

Motor vehicle crashes in pregnancy: Maternal and fetal outcomes

Natthida Owattanapanich, MD, Meghan R. Lewis, MD, FACS, Elizabeth R. Benjamin, MD, PhD, FACS, Monica D. Wong, MS, and Demetrios Demetriades, MD, PhD, FACS, Los Angeles, California

CONTINUING MEDICAL EDUCATION CREDIT INFORMATION

Accreditation

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the American College of Surgeons and American Association for the Surgery of Trauma. The American College of Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this journal-based activity for a maximum of 1.00 AMA PRA Category 1 Credit™. Physicians should claim only the credit commensurate with the extent of their participation in the activity. Of the AMA PRA Category 1 Credit™ listed above, a maximum of 1.00 credit meets the requirements for self-assessment.



AMERICAN COLLEGE OF SURGEONS
Inspiring Quality.
Highest Standards. Better Outcomes



AMERICAN COLLEGE OF SURGEONS
DIVISION OF EDUCATION

Objectives

After reading the featured articles published in the *Journal of Trauma and Acute Care Surgery*, participants should be able to demonstrate increased understanding of the material specific to the article. Objectives for each article are featured at the beginning of each article and online. Test questions are at the end of the article, with a critique and specific location in the article referencing the question topic.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons must ensure that anyone in a position to control the content of the educational activity (planners and speakers/authors/discussants/moderators) has disclosed all financial relationships with any commercial interest (termed by the ACCME as "ineligible companies", defined below) held in the last 24 months (see below for definitions). Please note that first authors were required to collect and submit disclosure information on behalf all other authors/contributors, if applicable.

Ineligible Company: The ACCME defines a "commercial interest" as any entity producing, marketing, re-selling, or distributing health care goods or services used on or consumed by patients. Providers of clinical services directly to patients are NOT included in this definition.

Financial Relationships: Relationships in which the individual benefits by receiving a salary, royalty, intellectual property rights, consulting fee, honoraria, ownership interest (e.g., stocks, stock options or other ownership interest, excluding diversified mutual funds), or other financial benefit. Financial benefits are usually associated with roles such as employment, management position, independent contractor (including contracted research), consulting, speaking and teaching, membership on advisory committees or review panels, board membership, and other activities from which remuneration is received, or expected. ACCME considers relationships of the person involved in the CME activity to include financial relationships of a spouse or partner.

Conflict of Interest: Circumstances create a conflict of interest when an individual has an opportunity to affect CME content about products or services of a commercial interest with which he/she has a financial relationship.

The ACCME also requires that ACS manage any reported conflict and eliminate the potential for bias during the session. Any conflicts noted below have been managed to our satisfaction. The disclosure information is intended to identify any commercial relationships and allow learners to form their own judgments. However, if you perceive a bias during the educational activity, please report it on the evaluation.

AUTHORS/CONTRIBUTORS				
Natthida Owattanapanich, Meghan R. Lewis, Elizabeth R. Benjamin, Monica D. Wong, and Demetrios Demetriades - No Disclosures.				
PLANNING COMMITTEE / EDITORIAL COMMITTEE	NOTHING TO DISCLOSE	DISCLOSURE		
		COMPANY	ROLE	RECEIVED
Ernest E. Moore, Editor		Haemonetics	PI	Shared US Patents
		Instrumentation Laboratory	PI	Research Support
		Stago, Humacyte, Prytime, Genentech	PI	Research Support
		ThromboTherapeutics	Co-founder	Stock
Associate Editors David B. Hoyt, Ronald V. Maier, and Steven Shackford	X			
Editorial Staff and Angela Sauaia	X			

Claiming Credit

To claim credit, please visit the AAST website at <http://www.aast.org/> and click on the "e-Learning/MOC" tab. You must read the article, successfully complete the post-test and evaluation. Your CME certificate will be available immediately upon receiving a passing score of 75% or higher on the post-test. Post-tests receiving a score of below 75% will require a retake of the test to receive credit.

Credits can only be claimed online

Cost

For AAST members and *Journal of Trauma and Acute Care Surgery* subscribers there is no charge to participate in this activity. For those who are not a member or subscriber, the cost for each credit is \$25.

Questions

If you have any questions, please contact AAST at 800-789-4006. Paper test and evaluations will not be accepted.

BACKGROUND:	Motor vehicle crashes (MVCs) are a leading cause of death in pregnant women. Even after minor trauma, there is risk of fetal complications. The purpose of this study was to compare injuries and outcomes in pregnant with matched nonpregnant women after MVC and evaluate the incidence and type of pregnancy-related complications.
METHODS:	Retrospective study at a Level I trauma center included pregnant MVC patients, admitted 2009 to 2019. Pregnant patients were matched for age, seatbelt use, and airbag deployment with nonpregnant women (1:3). Gestation-related complications included uterine contractions, vaginal bleeding, emergency delivery, and fetal loss.
RESULTS:	During the study period, there were 6,930 MVC female admissions. One hundred forty-five (2%) were pregnant, matched with 387 nonpregnant. The seat belt use (71% in nonpregnant vs. 73% in pregnant, $p = 0.495$) and airbag deployment (10% vs. 6%, $p = 0.098$) were similar in both groups. Nonpregnant women had higher Injury Severity Score (4 vs. 1, $p < 0.0001$) and abdominal Abbreviated Injury Scale (2 vs. 1, $p < 0.001$), but a smaller proportion sustained abdominal injury (18% vs. 53%, $p < 0.0001$). Mortality (1% vs. 0.7%, $p = 0.722$), need for emergency operation (6% vs. 3%, $p = 0.295$) or angiointervention (0.3% vs. 0%, $p = 0.540$), ventilator days (3 vs. 8, $p = 0.907$), and intensive care unit (4 vs. 4, $p = 0.502$) and hospital length of stay (2 vs. 2, $p = 0.122$) were all similar. Overall, 13 (11.1%) patients developed gestation-related complications, most commonly uterine contractions (6.3%), need for emergency delivery (3.5%), and vaginal bleeding (1.4%).
CONCLUSION:	Most pregnant patients hospitalized for MVC suffered minor injuries. Pregnant women had lower Injury Severity Score and abdominal Abbreviated Injury Scale than matched nonpregnant women. However, there was still a considerable incidence of gestation-related complications. It is imperative that pregnant patients be closely monitored even after minor trauma. (<i>J Trauma Acute Care Surg.</i> 2021;90: 861–865. Copyright © 2021 Wolters Kluwer Health, Inc. All rights reserved.)
LEVEL OF EVIDENCE:	Prognostic and epidemiological, level III
KEY WORDS:	Pregnancy; trauma; motor vehicle crashes.

Motor vehicle crashes (MVC) remain the leading cause of trauma death in the United States.¹ Trauma complicates approximately 10% of all pregnancies and is the leading cause of both maternal and fetal mortality.^{2–4} Additionally, MVC is a risk factor for pregnancy-related complications, such as preterm labor, placental abruption, and uterine rupture.⁵ The management of a pregnant woman who has sustained trauma is challenging, because pregnancy has significant physiologic demands that may confuse and complicate the evaluation, resuscitation, and definitive management of trauma patients.

Although pregnancy has not been determined to be an independent predictor of the need for trauma team activation (TTA),⁶ pregnant trauma patients warrant specialized attention because of the complex physiology and risk of fetal loss. There are limited data available on maternal and fetal outcomes after MVC. The purpose of this study was to compare the injury patterns, injury severity, and outcomes of pregnant women with nonpregnant women and identify the incidence and types of pregnancy-related complications.

PATIENTS AND METHODS

A single-center retrospective observational study was performed using Level I trauma center registry and chart reviews. All pregnant trauma patients with age at least 18 years and a matched group of nonpregnant female patients, whose age was between 15 and 45 years, from January 2009 to September

2019, were included. Patients were excluded if they had any of the following: death in the emergency department (ED) or arrival without signs of life; transferred from another hospital. Institutional review board approval was sought from the University of Southern California, and the exemption was granted.

Variables examined included patient demographics (age), injury data (year of injury, the documentation of seat belt usage, airbag deployment, Abbreviated Injury Scale [AIS] by body region, and Injury Severity Score [ISS]), clinical data (vital signs and Glasgow Coma Scale score field, and ED), gravida data (Gravida/para/abortion [GPA], gestational age, and fetal heart rate at ED), pregnancy complications (uterine contractions, vaginal bleeding, premature rupture of membranes, amniotic fluid embolization, in-hospital delivery, which included both vaginal delivery and cesarean section), and outcomes (need for emergency operation or interventional radiology, mortality, complications, hospital length of stay [LOS], and intensive care unit [ICU] LOS). Associated with abdominal AIS was defined as a patient that sustained abdominal injury with abdominal AIS at least 1.

The uterine contraction is defined by the visualization of any contraction in the 10-minute window by the use of external tocometer. Patients with gestational age (GA) younger than 37 weeks, who had persistent contraction with at least six times in an hour, were determined as premature contraction. Fetal heart rate was measured by hand-held Doppler ultrasound probe or the external transducer, which is placed on the maternal abdomen and held in place by an elastic belt. The termination of pregnancy is the ending of pregnancy by either vaginal delivery or caesarean section.

Univariate analysis compared patient characteristics, injury data, and outcomes between study groups. Continuous variables presented as median (interquartile range) and compared using Student's t test. Categorical variables presented as number (percentages) and compared using the χ^2 test. Propensity score matching analysis was used to compare pregnant and nonpregnant patients. Patients were matched on age, seat belt usage, and air bag deployment with 3:1 nearest-neighbor propensity

Submitted: October 8, 2020, Revised: December 30, 2020, Accepted: January 13, 2021, Published online: January 25, 2021.

From the Division of Trauma and Surgical Critical Care, LAC+USC Medical Center, University of Southern California, Los Angeles, California.

Presentation: Poster presentation at the Virtual Clinical Congress 2020 of the American College of Surgeons (ACS), October 3–7, 2020.

Address for reprints: Meghan R. Lewis, MD, Division of Trauma and Surgical Critical Care, LAC + USC Medical Center, University of Southern California, 2051 Marengo St, Inpatient Tower, C5L100, Los Angeles, CA 90033; email: meghan.lewis@med.usc.edu.

DOI: 10.1097/TA.0000000000003093

TABLE 1. Baseline Characteristics

	Patients (N = 6,930)		p
	Pregnancy (n = 145)	Nonpregnancy (n = 6,785)	
Age (median, IQR), y	25 (22–30)	28 (23–36)	<0.001
Protective device			
Deployed airbag	15 (10%)	461 (7%)	0.089
Seat belt	107 (74%)	1,691 (25%)	<0.001
Associated injuries, median (IQR)			
Head AIS score	2 (1–3)	2 (1–3)	0.956
Face AIS score	1 (1–2)	1 (1–2)	0.393
Chest AIS score	2 (1–3)	3 (2–3)	0.182
Abdomen AIS score	1 (1–1)	2 (1–3)	<0.001
Extremities AIS score	2 (1–3)	2 (2–2)	0.644
External AIS score	—	1 (1–1)	0.294
ISS	1 (1–2)	4 (1–9)	<0.001
TTA	95 (66%)	3,377 (50%)	0.005
Field vital signs			
HR > 120 bpm	4 (3%)	555 (10%)	0.009
SBP < 90 mm Hg	4 (3%)	201 (4%)	0.698
Ed vital signs			
HR > 120 bpm	5 (4%)	672 (10%)	0.009
SBP < 90 mm Hg	2 (1%)	144 (2%)	0.521
GCS < 9	2 (1%)	223 (3%)	0.192

Continuous variables presented as median (IQR). Categorical variables presented as n (%).
SBP, systolic blood pressure; GCS, Glasgow Coma Scale.

score matching without replacement. The matching tolerance was 0.1. Data were collected and analyzed using IBM SPSS Statistics 23 (IBM Corporation, Armonk, NY).

RESULTS

Patients Demographics and Injury Data

Over the study period, 6,930 female patients who sustained MVC were identified. Of these, 145 (2%) were pregnant. The baseline patient characteristics are displayed in Table 1. The pregnancy group was slightly younger than the nonpregnancy group, and this difference was statistically significant (25 [22–30] vs. 28 [23–36], $p < 0.001$). Pregnant patients had a significantly higher rate of seat belt usage (74% vs. 25%, $p < 0.001$). More patients in the pregnancy group satisfied the standard TTA criteria (66% vs. 50%, $p = 0.005$), despite significantly lower abdominal AIS score and ISS in the pregnancy group (1 [1–1] vs. 2 [1–3], $p < 0.001$ and 1 [1–2] vs. 4 [1–9], $p < 0.001$, respectively).

After propensity score matching with age, seat belt usage, and deployed airbag, there were 145 patients in the pregnancy group and 387 patients in the nonpregnancy group (Table 2). Pregnant patients were less likely to present with tachycardia (heart rate [HR] > 120/min) than nonpregnant patients in the field and in the ED (3% vs. 10%, $p = 0.020$ and 4% vs. 9%, $p = 0.034$, respectively). There was no difference in the incidence of hypotension between the two groups.

Pregnant patients had a significantly higher incidence of associated abdominal injuries (53% vs. 18%, $p < 0.001$).

However, in terms of severity, the median abdominal AIS in the pregnancy group was significantly lower (1 [1–1] vs. 2 [1–3], $p < 0.001$). Nonpregnant patients had a significantly higher ISS (4 [1–9] vs. 1 [1–2], $p < 0.001$).

Pregnancy Characteristics and Obstetric Outcomes

Of 145 pregnant patients, the median GA was 24 weeks. In 70 (48%) patients the fetus was viable (>23 weeks) (Table 3). The median fetal heart rate at presentation was 144 bpm (135–150 bpm). No fetal distress (fetal heart rate, <90) was present. During the in-hospital admission, 13 (11%) patients developed gestational complications, the most common of which were uterine contractions (6%), termination of pregnancy (4%), and vaginal bleeding (1%). All patients with vaginal bleeding presented without abdominal pain, and none underwent urgent delivery during hospitalization. There was no incidence of premature rupture of membranes or placental abruption.

The characteristics and outcomes of patients who needed in-hospital delivery are demonstrated in Table 4. The majority of patients were in the third trimester (80%), and they frequently presented with nonrecurring decreased fetal heart rate and premature contractions. Interestingly, 60% of these patients had only minor injury with ISS less than 8. A cesarean section was performed in 4 (80%) patients and vaginal delivery in 1 (20%). The range of time from ED to delivery was between 2 hours and 2 days. One patient presented with cardiac arrest

TABLE 2. Baseline Characteristics After Matching With Age, Seat Belt, and Deployed Airbag

	Patients (N = 532)		p
	Pregnancy (n = 145)	Nonpregnancy (n = 387)	
Age (median, IQR), y	25 (22–30)	26 (22–30)	0.298
Protective device			
Deployed airbag	24 (6%)	15 (10%)	0.098
Seat belt	107 (74%)	276 (71%)	0.495
Associated injuries (median, IQR)			
Head AIS score	2 (1–3)	2 (1–2)	0.451
Face AIS score	1 (1–2)	2 (1–2)	0.210
Chest AIS score	2 (1–3)	3 (2–3)	0.453
Abdomen AIS score	1 (1–1)	2 (1–3)	<0.001
Extremities AIS score	2 (1–3)	2 (2–2)	0.837
External AIS score	—	1 (1–1)	0.185
Associated with abdominal AIS score ≥ 1	77 (53%)	70 (18%)	<0.001
ISS	1 (1–2)	4 (1–9)	<0.001
ISS > 15	7 (5%)	34 (9%)	0.126
TTA	95 (66%)	227 (59%)	0.315
Field vital signs			
HR > 120 bpm	4 (3%)	32 (10%)	0.020
SBP < 90 mm Hg	4 (3%)	16 (5%)	0.401
Ed vital signs			
HR > 120 bpm	5 (4%)	34 (9%)	0.034
SBP < 90 mm Hg	2 (1%)	5 (1%)	0.960
GCS < 9	2 (1%)	5 (1%)	0.952

Continuous variables presented as median (IQR). Categorical variables presented as n (%).

TABLE 3. Pregnancy Characteristics and Obstetric Outcomes

	Pregnancy (n = 145)
GPA	
Gravidity	2 (2–3)
Parity	1 (0–2)
Abortus	0 (0–1)
GA (weeks)	24 (14–32)
ED fetal heart rate (bpm)	144 (135–150)
Uterine contraction	9 (6%)
vaginal bleeding	2 (1%)
In admission vaginal delivery	1 (1%)
Cesarean section	4 (3%)

Continuous variables presented as median (interquartile range). Categorical variables presented as n (%).

and underwent emergency room resuscitative thoracotomy and cesarean section, with no maternal or fetal survival. Of the delivery cases, 40% of newborns had low appearance, pulse, grimace, activity, and respiration (APGAR) score requiring admission to the neonatal intensive care unit.

Clinical Outcomes After Propensity Matching

Overall mortality after sustaining MVC was 1% (n = 5) (Table 5). There was no significant difference in mortality among pregnant and nonpregnant patients (0.7% vs. 1%, $p = 0.722$). The cause of death in the pregnant patient was severe head injury. Additionally, the need for emergency operation or angiointervention was not significantly different between groups (3% vs. 6%, $p = 0.295$ and 0% vs. 0.3%, $p = 0.540$, respectively). There was no significant difference in hospital LOS, ICU LOS, or ventilator days.

DISCUSSION

The pregnant trauma patient poses major diagnostic and therapeutic challenges, because of altered anatomy and physiology, as well as the risk of fetal complications. During early pregnancy, the uterus is well protected within the pelvic ring. However, in advanced pregnancy, the enlarged uterus is not well protected, and

TABLE 5. Outcomes

	Patients (N = 532)		
	Pregnancy (n = 145)	Nonpregnancy (n = 387)	p
Mortality	1 (0.7%)	4 (1%)	0.722
Need for emergency or	5 (3%)	22 (6%)	0.295
Need for emergency ir	0 (0%)	1 (0.3%)	0.540
Hospital LOS, d	2 (1–3)	2 (1–4)	0.122
ICU LOS, d	4 (3–11)	4 (2–6)	0.502
Ventilator days	8 (2–20)	3 (1–10)	0.907

Continuous variables presented as median (interquartile range). Categorical variables presented as n (%).

OR, operating room; IR, intervention radiology.

becomes vulnerable to external blunt trauma, resulting in a risk of pregnancy-related complications. This study showed significant gestational complications, after even minor injuries.

Almost all pregnancy-related complications occurred in the third trimester. This is consistent with previous literature which suggested that obstetrical complications depend on the GA.⁷ One possible explanation for this higher incidence of complications in the last trimester may be related to improper seat belt usage. Although the reported prevalence estimates of seat belt use across several studies indicate that most women wear seat belts during pregnancy, not all of these women do it properly.^{8–10} This improper seat belt placement often happens in the last trimester with the protrusion of the uterus.¹¹

Another important anatomical change occurring in advanced pregnancy is the displacement of the abdominal viscera cephalad and laterally, resulting in different injury patterns. This study showed that although there was no significant difference in the head, face, chest, and extremity AIS between the two study groups, the abdominal AIS was significantly lower in the pregnancy group ($p < 0.001$).

The most common indications for urgent delivery were nonrecurring increased fetal heart rate and uterine contractions. This finding supports the recommendation for cardiotocographic monitoring of all pregnant women of at least 20-week gestation post trauma.^{12,13}

TABLE 4. All Pregnancy With in-Hospital Delivery

	GPA, GA	Abdominal AIS	ISS	Presentation at ED	Route of Delivery	Indication for Delivery	Time From ED to Delivery	Child Status, APGAR	Patient Status, Discharge Day
1	—, 24 wk	—	34	Cardiac arrest	Cesarian section	Cardiac arrest	10 min	Death	Death
2	G1P0A0, 33 + 4 wk	2	5	Uterine contraction, FHR 120/min	Cesarian section	Nonrecurring FHR and premature contraction	2.5 h	Viable, 1, 5, 7 Admit NICU	Discharged home day 4
3	G4P2A1, 35 + 6wk	—	1	Uterine contraction	Cesarian section	Premature contraction	2 d	Viable, 8, 8 Admit ward	Discharged home day 3
4	G4P2A1, 32 + 5 wk	2	17	No uterine contraction or bleeding, FHR 165/min	Cesarian section	Nonrecurring FHR and fetal distress	8 h	Viable, 1, 7 Admit NICU	Pelvic packing according to pelvic fracture, Transfer day 17
5	G1P0A0, 37 + 6 wk	—	1	Uterine contraction, FHR 150/min	Vaginal delivery	Preterm labor	1 d 5 h	Viable, 9, 9 Admit ward	Discharged home day 4

Continuous variables presented as median (interquartile range). Categorical variables presented as n (%) ED.

In advanced pregnancy, there are some significant cardiovascular physiological changes that should be considered in the initial evaluation and resuscitation of trauma patients. During the second trimester, the blood pressure drops slightly and the heart rate typically increases. There is also an increase in blood volume with relative anemia. Blood loss up to 1500 mL is often tolerated well before maternal hypotension occurs, because of autotransfusion from the placenta to the mother during maternal blood loss.¹⁴ However, despite maternal hemodynamic stability, the fetus may still develop hypoxia.

Unexpectedly, in our study, pregnant patients were significantly less likely to present with tachycardia (HR > 120) than matched nonpregnant patients. This was observed in early and advanced pregnancy. It is possible that this was due to the increased blood volume in pregnancy and autotransfusion from the placenta, which may have compensated without tachycardia. The absence of tachycardia may result in undertriage on the basis of standard TTA criteria. These results confirm the finding of prior studies demonstrating that normal admission vital signs in pregnancy does not reliably correlate with outcomes.^{11,15}

In this study, the majority of pregnant patients sustained minor trauma with low ISS. Consistent with prior studies, patients with relatively minor injuries can still experience gestational complications.^{16,17} Therefore, ISS is not necessarily a good predictor of perinatal complications.

The lower injury burden in pregnant patients in our study might have been partially attributable to the higher incidence of seat belt usage in this population (74% vs. 25%, $p < 0.0001$). Unbelted pregnant patients are known to experience significantly increased fetal complications and death.⁸ However, when comparing groups of patients with similar usage of protective devices in our study, pregnant patients still demonstrated a lower ISS. The major difference in injury pattern between pregnant and nonpregnant patients was frequency and severity of abdominal injury. Although associated abdominal injury was more common in pregnant patients, the abdominal ISS was lower. A possible explanation of this may be a potential protective effect of the enlarged uterus, which sits in front of other intra-abdominal organs. Alternatively, the inclination toward fetal safety might have lead pregnant patients to instinctually protect their abdomen during trauma.

The strength of this study is a large sample size of pregnancy in trauma, which specified only the mechanism of MVCs. Furthermore, by cohort matching for the protective device usage with nonpregnant patients, the homogeneity of the study population was enhanced.

We acknowledge several limitations to our study, according to its single-center and retrospective nature. Without the clarification of proper usage of seat belts, we cannot know if this was a contributing factor. Lack of long-term outcomes of the fetus or late complications after discharge could lead to an underestimation of the number of patients with complications. Additionally, the mortality was too low to identify the effect of pregnancy in mortality with adjustment of all confounding factors in the multivariate analysis. These limitations could be addressed with a future large, prospective multi-center study.

In summary, MVCs lead to considerable obstetric complications in pregnancy, regardless of the severity of injury. Initial

presentation with normal vital signs does not determine the fetal outcomes. Closed cardiotocographic monitoring and hospital admission for monitoring may therefore be beneficial.

