivery (44 [41.5%] of 106 vs 80 [24.4%] of 328; $P = .001$). Among the 106 women (24.4%) with premature rupture of membranes, there was a marginal association between shorter duration of rupture before onset of labor and endometritis (median duration, 112 minutes for case patients vs 203 minutes for control patients; $P = .099$). Women with premature rupture of membranes were marginally more likely to receive a clinical diagnosis of chorioamnionitis than were women whose membranes ruptured at or after the onset of labor (25 [23.6%] of 106 vs 53 [16.2%] of 328; $P = .083$). Overall, in univariate analysis patients with clinical chorioamnionitis had significantly increased risk of developing endometritis, compared with patients without chorioamnionitis. There was no association between subclinical chorioamnionitis identified solely by means of the pathology reports and endometritis (Table 3).

Independent risk factors for endometritis identified in the multivariable analysis included younger age and anemia and/or blood transfusion (Table 4). Anemia and/or blood transfusion was associated with a more than 2-fold increased risk of endometritis. We combined postoperative anemia and blood transfusion into 1 variable for analysis, because for some women who received multiple transfusions, no blood sample was collected at the suspected nadir of the blood hemoglobin level. In addition, some women with low hemoglobin values refused blood transfusion, so neither variable alone captured all women with severe anemia. Lack of private health insurance, amniotomy, increased duration of rupture of membranes, and clinical chorioamnionitis were associated with marginally increased risk of endometritis, controlling for labor. Age was modeled as a linear variable because of the absence of convincing evidence of nonlinearity (Table 4). Duration of rupture of membranes was modeled by using the term $1/(\text{duration of rupture in minutes} + 1)^{1/2}$ and the fractional polynomial approach. The odds of endometritis increased immediately after rupture of membranes but did not increase appreciably with increased duration of rupture, adjusting for the other variables in the model. We tested the presence of internal fetal monitors rather than amniotomy in a separate model, but it was not significantly associated with endometritis after adjusting for duration of rupture of membranes and the other variables ($P = .251$).

DISCUSSION

Our results show that younger age and perioperative anemia or transfusion independently increased the risk of endometritis for women who underwent LTCD at an urban tertiary care university-affiliated hospital. Clinical chorioamnionitis, amniotomy, greater duration of membrane rupture, and lack of private health insurance were marginally associated with increased risk of endometritis.

We determined that the risk of endometritis increased in linear fashion with decreasing age. Younger age has been reported to be associated with an increased risk of endometritis in 2 studies,[25,26] although the reason for this increased risk is unknown. Despite the use of our multivariate analysis in our study, residual confounding may exist because of undiagnosed sexually transmitted infections or undocumented group B streptococcal vaginal colonization, among other factors. This may be preferentially true in younger women, who had significantly fewer prenatal visits than did older women and therefore less opportunity for diagnostic testing.

In univariate analysis, spontaneous and assisted rupture of membranes (amniotomy), regardless of duration, were both associated with significantly increased risk of endometritis. After inclusion of amniotomy and other variables in the multivariate model, the duration of rupture of membranes was only marginally significant. Amniotomy was associated with 1.7-fold increased odds of endometritis and is biologically plausible as a risk factor, as a result of the potential for introduction of organisms from the vagina and cervix into the amniotic fluid during the procedure. In previous studies including multivariate analysis, rupture of membranes has been analyzed as a binary or categorical variable.[6,16] The studies that analyzed rupture as a categorical variable are more difficult to interpret, since in most of these studies the reference category consisted of women without ruptured membranes plus women with ruptured membranes of defined duration (eg, less than 8 hours), compared with women whose membranes were ruptured for longer durations (eg, more than 8 hours). In our study, the odds of endometritis increased approximately 1.7-fold within 1 hour after rupture of membranes and remained at that level with increasing duration of rupture. Thus, our results are more consistent with increased risk of endometritis associated with rupture per se, regardless of the duration.

Duration of labor and occurrence of labor (yes or no) were not associated with increased risk of endometritis after controlling for duration of rupture of membranes. Rupture of membranes allows for ascending spread of bacteria into the previously sterile amniotic fluid, and thus this variable is more biologically plausible in the model than labor per se. Internal monitors was also excluded from the multivariate model after controlling for duration of ruptured membranes, although it was associated with more than a 3-fold higher risk of endometritis in univariate analysis.

