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Pregnant trauma patients may be at increased risk of mortality compared to nonpregnant women of reproductive age: trends and outcomes over 10 years at a level I trauma center

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Abstract

Background: Pregnancy has been identified as a risk factor for poor outcomes after traumatic injury, but prior outcome analyses are conflicting and dated. We sought to examine outcomes in a contemporary cohort.

Methods: Retrospective cohort analysis at a level I trauma center's institutional registry from 2009 to 2018, with comparison to population-level demographic trends in women of reproductive age and pregnancy prevalence. Unadjusted cohorts of pregnant versus nonpregnant trauma patients were compared. Pregnant patients then were matched on age, mechanism of injury, year, and injury severity score with nonpregnant controls for adjusted analysis with a primary outcome of maternal mortality.

Results: Despite declining birth and pregnancy rates in the population, pregnant women comprised a stable 5.3% of female trauma patients of reproductive age without decline over the study period ($p = 0.53$). Compared with nonpregnant women, pregnant trauma patients had a lower injury severity score (1 [1–5] vs 5 [1–10] $p < 0.0001$) and a shorter length of stay (1 [1–2] vs 1 [1–4] $p = 0.04$), were less likely to have CT imaging (48.8% vs 67.4%, $p < 0.0001$) and more likely to be admitted (89.3% vs 79.2%, $p = 0.003$). Positive toxicology screens were less prevalent in pregnant women, but only for ethanol (5.4% vs 31.4%, $p < 0.0001$); there was no difference in rates of cannabis, opiates, or cocaine. After matching to adjust for age, year, mechanism of injury, and injury severity score, mortality occurred significantly more frequently in the pregnant cohort (2.1% vs 0.2%, OR = 13.5 [1.39–130.9], $p = 0.02$).

Conclusion: Pregnant trauma patients have not declined in our population despite population-level declines in pregnancy. After adjusting for lower injury severity, pregnant women were at substantially greater risk of mortality. This supports ongoing concern for pregnant trauma patients as a vulnerable population. Further efforts should optimize systems of care to maximize the chances of rescue for both mother and fetus.

Keywords

injury, pregnancy, pregnant, trauma, women, women of reproductive age

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Introduction

Trauma and unintentional injury are the leading cause of death among women of reproductive age (WRA) in the United States[1] and a common event that impacts approximately 7% of all pregnancies.[2] The associated changes to anatomy and physiology that accompany pregnancy may hinder the ability to diagnose and treat traumatic injuries. In addition, anxiety on the part of the treatment team can be heightened by the presence of the fetus.[3] Historically, pregnancy has been identified as a risk factor for increased morbidity and mortality in trauma patients, though outcomes have been conflicting, with some studies suggesting a protective effect of pregnancy in trauma.[4]

We sought to use a contemporary cohort to evaluate the hypothesis that pregnancy is associated with worsened clinical outcomes in the setting of traumatic injury. We also sought to compare trends and analyze resource utilization devoted to the care of this population, including the use of imaging modalities, need for surgical intervention, length of stay, and cost of care. For pregnant patients, we sought to further define determinants of maternal and fetal outcomes.

Methods

We queried our institutional trauma registry for all female patients of reproductive age from January 2009 to December 2018 and separated them into pregnant and nonpregnant cohorts. Population-level statistics were calculated to determine the number of WRA (i.e. 15–44 years old) in our geographic area (defined as the state of Oregon) as a denominator for each year of the study period using a method proposed and validated by the Centers for Disease Control and Prevention (CDC).[5] Legacy Emanuel Medical Center is an urban level I trauma center (one of only two serving the state of Oregon) with 554 beds and approximately 2700 trauma admissions yearly.