AUTHORSHIP

D.D., E.B., and M.L. provided the study concept. N.O., M.W. performed the data collection. N.O., M.W. performed the data analysis. N.O., E.B., M.L., and D.D. performed the data interpretation. All authors participated in writing and critically reviewing the final article.

DISCLOSURE

The authors declare no funding or conflicts of interest.

REFERENCES

- Ikossi DG, Lazar AA, Morabito D, Fildes J, Knudson MM. Profile of mothers at risk: an analysis of injury and pregnancy loss in 1,195 trauma patients. *J Am Coll Surg*. 2005;200:49–56.
- Heron M. Deaths: leading causes for 2017. *Natl Vital Stat Rep*. 2019;68(6):1–77.
- Mendez-Figueroa H, Dahlke JD, Vrees RA, Rouse DJ. Trauma in pregnancy: an updated systematic review. *Am J Obstet Gynecol*. 2013;209(1):1–10.
- Weiss HB, Songer TJ, Fabio A. Fetal deaths related to maternal injury. *JAMA*. 2001;286(15):1863–1868.
- El-Kady D, Gilbert WM, Anderson J, Danielsen B, Towner D, Smith LH. Trauma during pregnancy: an analysis of maternal and fetal outcomes in a large population. *Am J Obstet Gynecol*. 2004;190(6):1661–1668.
- Greene W, Robinson L, Rizzo AG, Sakran J, Hendershot K, Moore A, Weatherspoon K, Fakhry SM. Pregnancy is not a sufficient indicator for trauma team activation. *J Trauma*. 2007;63(3):550–555.
- Petrone P, Jiménez-Morillas P, Axelrad A, Marini CP. Traumatic injuries to the pregnant patient: a critical literature review. *Eur J Trauma Emerg Surg*. 2019;45(3):383–392.
- Klinich KD, Flannagan CA, Rupp JD, Sochor M, Schneider LW, Pearlman MD. Fetal outcome in motor-vehicle crashes: effects of crash characteristics and maternal restraint. *Am J Obstet Gynecol*. 2008;198(4):450.e1–450.e9.
- Jamjute P, Eedarapalli P, Jain S. Awareness of correct use of a seatbelt among pregnant women and health professionals: a multicentric survey. *J Obstet Gynaecol*. 2005;25(6):550–553.
- McGwin G Jr, Russell SR, Rux RL, Leath CA, Valent F, Rue LW. Knowledge, beliefs, and practices concerning seat belt use during pregnancy. *J Trauma*. 2004;56(3):670–675.
- Hitosugi M, Koseki T, Kinugasa Y, Hariya T, Maeda G, Motozawa Y. Seatbelt paths of the pregnant women sitting in the rear seat of a motor vehicle. *Chin J Traumatol*. 2017;20(6):343–346.
- Barraco RD, Chiu WC, Clancy TV, et al. EAST Practice Management Guidelines Work Group. Practice management guidelines for the diagnosis and management of injury in the pregnant patient: the EAST practice management guidelines work group. *J Trauma*. 2010;69(1):211–214.
- Jain V, Chari R, Maslovitz S, Maternal Fetal Medicine Committee, et al. Guidelines for the Management of a Pregnant Trauma Patient. *J Obstet Gynaecol Can*. 2015;37(6):553–574.
- Cusick SS, Tibbles CD. Trauma in pregnancy. *Emerg Med Clin North Am*. 2007;25(3):861–71, xi.
- Jenkins PC, Stokes SM, Fakoyeh S, Bell TM, Zarzaur BL. Clinical indicators of hemorrhagic shock in pregnancy. *Trauma Surg Acute Care Open*. 2017;2:e000112.
- Schiff MA, Holt VL. Pregnancy outcomes following hospitalization for motor vehicle crashes in Washington state from 1989 to 2001. *Am J Epidemiol*. 2005;161(6):503–510.
- Schiff MA, Holt VL. The injury severity score in pregnant trauma patients: predicting placental abruption and fetal death. *J Trauma*. 2002;53(5):946–949.