Severe anemia or transfusion of packed red blood cells was

TABLE 3. Univariate Comparisons of Categorical Risk Factors in Case Patients with Endometritis and Control Patients without Endometritis after Low Transverse Cesarean Delivery

Risk factor	No. (%) of patients		OR (95% CI)	*P*
	Case patients (n = 124), no. (%)	Control patients (n = 310), no. (%)		
Demographics and comorbidities				
Nonwhite race	104 (83.9)	210 (67.7)	2.48 (1.45–4.23)	.001
Nonmarried status (single, divorced, or widowed)	105 (84.7)	199 (64.2)	3.08 (1.80–5.30)	<.001
Nonprivate health insurance (Medicaid, Medicare, Public Aid, or none)	98 (79.0)	185 (59.7)	2.55 (1.56–4.15)	<.001
Gonorrhea or *Chlamydia* infection during pregnancy	19 (15.3)	24 (7.7)	2.16 (1.14–4.10)	.019
Trichomonas infection during pregnancy	16 (12.9)	27 (8.7)	1.55 (0.81–3.00)	.189
Group B *Streptococcus* colonization	23 (18.5)	46 (14.8)	1.31 (0.75–2.27)	.340
Steroid use	15 (12.1)	55 (17.7)	0.64 (0.35–1.18)	.151
Tobacco use				
Previous use, quit during pregnancy	12 (9.7)	17 (5.5)	1.73 (0.80–3.76)	.165
Current use	15 (12.1)	55 (17.7)	0.67 (0.36–1.24)	.203
ASA score class 3 or 4[a]	41 (33.6)	74 (23.9)	1.61 (1.02–2.54)	.042
Obstetrics-related variables				
Previous abortion	40 (32.3)	121 (39.0)	0.74 (0.48–1.16)	.188
No. of previous cesarean deliveries				
0	102 (82.3)	208 (67.1)	Reference	…
1	17 (13.7)	68 (21.9)	0.51 (0.29–0.91)	.023
⩾2	5 (4.0)	34 (11.0)	0.30 (0.11–0.79)	.015
Preeclampsia	36 (29.0)	53 (17.1)	1.98 (1.22–3.23)	.006
Premature rupture of membranes	44 (35.5)	62 (20.0)	2.20 (1.39–3.49)	.001
Labor				
None	26 (21.0)	150 (48.4)	Reference	…
Spontaneous	55 (44.4)	99 (31.9)	3.21 (1.89–5.45)	<.001
Induced	43 (34.7)	61 (19.7)	4.07 (2.30–7.20)	<.001
Rupture of membranes				
None	23 (18.5)	147 (47.4)	Reference	…
Spontaneous	41 (33.1)	89 (28.7)	2.94 (1.66–5.23)	<.001
Amniotomy	60 (48.4)	74 (23.9)	5.18 (2.97–9.04)	<.001
Use of Foley bulb for cervical ripening	9 (7.3)	10 (3.2)	2.35 (0.93–5.93)	.071
Use of internal fetal monitors	86 (69.4)	118 (38.1)	3.68 (2.36–5.75)	<.001
Amnioinfusion	46 (37.1)	59 (19.0)	2.51 (1.58–3.98)	<.001
Presence of meconium in amniotic fluid	44 (35.5)	82 (26.5)	1.53 (0.98–2.39)	.062
Chorioamnionitis				
None	74 (59.7)	228 (73.5)	Reference	…
Subclinical chorioamnionitis (pathology only)	14 (11.3)	40 (12.9)	1.08 (0.56–2.09)	.823
Clinical chorioamnionitis[b]	36 (29.0)	42 (13.5)	2.64 (1.58–4.43)	<.001
Surgical variables				
Elective cesarean delivery	12 (9.7)	95 (30.6)	0.24 (0.13–0.46)	<.001
Bilateral tubal ligation	10 (8.1)	58 (18.7)	0.38 (0.19–0.77)	.007
General anesthesia	17 (13.7)	28 (9.0)	1.60 (0.84–3.04)	.152
Exteriorization of uterus	115 (92.7)	287 (92.6)	1.02 (0.46–2.28)	.954
Manual removal of placenta	82 (66.1)	242 (78.1)	0.55 (0.35–0.87)	.010
Use of staples for skin closure	115 (92.7)	267 (86.1)	2.06 (0.97–4.36)	.060
Antibiotic therapy				
Agents				
Cefazolin or cefotetan	52 (41.9)	155 (50.0)	Reference	…
Amp, pen, or clindamycin alone	14 (11.3)	35 (11.3)	1.19 (0.60–2.39)	.620
Amp, pen, or clindamycin with a cephalosporin	22 (17.7)	46 (14.8)	1.43 (0.78–2.59)	.245
Gentamycin, tobramycin, or amp-sulb	27 (21.8)	43 (13.9)	1.87 (1.05–3.33)	.033
None	9 (7.3)	31 (10.0)	0.87 (0.39–1.94)	.725
Timing of administration				
Only after incision	52 (41.9)	145 (46.8)	Reference	…
Within 1 hour before incision	13 (10.5)	26 (8.4)	1.39 (0.67–2.91)	.377

