8-2010

Comparison of costs of surgical site infection and endometritis after cesarean delivery using claims and medical record data

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colony count reduction with the wipes was significantly greater than with the hand rub ($P = .001$, by the Mann-Whitney *U* test).

Most of the cultured bacteria were normal skin flora, such as coagulase-negative staphylococci. Seventeen stethoscopes (20%) grew *S. aureus,* one isolate of which was methicillin-resistant *S. aureus.* One culture yielded *Enterococcus* species, and 1 yielded *Enterobacter aerogenes.* For those stethoscopes that harbored *S. aureus,* the median colony count was 5 CFU (range, 1–30 CFU). Both cleaning methods effectively reduced *S. aureus* colonization. Eradication of *S. aureus* was achieved on 3 of 4 stethoscopes in the alcohol wipe group and on 7 of 13 in the hand rub group ($P = .603$, by the Fisher exact test).

Our data confirmed that stethoscope contamination with bacterial pathogens, including *S. aureus,* is common. A single cleaning of stethoscopes with alcohol-based hand rub reduced bacterial contamination of stethoscopes by approximately 90% and was 54% successful in eradicating *S. aureus.* Routine use of the alcohol products on stethoscopes may be more effective in reducing bacterial contamination than a single application. At this time, there are no data on the long-term impact of repeated alcohol applications on stethoscope integrity.

These data also show that a single cleaning with an alcohol wipe was more effective than the alcohol-based hand rub in decontamination of stethoscopes, possibly because of the mechanical effect of the cotton pledget. However, given traditionally poor compliance with hand hygiene, advocating routine use of a second procedure involving alcohol wipes to disinfect stethoscopes is impractical and unlikely to be performed reliably. With the wide availability of alcohol-based hand rub, the combination of hand and stethoscope rubbing in a single maneuver has practical appeal and, if the preliminary findings of this study are confirmed, could become part of routine bedside practice.

ACKNOWLEDGMENTS

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article.

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Received December 9, 2009; accepted February 10, 2010; electronically published June 28, 2010.

Presented in part: The 15th Annual Scientific Meeting of the Society for Healthcare Epidemiology of America; Los Angeles, California; April 2005.

 0899-823X/2010/3108-0020$15.00. DOI: 10.1086/655437

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Comparison of Costs of Surgical Site Infection and Endometritis after Cesarean Delivery Using Claims and Medical Record Data

We used administrative and clinical data from a case-control study to calculate the costs of surgical site infection and endometritis after cesarean delivery. Attributable costs determined by multivariate generalized least-squares regression models with the 2 data sets were similar, suggesting that administrative data can be used to calculate infection costs.

Infect Control Hosp Epidemiol 2010; 31(8):872-875

Calculation of the attributable costs due to hospital-acquired infection requires adjustment for factors associated both with infection and with increased or decreased costs. In many reports, attributable costs are determined using multivariate models or matching algorithms adjusted for demographic characteristics, comorbidities, and procedure-associated data abstracted from medical records.[1,2] Alternatively, we and others have used administrative data (primarily *The International Classification of Diseases, 9th Edition, Clinical Modification [ICD-9-CM]* diagnosis and procedure codes) to define comorbidities and procedures.[3,4] To our knowledge, no investigators have compared the use of medical record versus claims data to determine the attributable costs of a hospital-acquired infection. We used the 2 sources of data to create covariates

for regression models, which we constructed to calculate costs attributable to surgical site infection (SSI) and endometritis among women who underwent cesarean delivery.