Pregnancy was defined as either a positive pregnancy test (urine or serum beta human chorionic gonadotropin (bHCG)) or a clinically apparent pregnancy (e.g. ultrasound result, gravid uterus) recorded during the trauma admission. From the cohort of nonpregnant WRA, we created a matched control cohort, using a greedy matching algorithm ("gmatch" SAS macro) for an up to 4:1 match on age (± 2 years), year (exact), trauma mechanism (penetrating vs blunt), and injury severity score (ISS). ISS was treated as a categorical variable using quartiles based on prior literature demonstrating its non-normal (positively skewed) distribution and, despite its numeric scale, its unsuitability for treatment as a continuous variable.[6]

Nonpregnant and pregnant cohorts were analyzed with respect to both clinical and outcome variables. The primary outcome was patient (maternal) mortality. Secondary outcomes included total hospital charges, use of computed tomography (CT) imaging modalities, length of stay, occurrence of a surgical intervention, and (for the pregnant cohort) fetal delivery during the trauma admission and/or fetal mortality. We included fetal mortality if it occurred during the trauma admission or a subsequent admission. Total hospital charges were indexed to inflation using the Bureau of Labor Statistics Consumer Price Index (CPI) subindex specific to inpatient hospital services, with yearly values used to generate a conversion factor to 2018 dollars.[7] Focused analysis of clinical outcomes (by manual retrospective chart review) was performed on patients of the pregnant cohort, documenting gestational age, operative interventions, and fetal and maternal morbidity and mortality.

Descriptive variables are reported as median (interquartile range) and number (percentage) unless otherwise noted. Continuous outcomes were compared using a Mann–Whitney–Wilcoxon test. Binary outcomes were compared using Fisher's exact tests and odds ratios with 95% confidence intervals. Trends over the time were examined using a Mann–Kendall test for trend (a nonparametric test to determine the presence and direction of a trend over time),[8] performed using R (R 3.6.0, The R Foundation for Statistical Computing, Vienna, Austria). All other analyses were performed using SAS (version 9.4; SAS Institute, Cary, NC, USA) with a predetermined alpha = 0.05 for statistical significance.

This study received Institutional Review Board approval. We followed all items, as applicable, of the consensus checklist for retrospective cohort studies contained in version 4 of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[9]

Results

We identified a cohort of n = 2647 WRA presenting as trauma patients, which represents 9.8% of all trauma patients (n = 26,882) seen over this period. Of these WRA, n = 140 (5.3%) were pregnant and n = 2507 (94.7%) were not, which is not significantly different from the proportion of WRA in the general population who are pregnant (5.0%, p = 0.44).

While the total population of WRA in Oregon grew over the study period (n = 755,964 in 2009 to n = 811,660 in 2018, a 7.3% increase, p for trend = 0.0001; see Figure 1), the proportion of WRA who were pregnant demonstrated a significantly declining trend (5.4% in 2009 to 4.5% in 2018, a 16.2% decrease, p = 0.0001), which is in keeping with a national population-level trend of declining pregnancy and live birth rates.[10] This decline more than compensated for growth in the female population, resulting in a significantly decreasing absolute number of pregnant women in the population (n = 40,483 in 2009 to 36,406 in 2018, a 10.1% decrease, p = 0.03; see Figure 2). Despite this larger population decline, the proportion of trauma patients who were pregnant remained stable over the study period (p = 0.53). Of all pregnant women in the

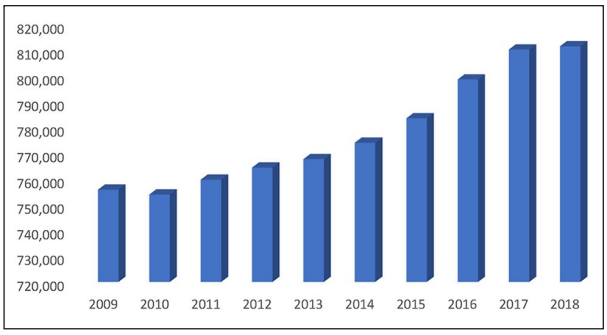

Figure 1. WRA in Oregon, by year.