TABLE 3. (*Continued*)

Risk factor	No. (%) of patients: Case patients (n = 124), no. (%)	Control patients (n = 310), no. (%)	OR (95% CI)	P
1–8 hours before incision	50 (40.3)	108 (34.8)	1.29 (0.81–2.05)	.278
No antibiotics	9 (7.3)	31 (10.0)	0.81 (0.36–1.81)	.608
Postoperative variables				
Transfusion[c]				
Leukocyte-depleted blood only	17 (13.7)	14 (4.5)	3.64 (1.73–7.67)	.001
Non–leukocyte-depleted blood	10 (8.1)	8 (2.6)	3.75 (1.44–9.77)	.007

NOTE. Amp, ampicillin; ASA, American Society of Anesthesiologists; CI, confidence interval; OR, odds ratio; pen, penicillin; sulb, sulbactam.

[a] Data missing for 3 patients.

[b] Defined by fever during labor, fundal tenderness, and/or physician diagnosis.

[c] Information on type of blood product (leukodepleted or not) missing for 1 patient with packed red blood cell transfusion.

associated with 2-fold increased odds of endometritis in the multivariate model. Anemia has been reported in one study as an independent risk factor for endometritis.[6] Severe anemia was not solely a proxy for excessive blood loss during surgery, since estimated volume of blood loss was not associated with increased risk of endometritis in our study population. We and others have reported that transfusion increases the risk of a variety of hospital-acquired infections.[27-30] The reason for the association of severe anemia with increased risk of endometritis is not entirely clear, but the association may be due, in part, to residual confounding with underlying severity of illness. In addition, some investigators have suggested that transfusion increases the risk of infection because of immunomodulation and release of bioactive mediators from contaminating allogeneic white blood cells.[27,31] Almost two-thirds of the patients who received blood transfusions in our study received only leukodepleted blood. Interestingly, there was no difference between the risk of endometritis associated with transfusion of leukodepleted blood and the risk associated with transfusion of nonleukodepleted blood. Our finding supports the findings of some researchers who have recently questioned the impact of leukodepletion on rates of nosocomial infection associated with transfusion.[32,33]

Chorioamnionitis was associated with significantly increased odds of endometritis in univariate analysis but was not formally associated with increased risk of endometritis in the multivariate model. In other publications that report an increased risk of endometritis associated with chorioamnionitis, investigators have controlled for duration of rupture or labor as categorical or binary variables, which most likely resulted in residual confounding.[5,17]

Nonprivate health insurance, our proxy for low socioeconomic status, was associated with a marginally increased risk of endometritis. Reasons for this association may include higher rates of sexually transmitted infections, higher risk of group B streptococcal colonization, and less likelihood of treatment of these infections because of fewer prenatal care visits. In addition, micronutrient and vitamin insufficiency may in part explain this relationship. Women with Medicaid coverage and African-American women have increased likelihood of prepregnancy anemia and are less likely to report multivitamin use than are non-Hispanic white women and women with private insurance.[34,35] Higher body mass index has also been shown to be associated with lower diet quality during pregnancy.[36] A variety of micronutrients play critical roles in immune responses,[37,38] so it is plausible that micronutrient deficiencies associated with poor diet and lower multivitamin use could be associated with increased risk of endometritis in women with low socioeconomic status.

In contrast to the results of some previous work, we did not find an association between group B *Streptococcus* colonization and development of endometritis. This may be due to our inability to identify all women with group B *Streptococcus* colonization on the basis of retrospective review of hospital records. It is also possible that we did not detect risk of endometritis associated with group B *Streptococcus* colonization as a result of abrogation of this risk by antibiotic prophylaxis during labor. More than one-quarter of the women in our study received ampicillin, penicillin, or clindamycin before surgery (alone or in combination with cephalosporin prophylaxis). More than one-half of the women with documented group B streptococcal colonization received antibiotic prophylaxis against group B streptococcal infection, and another 20% of women with group B streptococcal colonization (14 of 69 patients) were treated for chorioamnionitis. Dumas et al[39] recently reported that antibiotic prophylaxis against group B streptococcal infection was associated with significantly decreased risk of endometritis after vaginal delivery. Thus, it is possible that antibiotic prophylaxis and therapy in our study was successful at decreasing the risk of endometritis due to group B *Streptococcus* colonization.

A limitation of this study is the analysis of older data. During this study, routine administration of prophylactic antibiotics for cesarean delivery was performed at the time of cord clamping rather than before incision. In our population, almost one-half of the women received antibiotics before incision, and receipt of prophylactic antibiotics at cord clamping was not associated with increased risk of endometritis. Although earlier

TABLE 4. Multivariable Model for Risk Factors for Endometritis after Low Transverse Cesarean Delivery

Variable	Reference point[a]	Adjusted OR (95% CI)	*P*
No health insurance or no private health insurance[b]	…	1.72 (0.99–3.00)	.057
Clinical chorioamnionitis[c]	…	1.60 (0.89–2.87)	.115
Anemia[d] and/or perioperative transfusion	…	2.18 (1.30–3.68)	.003
Amniotomy	…	1.69 (0.97–2.95)	.064
Presence of labor	…	1.23 (0.62–2.45)	.555
Younger age	…	0.93 (0.90–0.97)	<.001
Duration of rupture before cesarean delivery[e]			.094
None	0	Reference	
<1 hour	0.6	1.72 (0.91–3.25)	
1–3 hours	2.0	1.81 (0.90–3.64)	
3–6 hours	4.8	1.85 (0.90–3.81)	
6–12 hours	8.9	1.87 (0.90–3.90)	
12–24 hours	16.4	1.89 (0.90–3.96)	
24–72 hours	35.3	1.90 (0.90–4.02)	

NOTE. Model C statistic, 0.769; there were 124 case patients with endometritis and 310 control patients without endometritis. CI, confidence interval; OR, odds ratio.

[a] Reference point is the mean value for each category for continuous variables.

[b] Defined as Medicaid, Medicare, or Public Aid.

[c] Defined by fever, fundal tenderness, or physician diagnosis.

[d] Defined as hemoglobin level $\leqslant 8$ g/dL.

[e] Results are presented at relevant exposures for duration of rupture by using coefficients for the best-fitting fractional polynomials in the multivariable model. The OR of endometritis for duration of rupture of membranes was calculated as $\log \mathrm{OR}_{\mathrm{duration}} = 0.037 - 0.655[1/(\mathrm{duration\ of\ rupture} + 1)^{1/2}]$.

administration of prophylactic antibiotics should theoretically decrease the risk of endometritis, it would not be expected to alter the association of other variables with the risk of endometritis.

In summary, perioperative anemia or transfusion and younger age were independently associated with increased odds of endometritis, while lack of private health insurance, amniotomy, and longer duration of rupture of membranes were associated with marginally increased odds of infection. While most of these factors are not easily modifiable, knowledge of the increased risk associated with specific factors can be used to tailor antibiotic prophylaxis regimens and heighten surveillance for signs of endometritis in the postoperative period in women at highest risk of infection.

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