We performed a case-control study on a subset of 491 women who underwent low transverse cesarean delivery at Barnes-Jewish Hospital, a 1,250-bed tertiary care hospital affiliated with Washington University School of Medicine (St Louis, MO) during the period July 1, 1999 through June 30, 2001. We previously reported independent risk factors for SSI and endometritis in this population.[5,6] Endometritis was considered to be present if there was fever that began more than 24 hours after or continued at least 24 hours after delivery, as well as fundal tenderness.[6] SSI was defined on the basis of the criteria of the National Nosocomial Infections Surveillance System.[5,8]

Electronic data were collected for all patients from the Barnes-Jewish Hospital Medical Informatics database for the original surgical admission, including demographic information, microbiology and laboratory test results, and *ICD-9-CM* diagnosis and procedure codes. *ICD-9-CM* diagnosis codes were also collected for the 12 months preceding the cesarean delivery to identify comorbidities. Comorbidity and procedure variables were created from the administrative data using the Clinical Classification diagnostic groupings, which are available at the Web site of the Healthcare Cost and Utilization Project.[7]

Clinical data, including obstetric history, relevant comorbidities thought to be associated with risk of SSI or endometritis, prophylactic and therapeutic antibiotics, and duration of rupture of membranes and labor, were collected from the surgical hospitalization records as described previously.[5,6]

Total hospital cost data (direct, indirect, and fixed costs) were obtained from the Barnes-Jewish Hospital cost accounting database (Trendstar; McKesson) for the surgical admission and any inpatient surgery, outpatient surgery, and emergency readmission to the hospital within 30 days after surgery, excluding the costs before the day of the cesarean delivery, as described previously.[9] All costs were inflation adjusted to 2008 US dollars using the medical care component of the Consumer Price Index.[10]

Attributable costs were determined as previously described using multivariate generalized least-squares (GLS) regression.[3,9,11] All variables with *P* value less than or equal to .05 in univariate analysis or with biologic plausibility were entered into the initial model; *P* values greater than .25 were used for exclusion in the model. An intermediate regression was performed to predict costs in 2008 US dollars.[11] Attributable costs were calculated from the coefficients in the GLS model, as described elsewhere.[3,9] All statistical analyses were performed using Stata software, version 9.2 (Stata Corp). Approval for this study was obtained from the Washington University Human Research Protection Office.

The study population was restricted to women with complete cost data for the original surgical hospitalization and any additional hospitalization(s) within 30 days after low transverse cesarean delivery. The population included 80 women with SSI, 121 women with endometritis, and 309 control patients without infection. Nineteen women had both SSI and endometritis.

Separate GLS models were created to determine the impact of SSI and endometritis on hospital costs using the 2 sources of data (administrative data and medical records) to identify covariates. In the administrative data model, covariates associated with significantly increased costs were young age, severe complications of delivery, pneumonia, pulmonary collapse or insufficiencies, preeclampsia or eclampsia, chorioamnionitis, maternal cardiac conditions, sexually transmitted infection, obstetric laceration and/or trauma, ovarian procedures, and placement of a central venous catheter. In the alternative model using medical record data, covariates associated with significantly increased costs included age, nonwhite race, labor induction, use of drains, additional surgical procedure other than bilateral tubal ligation, transfusion and/or anemia, severe preeclampsia or eclampsia, use of general anesthesia, inhaled steroids, preoperative antibiotics for therapy of chorioamnionitis, and postoperative hematoma. The attributable costs of SSI and endometritis estimated by the 2 multivariate GLS regression models were very similar, regardless of the source of data used to specify covariates (Table 1).

We compared attributable costs of SSI and endometritis after cesarean delivery calculated using electronically available administrative and demographic data with costs calculated using manually collected medical record data to specify model covariates. The estimated attributable costs calculated using GLS regression models for both SSI and endometritis were similar, regardless of the source of data used to specify covariates. This finding suggests that administrative data can be used to estimate costs of these hospital-acquired infections. Administrative data are available from many institutions with diverse patient populations through the Healthcare Cost and Utilization Project. Our results suggest that these data can be used to determine variation in costs of infection by institution and by type of surgery.

