Effect of Pregnancy on Adverse Outcomes After General Surgery

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IMPORTANCE The literature regarding the occurrence of adverse outcomes following nonobstetric surgery in pregnant compared with nonpregnant women has conflicting findings. Those differing conclusions may be the result of inadequate adjustment for differences between pregnant and nonpregnant women. It remains unclear whether pregnancy is a risk factor for postoperative morbidity and mortality of the woman after general surgery.

OBJECTIVE To compare the risk of postoperative complications in pregnant vs nonpregnant women undergoing similar general surgical procedures.

DESIGN, SETTING, AND PARTICIPANTS In this retrospective cohort study, data were obtained from the American College of Surgeons' National Surgical Quality Improvement Program participant user file from January 1, 2006, to December 31, 2011. Propensity-matched females based on 63 preoperative characteristics were matched 1:1 with nonpregnant women undergoing the same operations by general surgeons. Operations performed between January 1, 2006, and December 31, 2011, were analyzed for postoperative adverse events occurring within 30 days of surgery.

MAIN OUTCOMES AND MEASURES Rates of 30-day postoperative mortality, overall morbidity, and 21 individual postoperative complications were compared.

RESULTS The unmatched cohorts included 2764 pregnant women (50.5% underwent emergency surgery) and 516,705 nonpregnant women (13.2% underwent emergency surgery) undergoing general surgery. After propensity matching, there were no meaningful differences in all 63 preoperative characteristics between 2539 pregnant and 2539 nonpregnant patients (all standardized differences, <0.1). The 30-day mortality rates were similar (0.4% in pregnant women vs 0.3% in nonpregnant women; P = .82), and the rate of overall morbidity was also not significantly different between pregnant vs nonpregnant patients (6.6% vs 7.4%; P = .30).

CONCLUSIONS AND RELEVANCE There was no significant difference in overall morbidity or 30-day mortality rates in pregnant and nonpregnant propensity-matched women undergoing similar general surgical operations. General surgery appears to be as safe for pregnant women as it is for nonpregnant women.

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H
torical data1 suggest that 1 in 500 pregnant patients require nonobstetric surgery. Pregnancy is associ-
ated with physiologic changes in body habitus and the
cogulation,2 cardiovascular,3 pulmonary,4 and immune5 sys-
tems. These changes pose a diagnostic and treatment chal-
gen to surgeons because physical examination findings
and laboratory test values are different from those routinely
outrived.6,7 Therefore, it might be expected that postope-
erative complications in pregnant patients are increased
pared with those in nonpregnant patients. Several retrospec-
tive studies6,8 have supported this hypothesis. However,
equivalent complication rates between pregnant and nonpreg-
ant patients have also been reported.10,11 Review of these dis-
parate studies suggests that the heterogeneity of outcomes is
likely the result of differences in the types of operations studied
and the inability to account for differences in patient char-
acteristics of pregnant and nonpregnant women in the statisti-
cal analyses.

Although several investigators9–13 report that they have ad-
justed for differences in patient baseline characteristics, none of
these studies has attempted to do this using propensity
matching. Because pregnancy usually occurs in younger
women as well as considering the broad alterations across the
body’s physiology as a result of pregnancy, we anticipated dif-
f erences in preoperative characteristics between nonpreg-
ant and pregnant patients. Therefore, we used propensity
matching, a technique recommended14 for comparison of
rors’ of interest with low event rates.

Using the American College of Surgeons’ National Surgi-

cal Quality Improvement Program (ACS NSQIP) participant use
ile (PUF), we evaluated adverse operative outcome rates in
general surgery contrasting pregnant with propensity-
matched nonpregnant women. We hypothesized that preg-
nant women are at greater risk of complications than are com-
parable nonpregnant women undergoing similar general
surgical operations.

Methods

Study Design and Population

This retrospective cohort study compared 30-day postope-
surgical outcomes of pregnant vs nonpregnant women un-
dergoing nonobstetric operations by general surgeons. Pa-

tients were identified from the ACS NSQIP PUF, a database of
urgical procedures performed in hospitals participating in the
ACS NSQIP from January 1, 2006, to December 31, 2011. Pa-

tients were excluded if they were male, underwent obstetric
urgery, or were missing one or more of the preoperative pa-
tient characteristics used in the study. Nonpregnant women
were also excluded if they underwent operations that were not
formed in the group of pregnant patients. The Colorado Mul-
ple Institutional Review Board classified this study as not in-
volving human subject research.

Primary Outcome

The primary outcome variables for the analyses in this study
were death from any cause and overall morbidity (≥1 of the 21
ACS NSQIP perioperative complications) occurring within 30
days of the index operation. These complications included
acute renal failure requiring dialysis or hemofiltration; pro-
gressive renal insufficiency; bleeding requiring transfusion of
more than 4 U of packed red blood cells; cardiac arrest requir-
ing cardiopulmonary resuscitation; Q-wave myocardial infar-
dion; deep venous thrombosis or thrombophlebitis requiring
treatment; pulmonary embolism; pneumonia; prolonged
(>48 hours) intubation; unplanned intubation; septic shock;
cerebrovascular accident (including trauma such as a fall, re-
sulting in an injury to the head) or stroke with subsequent neu-
rologic deficit; sepsis; superficial surgical site infection; deep
incisional surgical site infection; organ or organ space surgi-
cal site infection; urinary tract infection; wound disruption;
peripheral nerve injury; graft, prosthesis, or flap failure; and
coma lasting longer than 24 hours.13

Statistical Analysis

Differences between pregnant and nonpregnant patients were
compared with χ2 tests for categorical variables and 2-tailed
dependent t tests for continuous variables in the un-
matched cohorts. Differences between the groups were also
evaluated using the standardized differences14 to enable com-
parison of covariate imbalance between the matched and un-
matched cohorts. The absolute value of the standard differ-
ence of less than 0.1 indicates that the groups are well balanced
for that characteristic; differences greater than 0.1 or less than
–0.1 indicate some imbalance. The McNemar test, either in its
large sample size approximation or exact form, was used to
compare 30-day mortality and morbidity in the propensity-
matched cohorts.

Propensity-score matching methods were used to reduce
confounding related to nonrandom assignment of pregnancy.15
A propensity score is the predicted probability, based on lo-
gistic regression, that a given woman will be pregnant. This
approach was used because of its performance and simplicity.
Pregnant patients were propensity matched 1:1 to controls with
a greedy algorithm.16 The propensity score logit model in-
cluded 63 patient preoperative characteristics.

Despite the large sample of nonpregnant women, we con-
ducted one-to-one matching to avoid the possible bias of many-
to-one matching.17 Each pregnant patient was matched to a
single nonpregnant control patient if her predicted propensi-
ity scores were identical to 8 decimal places. If such a match
was not found, the pregnant patient was matched to a
nonpregnant patient on the basis of a 7-, 6-, 5-, 4-, 3-, 2-, or
1-decimal place match, tested sequentially. Missing values were
treated as a separate category for the categorical variables of
race/ethnicity, body mass index, and the 12 preoperative lab-
atory test values. Laboratory test values were coded as miss-
ing, abnormal low, normal, and abnormal high according to val-
ues presented in a widely used medical textbook.18

Differences in complications and mortality rates were also
analyzed in subgroups of emergency and nonemergency op-
erations. To retain high power, we included an interaction term
for pregnancy and emergency in a conditional logistic regres-
sion model. Evidence of an interaction would indicate that the
association between pregnancy and complication rates was dif-
...
Figure 1. Strengthening the Reporting of Observational Studies in Epidemiology Flow Diagram of Pregnant vs Nonpregnant Women Undergoing the Same General Surgical Operations

Data were obtained from the American College of Surgeons’ National Surgical Quality Improvement Program (ACS NSQIP) (2006-2011). CPT indicates Current Procedural Terminology.

Results

There were 651 594 adult women undergoing operations by general surgeons in the ACS NSQIP PUF from 2006 to 2011. Exclusion criteria and sample size of patients in this analysis are demonstrated in the Strengthening the Reporting of Observational Studies in Epidemiology diagram (Figure 1). Of the 651 594 patients, 49 977 (7.7%) were excluded because they were missing 1 or more preoperative patient characteristic, and 2011 patients (0.3%) were excluded because they underwent an obstetric operation. An additional 80 137 nonpregnant patients (12.3%) were excluded because they underwent an operation that was not performed in the group of pregnant patients. A total of 519 469 patients remained: 2764 (0.5%) were pregnant and 516 705 (99.5%) were nonpregnant.

Characteristics of unmatched pregnant patients and nonpregnant patients are presented in eTable 1 in the Supplement. The unmatched pregnant patients were significantly younger than the nonpregnant patients (29.8 vs 53.0 years; \( P < .001 \)). Compared with the nonpregnant patients, the pregnant women were more likely to undergo surgery as an inpatient (2074 [75.0%] vs 308 375 [59.7%]; \( P < .001 \)) and undergo an emergency operation (1396 [50.5%] vs 68 156 [13.2%]; \( P < .001 \)). Pregnant patients generally had lower rates of preoperative comorbidities but higher rates of abnormal laboratory test results (high white blood cell count and low blood urea nitrogen, hematocrit, serum creatinine, serum sodium, and serum albumin levels) compared with nonpregnant patients.

The standardized differences for the proportions or means between the pregnant and nonpregnant unmatched cohorts are reported in eTable 1 in the Supplement. The standardized differences were greater than 0.1 or less than −0.1 for 31 of the 63 preoperative patient characteristics (49.2%), indicating the expected, important imbalances between pregnant and nonpregnant patients in the unmatched cohorts.

In the unmatched cohort, 10 of 2764 pregnant patients (0.4%) died within 30 days of surgery compared with 5759 of 516 705 nonpregnant patients (1.1%) (\( P < .001 \)) (Table). The overall morbidity rate was also lower for pregnant patients (183/2764 [6.6%] vs 48 394/516 705 [9.4%]; \( P < .001 \)) than nonpregnant patients. Pregnant patients had significantly lower rates of superficial surgical site infection, urinary tract infection, bleeding requiring transfusion of more than 4 U of packed red blood cells, myocardial infarction, and unplanned intubation compared with nonpregnant patients in the unmatched cohort (Table).

The propensity model is provided in eTable 2 in the Supplement. Thirty-seven of the preoperative patient characteristics were significant predictors of pregnancy, with the C statistic for the full model of 0.939. A total of 2539 of the 2764 pregnant patients (91.9%) were matched to 2539 of 516 705 (0.5%) nonpregnant patients. The standardized differences in baseline characteristics between the groups before and after matching on the propensity score are shown in Figure 2. In the propensity-matched cohort, none of the 63 patient characteristics had standardized differences greater than 0.1 or less than −0.1, indicating that the propensity-matched samples were well balanced.

As reported in the Table for the propensity-matched cohort, there was no significant difference in the 30-day mortality rates between pregnant and nonpregnant patients (0.4% vs 0.3%; \( P = .82 \)) or in the overall morbidity rate in the preg-
nant patients vs nonpregnant women (6.6% vs 7.4%; P = .30). No significant differences were found when we compared the rates of the 21 individual complications in the pregnant vs nonpregnant patients after propensity matching. There was no evidence of a different association between pregnancy and overall morbidity or mortality rates in the emergency and nonemergency subgroups (interaction P values: overall morbidity, P = .11; mortality, P = .74).

### Discussion

We performed an analysis of pregnant women matched to nonpregnant women undergoing general surgical operations using the ACS NSQIP PUF to determine whether pregnancy was associated with an increased rate of postoperative adverse outcomes. We observed that pregnant patients had different preoperative risk factors than nonpregnant women: the pregnant women were younger, had fewer comorbidities, and more frequently had abnormal laboratory test values. Pregnant women were also more likely to undergo emergency procedures. Unbalanced preoperative risk factors between the groups were balanced after propensity matching, thereby minimizing bias in comparison of outcomes between the 2 patient populations. Analysis of matched cohorts showed no significant differences in 30-day mortality or the occurrence of 1 or more complications between the groups. Nonobstetric general surgery appears to be as safe in pregnant women as in nonpregnant women.

Prior studies reporting increased complication rates in pregnant vs nonpregnant women undergoing nonobstetric surgery come from analysis of the Health Care Utilization Proj-

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%)</th>
<th>Unmatched Nonpregnant</th>
<th>Pregnant</th>
<th>P Value</th>
<th>Matched Nonpregnant</th>
<th>Pregnant</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superficial surgical site infection</td>
<td>12 975 (2.5)</td>
<td>46 (1.7)</td>
<td>.005</td>
<td>44 (1.7)</td>
<td>36 (1.4)</td>
<td>.43</td>
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<tr>
<td>Sepsis</td>
<td>7854 (1.5)</td>
<td>36 (1.3)</td>
<td>.15</td>
<td>38 (1.5)</td>
<td>35 (1.4)</td>
<td>.82</td>
<td></td>
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<tr>
<td>Urinary tract infection</td>
<td>8169 (1.6)</td>
<td>28 (1.0)</td>
<td>.02</td>
<td>29 (1.1)</td>
<td>27 (1.1)</td>
<td>.89</td>
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<tr>
<td>Organ/organ space surgical site infection</td>
<td>6072 (1.2)</td>
<td>30 (1.1)</td>
<td>.66</td>
<td>42 (1.7)</td>
<td>29 (1.1)</td>
<td>.15</td>
<td></td>
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<tr>
<td>Deep incisional surgical site infection</td>
<td>3246 (0.6)</td>
<td>14 (0.5)</td>
<td>.42</td>
<td>13 (0.5)</td>
<td>14 (0.6)</td>
<td>&gt;.99</td>
<td></td>
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<td>Wound disruption</td>
<td>2133 (0.4)</td>
<td>11 (0.4)</td>
<td>.90</td>
<td>6 (0.2)</td>
<td>9 (0.4)</td>
<td>.61</td>
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<tr>
<td>Cardiac</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleeding requiring transfusion of &gt;4 U of PRBCs</td>
<td>7345 (1.4)</td>
<td>27 (1.0)</td>
<td>.049</td>
<td>19 (0.8)</td>
<td>26 (1.0)</td>
<td>.37</td>
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<td>Cardiac arrest requiring CPR</td>
<td>1291 (0.2)</td>
<td>2 (0.1)</td>
<td>.06</td>
<td>1 (0.04)</td>
<td>2 (0.1)</td>
<td>&gt;.99</td>
<td></td>
</tr>
<tr>
<td>Q-wave MI</td>
<td>901 (0.2)</td>
<td>0</td>
<td></td>
<td>1 (0.04)</td>
<td>0</td>
<td>NA</td>
<td></td>
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<tr>
<td>Respiratory</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Prolonged intubation (&gt;48 h)</td>
<td>8002 (1.5)</td>
<td>35 (1.3)</td>
<td>.023</td>
<td>28 (1.1)</td>
<td>35 (1.4)</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>5340 (1.0)</td>
<td>22 (0.8)</td>
<td>.22</td>
<td>14 (0.6)</td>
<td>21 (0.8)</td>
<td>.30</td>
<td></td>
</tr>
<tr>
<td>Unplanned intubation</td>
<td>4886 (0.9)</td>
<td>13 (0.5)</td>
<td>.01</td>
<td>11 (0.4)</td>
<td>13 (0.5)</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td>Septic shock</td>
<td>4276 (0.8)</td>
<td>14 (0.5)</td>
<td>.06</td>
<td>17 (0.7)</td>
<td>14 (0.6)</td>
<td>.72</td>
<td></td>
</tr>
<tr>
<td>Venous thromboembolism</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Deep venous thrombosis/thrombophlebitis</td>
<td>2617 (0.5)</td>
<td>10 (0.4)</td>
<td>.29</td>
<td>6 (0.2)</td>
<td>10 (0.4)</td>
<td>.45</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>1366 (0.3)</td>
<td>7 (0.3)</td>
<td>.18</td>
<td>1 (0.04)</td>
<td>7 (0.3)</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>Renal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute renal failure requiring dialysis or hemofiltration</td>
<td>1353 (0.3)</td>
<td>4 (0.1)</td>
<td>.23</td>
<td>3 (0.1)</td>
<td>4 (0.2)</td>
<td>&gt;.99</td>
<td></td>
</tr>
<tr>
<td>Progressive renal insufficiency*</td>
<td>1016 (0.2)</td>
<td>3 (0.1)</td>
<td>.30</td>
<td>2 (0.1)</td>
<td>3 (0.1)</td>
<td>&gt;.99</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke/cerebrovascular accident with neurologic deficit</td>
<td>621 (0.1)</td>
<td>0</td>
<td>.07</td>
<td>3 (0.1)</td>
<td>0</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Peripheral nerve injury</td>
<td>162 (0.03)</td>
<td>0</td>
<td>.35</td>
<td>1 (0.04)</td>
<td>0</td>
<td>NA</td>
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<tr>
<td>Graft/prosthesis/flap failure</td>
<td>337 (0.1)</td>
<td>0</td>
<td>.18</td>
<td>1 (0.04)</td>
<td>0</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Coma for &gt;24 h</td>
<td>255 (0.05)</td>
<td>0</td>
<td>.24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>30-d Mortality</td>
<td>5759 (1.1)</td>
<td>10 (0.4)</td>
<td>&lt;.001</td>
<td>8 (0.3)</td>
<td>10 (0.4)</td>
<td>.82</td>
<td></td>
</tr>
<tr>
<td>≥1 Complication</td>
<td>48 394 (9.4)</td>
<td>183 (6.6)</td>
<td>&lt;.001</td>
<td>188 (7.4)</td>
<td>168 (6.6)</td>
<td>.30</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CPR, cardiopulmonary resuscitation; MI, myocardial infarction; NA, not available; PRBCs, packed red blood cells.

* Progression was indicated by an increase in creatinine of more than 2 mg/dL from the preoperative value. To convert creatinine to micromoles per liter, multiply by 88.4.
Kuy et al reported increased rates of complications, length of stay, and cost for pregnant women undergoing thyroid and parathyroid surgery despite risk adjustment with logistic regression analysis for the dichotomous outcome (complications) and linear regression for the continuous variables (length of stay and cost). Using a similar time period, the same group evaluated pregnant women undergoing cholecystectomy. Prior to regression analysis, the pregnant patients had an increased complication rate. However, after age and procedure matching, as well as adjustment for insurance, race, and surgeon case volume, pregnancy was not associated with an increased risk of surgery-related complications.

Figure 2. Standardized Differences in Population Baseline Characteristics in Pregnant vs Nonpregnant Women Undergoing the Same General Surgical Operations Before and After Matching

- Age, y
- Race/ethnicity
- Body mass index category
- Work relative value unit
- Inpatient/outpatient operation
- Admitted directly from home
- Emergency operation
- Laparoscopic procedure
- ASA class
- Procedure category
- Year of operation
- Diabetes mellitus
- Cigarette smoker (within 1 y)
- ≥2 Alcoholic drinks/d (within 2 wk)
- Dyspnea (within 30 d)
- DNR order signed (within 30 d)
- Functional health status prior to surgery
- Ventilator dependent (within 48 h)
- Severe chronic obstructive pulmonary disease
- Pneumonia entering surgery
- Ascites (within 30 d)
- Esophageal varices (within 6 mo)
- Congestive heart failure (within 30 d)
- Myocardial infarction (within 6 mo)
- Percutaneous coronary intervention
- Major cardiac surgery
- Angina (within 30 d)
- BP >140/90 mm Hg or taking antihypertension medications
- Revascularization or amputation for peripheral vascular disease
- Rest pain or gangrene due to ischemia
- Acute renal failure (rising creatinine to >3 mg/dL within 24 h)
- Dialysis or hemofiltration (within 2 wk)
- Impaired sensorium in context of current illness (within 48 h)
- Coma entering surgery
- Hemiplegia/hemiparesis
- Transient ischemic attack
- CVA/stroke with residual neurologic deficit
- CVA/stroke without neurologic deficit
- Tumor involving CNS
- Paraplegia/paraparesis
- Quadriplegia/quadruparesis
- Disseminated cancer
- Open wound with or without infection
- Corticosteroid use for chronic condition
- >10% Loss of body weight (within 6 mo)
- Bleeding disorder requiring hospitalization
- Transfusion within 72 h
- Chemotherapy for cancer (within 30 d)
- Radiation therapy for cancer (within 90 d)
- Systemic sepsis (within 48 h)
- Prior operation (within 30 d)
- Preoperative sodium
- Preoperative nitrogen
- Preoperative creatinine
- Preoperative albumin
- Preoperative total bilirubin
- Preoperative AST level
- Preoperative alkaline phosphatase
- Preoperative white blood cell count
- Preoperative platelet count
- Preoperative hemocrit
- Preoperative partial thromboplastin time
- Preoperative INR or PT value

To convert creatinine to micromoles per liter, multiply by 88.4. Solid vertical line indicates 0, dashed lines, 0.1 and −0.1. ASA indicates American Association of Anesthesiologists; AST, aspartate aminotransferase; BP, blood pressure; CNS, central nervous system; CVA, cerebrovascular accident; DNR, do not resuscitate; INR, international normalized ratio; and PT, prothrombin time.
cal complications. A recent publication using the Health Care Utilization Project Nationwide Inpatient Sample reported that postoperative complication rates following appendectomy were higher in pregnant vs nonpregnant women. In that study, Abbasi et al\(^8\) matched more than 7000 pregnant women to 35,000 nonpregnant women based on age and then performed multivariable logistic regression on categories of race, obesity, income, and insurance type. Although postoperative complication rates were higher in the pregnant group, the most notable finding was that peritonitis on presentation was the highest predictor of postoperative complication rates. This study identified that pregnant women more frequently presented with peritonitis than did nonpregnant women. The authors concluded that this factor was the causality for this discrepancy between the groups.

In contrast, some studies report low postoperative complication rates in pregnant patients. Erekson et al\(^19\) analyzed the ACS NSQIP PUF. Their descriptive findings parallel our results of low maternal postoperative complication rates, but they did not contrast pregnant and nonpregnant women. Silvestri et al\(^10\) found a similar rate of morbidity between pregnant and nonpregnant women undergoing cholecystectomy and appendectomy. McMaster et al\(^20\) also found that pregnant patients had postoperative complication rates similar to those of nonpregnant women after breast surgery.

Because a prospective randomized clinical trial to identify whether pregnancy is a risk factor for postoperative complications is not feasible, only observational studies are available. The latter are dependent upon statistical adjustment to account for significant baseline differences between pregnant and nonpregnant patients. The ACS NSQIP PUF during our study time frame contained data on more than 500,000 nonpregnant women undergoing operations similar to those of pregnant patients. Propensity matching is well suited for this type of observational study in which a “large reservoir” of potential controls is contrasted to a moderately sized group.\(^21\) Propensity matching controls for measured baseline covariates before analysis of the outcomes.\(^22\) This technique does not require the complexity of forming multiple strata to balance covariates and is superior in reducing bias.\(^12\) Propensity matching is used frequently in medical studies because of its simplicity and robust performance, but it is not always reported appropriately.\(^23\) Key elements of propensity modeling that are often neglected include reporting the model construction, assessment of prematching and postmatching differences between groups, and appropriate outcome analysis.

In our study, the maximum C statistic for the propensity model was 0.939 (eTable 2 in the Supplement) compared with the value of 1.0 for a perfect model. This finding supports the conclusion that we have developed a reasonable model to predict pregnancy based on preoperative characteristics. The model eliminated measured, unbalanced preoperative variables quantified by standardized differences (Figure 2), and outcomes were appropriately assessed with a paired analysis contrasting pregnant to nonpregnant women. Other approaches, such as double robust inverse probability weighting, requiring specification of an outcomes regression model would not have been a feasible approach with these data given the small number of outcome events.\(^24\)

This study has strengths and limitations. Strengths include (1) a large sample from a broad range of hospitals, (2) a broad range of operations included in the database using a systematic sampling method, and (3) a standardized protocol for collection of the ACS NSQIP PUF, with central auditing of the data. The primary limitations of this study include (1) the observational design so that only association (ie, not causation) may be concluded and (2) a lack of data on fetal outcomes. There is clearly a risk to the fetus when a pregnant woman undergoes surgery. Fetal loss after appendectomy was found to be 4% in women with a normal appendix.\(^25\) The increasing number of reports indicates that infectious surgical indications, such as appendicitis and cholecystitis, are associated with an unfavorable outcome for the fetus.\(^26\) Attempting medical management of surgical diseases (eg, appendicitis and cholecystitis) is associated with a worse outcome compared with early operative management.\(^8,11\) Therefore, the well-being of the fetus represents an additional risk-benefit factor to consider in pregnant women, and an unclear diagnosis may require further expedient evaluation to minimize delay of definitive management.

**Conclusions**

Pregnant patients undergoing emergency and nonemergency general surgery do not appear to have elevated rates of mortality or morbidity. We did not account for fetal complications in this study and would not advocate that our findings be generalized to elective surgical situations that can be postponed until after delivery. Therefore, general surgery appears to be as safe in pregnant as it is in nonpregnant women. These findings support previous reports that pregnant patients who present with acute surgical diseases should undergo the procedure if delay in definitive care will lead to progression of disease.
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Critical revision of the manuscript for important intellectual content: H. B. Moore, Juarez-Colunga, Hammermeister, E. E. Moore, Meguid.

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Drafting of the manuscript: E. E. Moore, Meguid.

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