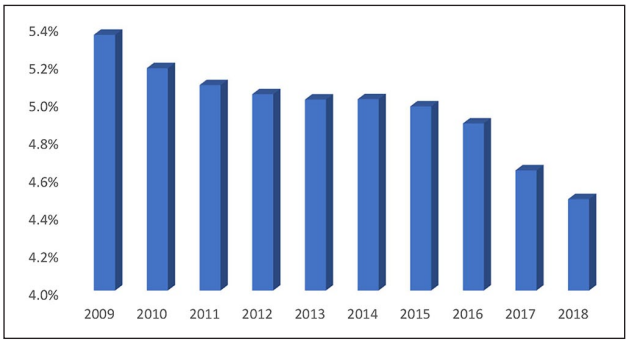

Figure 2. Percentage of the population who were pregnant, by year.

population, the proportion presenting as trauma patients during their pregnancy averaged 0.36 women per 1000.

Compared with the nonpregnant trauma population, pregnant trauma patients had a lower ISS and were less likely to have CT imaging. They also were more likely to be admitted, but had a shorter length of stay (see Table 1).

Toxicology screening was performed in n = 2190 (82.7%) of patients; this proportion did not differ between pregnant and nonpregnant cohorts (p = 0.73). Full results are presented in Table 1. Positive toxicology results were more prevalent in the nonpregnant cohort, but this difference was almost entirely explained by more ethanol-positive tests among nonpregnant women. There was no difference in the prevalence of cannabis, opiates, cocaine, or methamphetamines (Table 1).

Matching produced a control cohort with n = 618 nonpregnant trauma patients, and testing confirmed successful balancing between cohorts with respect to age (p = 0.91), ISS (p = 0.12), and mechanism (p = 0.15). Compared with their matched nonpregnant control cohort, pregnant trauma patients had significantly higher mortality (2.1% vs 0.2%, OR = 13.5 [1.39–130.9], p = 0.02; see Figure 3).

Detailed outcome analysis in the pregnant cohort included imaging utilization and outcomes, surgical intervention, and fetal and maternal outcomes. In 64 patients (46%), a head CT was obtained and n = 11 (17%) of these had an abnormal result. CT of the cervical spine was performed in 80 patients (57%), with an abnormal result in n = 5 (6.3%). CT of the abdomen and pelvis was performed in 61 patients (43.5%) and 23 (37.7%) of these had an abnormal result. Surgical intervention was undertaken in n = 17 (12.1%) pregnant patients, with the majority undergoing orthopedic surgical procedures. Laparotomy was performed in n = 3 patients and craniotomy in n = 1. Fetal loss occurred in n = 9 (6.4%) patients at a median gestational age of 12 [7–16] weeks. Fetal loss occurred in all cases of maternal mortality (n = 3). Delivery of a viable fetus during the trauma admission occurred in n = 2 patients (1.4%); both fetuses were greater than 34- week gestation and neither required advanced neonatal care.

One case of maternal and fetal death highlighted challenges in management of pregnant trauma patients and identified several process improvement opportunities. A 37-year-old woman presented as a level II trauma activation (the lowest of three acuity levels) after being a pedestrian struck by a motor vehicle in a parking lot. She was awake and conversant during prehospital transport. She was not identified as pregnant in the prehospital phase, but was later determined to have a singleton pregnancy at 33-week gestation. Initial vital signs were within normal limits, however, she rapidly decompensated within 5 min of hospital arrival and progressed to pulseless electrical activity (PEA) arrest. She was upgraded to a level I trauma with cardiopulmonary resuscitation (CPR) in progress; a gravid uterus was identified on physical examination. She underwent resuscitation, including endotracheal intubation and invasive line placement, massive transfusion protocol, bedside laparotomy, and thoracotomy with direct cardiac massage, without return of spontaneous circulation. Perimortem cesarean delivery was performed, but the fetus was determined to have died in utero. Cause of death appeared to be most consistent with intra- and retroperitoneal hemorrhage, with both uterine rupture and blunt liver injury observed.

Other maternal deaths included a 25-year-old woman (first trimester pregnancy), who died within the first hospital day from multiple gunshot wounds to the head and abdomen, and a 40-year-old woman (singleton pregnancy at approximately 21-week gestation), who died on hospital day two from cardiogenic shock following extensive blunt trauma to the chest and abdomen after being assaulted by her partner. No significant opportunities for improvement or systems changes were identified in these cases.

Discussion

Pregnant women comprise a stable proportion of our trauma patients despite declining birth and pregnancy rates in the population, which raises concern that the relative risk of suffering traumatic injury while pregnant may be increasing. Pregnant women are more likely to be admitted to the hospital despite having less severe injuries and less

Table 1. Baseline characteristics of the unadjusted pregnant and nonpregnant cohorts.

	Pregnant		Not pregnant		p
	n = 140		n = 2507		
Age (years)	25.5	[21.5, 32]	26	[21, 33]	0.75
ISS	1	[1, 5]	5	[1, 10]	< 0.0001
Penetrating trauma	5	(3.6%)	153	(6.1%)	0.27
Admitted	125	(89.3%)	1985	(79.2%)	0.003
CT head	61	(43.6%)	1671	(66.7%)	< 0.0001
CT spine	78	(55.7%)	1786	(71.2%)	0.0002
CT abdomen/pelvis	66	(47.1%)	1615	(64.4%)	< 0.0001
Toxicology					
Not performed	22	(15.7%)	435	(17.4%)	
Positive toxicology	24	(20.3%)	867	(41.8%)	< 0.0001
Ethanol	6	(5.4%)	643	(31.4%)	< 0.0001
Cannabis	16	(13.6%)	287	(13.9%)	0.88
Cocaine	2	(1.7%)	74	(3.6%)	0.42
Opiate	3	(2.5%)	55	(2.7%)	0.65
Methamphetamine	0	(0.0%)	20	(1.0%)	0.62
Length of stay (days)	1	[1, 2]	1	[1, 4]	0.042
Hospital charges	US$27,216	[US$19,612, US$35,999]	US$33,404	[US$25,590, US$61,962]	< 0.0001

CT: computed tomography; ISS: injury severity score.
Values are number (percentage) or median [interquartile range] as appropriate.

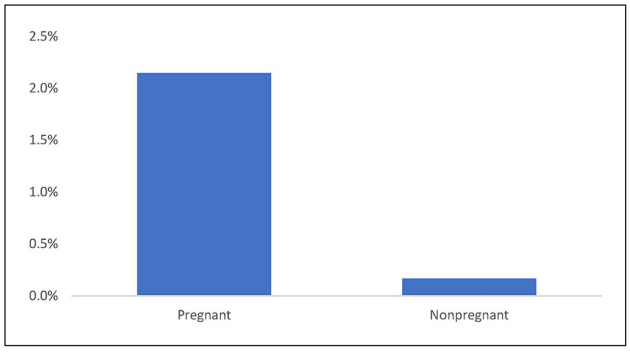

Figure 3. Mortality in the matched cohorts (p = 0.02).

substance use (primarily explained by less alcohol use), which likely reflects a deliberate (and appropriate) abundance of caution in this population. One factor driving admission of pregnant patients is the need for fetal monitoring, particularly in the third trimester. Another factor relates to the reduced number of abdominal CT scans obtained: in the setting of blunt abdominal trauma, serial abdominal exams and laboratory tests may replace initial CT imaging, but requires admission and longer observation. There is a suggestion that clinicians remain reluctant to utilize CT imaging in pregnant women, despite evidence that fetal exposure is comparatively small and guidelines discouraging the withholding of otherwise indicated imaging based on pregnancy.[11] This may be one driver of the slightly shorter length of stay in the pregnant cohort (and associated marginally decreased hospital costs).

However, after adjusting for injury severity and other confounders, pregnant women demonstrated higher mortality than their matched nonpregnant controls (see Table 2). This finding corroborates two prior analyses from earlier time periods demonstrating higher mortality,[12,13] in direct contrast to a national analysis suggesting that pregnancy has a protective effect in trauma.[4] Our analysis reinforces the concern that pregnancy remains a period of vulnerability and can complicate the challenges of appropriate assessment, resuscitation, and rescue after serious injury.

Why may pregnant women be at greater risk? Causal inference is beyond the power of this analysis, but prior studies have demonstrated higher rates of motor vehicle collision and assault (typically by an intimate partner)[14] during pregnancy, with higher ISSs specifically for the abdominal region compared with nonpregnant patients.[15] Substantial morbidity and mortality from abdominal injuries in pregnant patients have been highlighted by prior research.[16]

Once injured, pregnant women may face greater physiologic challenges in resuscitation—for instance, caval compression and impaired venous return by a gravid uterus.[17] Recognizing that the presence of the fetus may impair chances of maternal survival, recent efforts have reconceptualized the goals of perimortem cesarean delivery with the concept of "resuscitative hysterotomy" geared toward maternal rescue.[18]

Logistical and operational factors undoubtedly play a role as well. The most striking case in our cohort was one in which pregnancy was not recognized during the prehospital phase of care, and a patient with a potentially survivable

Table 2. Characteristics of the matched cohorts.

	Pregnant		Not pregnant		p
	n = 140		n = 618		
Age (years)	25.5	[21.5, 32]	26	[21, 32]	0.91
ISS	1	[1, 5]	1	[1, 5]	0.12
Penetrating trauma	5	(3.6%)	19	(3.1%)	0.15
Hospital charges	US$27,216	[US$19,612, US$35,999]	US$29,719	[US$23,313, US$42,234]	0.02
Length of stay (days)	1	[1, 2]	0	[1, 2]	0.06

ISS: injury severity score.

blunt injury died of hemorrhage (with concomitant fetal demise) with delayed resuscitation efforts that otherwise would have been immediately employed. Because she was initially triaged as a level II trauma and upgraded only after arrival, interventions were performed in the emergency department with suboptimal resources and coordination. In contrast, patients triaged to our highest level bypass the emergency department and go directly to the operating room, with an anesthesiologist and trauma surgeon in the room awaiting their arrival, a practice that has demonstrated improved survival for the most severely injured patients,[19] and may have improved the likelihood of rescue in this case. Had a third-trimester pregnancy been identified in the field, the in-house obstetrician also would have been alerted and would have been present in the operating room on patient arrival. Instead, he was called only after the patient had arrested, which delayed his assistance in the laparotomy and his performance of a perimortem cesarean delivery. Immediate perimortem cesarean delivery improves the probability of both maternal and fetal survival.[18] This case highlights the importance of considering pregnancy in all female patients of reproductive age and utilizing frank questioning as well as objective testing (bHCG, ultrasound) early in their clinical course.

This analysis has a number of limitations inherent to a retrospective, single-institution study. Small cohort size and modest injury severity contributed to limited numbers for analysis. It is important to recognize that our center does not see every trauma patient in the state, and that state-level demographic data used in denominators do not permit absolute population-level estimates, but do permit trend analyses. It is also important to note that trauma during pregnancy may be associated with adverse pregnancy outcomes remote from the trauma admission,[13,20] and that our study design underappreciates these late effects.

Some classification bias may have been present in under-identifying pregnant women, because while universal testing of all WRA was the institutional standard of care, it is likely that compliance with this standard was achieved in fewer than 100% of WRA. This type of bias is unlikely to change the results, as it would tend to skew findings toward the null hypothesis.

This study has limited external validity for centers that see more penetrating trauma or different demographics of their trauma population. Matching was able to adjust for the most striking baseline difference in patient characteristics, but it is possible some residual confounding was present.

Nonetheless, the magnitude of the increase in mortality observed lends credence to the finding that pregnant trauma patients experience higher risk of death.

Conclusion

Continued efforts are needed to reduce the occurrence of traumatic injury in pregnancy and to improve systems of care to optimize the chances of successful resuscitation and rescue of both mother and fetus. The timely recognition of pregnancy in women who are victims of traumatic injury is imperative for improving the evaluation and management of these patients. Provider education may also play an important role in improving management and outcomes, and advanced multidisciplinary team training and simulation may offer benefits over traditional educational efforts.[21,22]

Declaration of conflicting interests

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