We determined that the costs of SSI equaled $3,400–$3,700 and the costs of endometritis equaled $3,800–$4,000. These costs differ slightly from those reported in our previous study of infection costs after cesarean delivery,[9] because of the use of a case-control subset in this report, compared with use of the entire cohort of 1,597 women in the previous study. Our finding that administrative data could be used instead of clinical medical record data in our tertiary care institution to specify covariates in regression models must be confirmed with data from other facilities representing the great variety of acute care hospitals in the United States. Use of administrative data will facilitate comparison of costs of infection across facilities and can be used in the future to determine the economic impact of infection control prevention activities in institutions and at state and national levels.

TABLE 1. Coefficients from the 2 Generalized Least-Squares Models Using Administrative and Medical Record Data to Determine Attributable Costs of Surgical Site Infection and Endometritis

Variable	Administrative data		Medical record data	
	Value	*P*	Value	*P*
Surgical site infection	0.36 ± 0.04	<.001	0.36 ± 0.04	<.001
Endometritis	0.40 ± 0.03	<.001	0.35 ± 0.03	<.001
Age				
<18 years	0.10 ± 0.05	.053	0.12 ± 0.05	.022
>35 years	0.07 ± 0.04	.113	0.12 ± 0.04	.004
Nonprivate health insurance[a]	0.03 ± 0.03	.256	…	
Nonwhite race	…		0.10 ± 0.03	.002
Sexually transmitted disease	0.38 ± 0.15	.013	…	
Diabetes mellitus or gestational diabetes	0.07 ± 0.05	.142	…	
Maternal heart disease	0.18 ± 0.07	.011	…	
Labor induction	…		0.06 ± 0.03	.039
Drains	…		0.23 ± 0.05	<.001
Ovarian surgical procedure	0.46 ± 0.14	.001	…	
Surgical procedure other than bilateral tubal ligation	…		0.23 ± 0.07	.001
Obstetric laceration	0.28 ± 0.11	.013	…	
Severe complication of delivery	0.52 ± 0.11	<.001	…	
Central venous catheter[b]	0.54 ± 0.11	<.001	…	
Mild preeclampsia	0.12 ± 0.05	.017	0.06 ± 0.05	.203
Severe preeclampsia or eclampsia	0.27 ± 0.05	<.001	0.16 ± 0.05	.001
General anesthesia			0.22 ± 0.05	<.001
Clinical diagnosis of chorioamnionitis	0.20 ± 0.04	<.001	…	
Antibiotic prophylaxis against group B *Streptococcus* (ampicillin, penicillin, or clindamycin)	…		0.06 ± 0.03	.092
Antibiotic therapy before surgery for chorioamnionitis (gentamicin, tobramycin, or ampicillin-sulbactam)	…		0.18 ± 0.04	<.001
Pneumonia	0.31 ± 0.10	.002	…	
Pulmonary collapse or insufficiencies	0.30 ± 0.12	.015	…	
Transfusion and/or anemia	…		0.20 ± 0.03	<.001
Postoperative hematoma	…		0.20 ± 0.07	.006
Inhaled steroid therapy	…		0.30 ± 0.10	.003
R^2 for the model[c]	0.31		0.30	
Attributable cost, mean 2008 US$ (95% CI)				
Surgical site infection	$3,418 ($2,863–$4,081)		$3,684 ($2,867–$4,734)	
Endometritis	$3,794 ($3,177–$4,530)		$4,015 ($3,075–$5,243)	

NOTE. Data are estimated β coefficient ± standard error, unless otherwise indicated. CI, confidence interval.

[a] Public Aid, Medicaid, Medicare, or no health insurance.

[b] Inserted before the onset of surgical site infection and/or endometritis in case patients.

[c] Adjusted R^2 after accounting for the natural log transformation of costs.

ACKNOWLEDGMENTS

We thank Preetishma Devkota, Zohair Karmally, Cherie Hill, and Stacy Leimbach for assistance with data collection and management.

Financial support. This work was supported in part by grants from the Centers for Disease Control and Prevention (Prevention Epicenter Program, UR8/CCU715087), and the National Institutes of Health (K01AI065808 to M.A.O and K24AI06779401 to V.J.F). The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Potential conflicts of interest. All authors report no conflicts relevant to this article.

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Received September 3, 2009; accepted January 31, 2010; electronically published June 28, 2010.

 0899-823X/2010/3108-0021$15.00. DOI: 10.1086/655435

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Sustained and Prolonged Reduction in Central Line–Associated Bloodstream Infections as a Result of Multiple Interventions

Healthcare-associated bloodstream infections are a major source of morbidity and mortality among hospitalized patients. It has been estimated that 133,368 healthcare-associated bloodstream infections (BSIs) occur each year in the United States, resulting in 30,665 deaths. The major risk factor for healthcare-associated BSIs is a central venous catheter; an estimated 80,000 central venous catheter–associated BSIs occur in intensive care units (ICUs) each year.[1] Authoritative guidelines have been published that provide recommendations designed to reduce the rate of central line–associated (CLA) BSI.[1,2] In addition, the Institute for Healthcare Quality and Improvement promulgated a "bundle" of control measures that used feedback of process measures to further reduce CLABSI.[3]

A comparison of data reported by National Healthcare Safety Network (2006–2007)[4] with data reported by the National Nosocomial Infection Surveillance system (1992–2004)[5] demonstrates a reduction in the rate of CLABSIs over this time period in all ICUs. A large intervention study that used a before-and-after design demonstrated a dramatic reduction in the rate of CLABSI over 16–18 months by implementation of an infection control bundle of hand hygiene, full-barrier precautions during central line insertion, skin antisepsis with chlorhexidine, avoidance of the femoral catheterization site, and removal of unnecessary catheters.[6] However, only limited data are available that demonstrate a prolonged and sustained reduction of CLABSI in which this decrease correlates with specific intervention efforts. Here, we report data from the University of North Carolina Hospitals, an 800-bed tertiary care facility, that demonstrate a dramatic decrease in the rate of CLABSI over a 10-year period.

Infection control at University of North Carolina Hospitals is provided by 2 faculty members, 6 infection preventionists, 1 public health epidemiologist, and 1 laboratory technologist. Comprehensive hospital-wide surveillance was conducted using definitions recommended by the National Nosocomial Infection Surveillance[7] and, more recently, the National Healthcare Safety Network.[8] All data were entered into a computerized database. Rates of CLABSI were calculated as the number of infections per 1,000 central line–days. Simple linear regression models (least-squares method) were used to examine decreases in the rate of CLABSI over time. Statistical significance was assessed by comparing these regression lines to a line with a zero slope. On the basis of the decreased CLABSI rates, we calculated the number of CLABSIs prevented and the estimated cost savings associated with the decrease.

Over the 10 years period from 1999 to 2008, the number of CLABSIs decreased 73% ($P < .001$) for all the ICUs combined (Figure 1). Rates in individual ICUs were as follows (1999, 2008, statistical assessment of decrease): neonatal ICU rates for 1999 and 2008, 9.0 and 3.1, respectively ($P = .012$); pediatric ICU rates for 1999 and 2008, 7.8 and 4.1, respectively ($P = .013$); coronary care ICU rates for 1999 and 2008, 2.7 and 2.5, respectively ($P = .33$); surgery or trauma ICU rates for 1999 and 2008, 14.1 and 2.7, respectively ($P = .003$); neurosurgery ICU rates for 1999 and 2008, 12.7 and 3.0, respectively ($P = .068$); cardiothoracic ICU rates for 1999 and 2008, 7.4 and 0.8, respectively ($P < .001$); burn ICU rates for 1999 and 2008, 14.1 and 1.1, respectively ($P < .001$); and medicine or respiratory ICU rates for 1999 and 2008, 6.1 and 1.6, respectively ($P < .001$). Over the 10-year time period 1999–2008, we prevented 887 infections at a total cost savings of $20,615,654, based on published cost data and 244 deaths.[9]

The unit specific rates of CLABSI have been reported quarterly to medical and nursing directors since 1999. Multiple interventions were introduced during the past 10 years to aid in reducing the rate of CLABSI: