A Multi-institutional Study of Factors Associated
With Fetal Death in Injured Pregnant Patients

Frederick B. Rogers, MD; Grace S. Rozycki, MD; Turner M. Osler, MD; Steven R. Shackford, MD; Jennifer Jalbert; Orlando Kirton, MD; Thomas Scalea, MD; John Morris, MD; Steven Ross, MD; Mark Cipolle, MD; John Fildes, MD; Thomas Cogbill, MD; Jack Bergstein, MD; David Clark, MD; Heidi Frankel, MD; Richard Bell, MD; David Gens, MD; Daniel Cullinane, MD; Donald Kauder, MD; Raymond P. Bynoe, MD

Hypothesis: Factors associated with fetal death in injured pregnant patients are related to increasing injury severity and abnormal maternal physiologic profile.


Main Outcome Measure: Fetal survival.

Results: Of 27,715 female admissions, there were 372 injured pregnant patients (1.3%); 84% had blunt injuries and 16% had penetrating injuries. There were 14 maternal deaths (3.8%) and 35 fetal deaths (9.4%). The population suffering fetal death had higher injury severity scores ($P < .001$), lower Glascow Coma Scale scores ($P < .001$), and lower admitting maternal pH ($P = .002$). Most women who lost their fetus arrived in shock ($P = .005$, Fisher exact test) or had a fetal heart rate of less than 110 beats/min at some time during their hospitalization ($P < .001$). An Injury Severity Score greater than 25 was associated with a 50% incidence of fetal death. Placental abruption was the most frequent complication, occurring in 3.5% of patients and associated with 54% mortality. Cardiotrophic monitoring to detect potentially threatening fetal heart rates was performed on only 61% of pregnant women in their third trimester. Of these patients, 7 had abnormalities on cardiotrophic monitoring and underwent successful cesarean delivery.

Conclusions: Fetal death was more likely with greater severity of injury. Cardiotrophic monitoring is underused in injured pregnant patients in their third trimester even after admission to major trauma centers. Increased use of cardiotrophic monitoring may decrease the mortality caused by placental abruption.

Arch Surg. 1999;134:1274-1277

Severe trauma in a pregnant patient is relatively rare but of double magnitude; 2 individuals are at risk. Most studies on trauma during pregnancy are retrospective studies from a single institution with insufficient numbers of traumatized pregnant patients to make definitive conclusions. We sought to determine the factors associated with fetal and maternal death by collecting a large database of injured pregnant patients from multiple institutions. The collection of information in a large database, including demographic characteristics, etiology, Injury Severity Scores (ISSs), and treatment of pregnant trauma patients, may allow for more accurate predictions regarding outcome for injured pregnant patients and their developing children.

**Table 1** shows a maternal injury profile for fetal death and survival. The population suffering fetal death was characterized by a significantly higher mean ISS ($P < .001$) and by significantly lower GCS score ($P < .001$), Revised Trauma Score ($P < .001$), and admitting maternal pH ($P = .002$, $t$ test). Most women who lost their fetus had arrived in shock (systolic blood pressure, <90 mm Hg; $P = .005$, Fisher exact test) or had a fetal heart rate of less than 110 beats/min at some time during their hospitalization ($P < .001$,
MATERIAL AND METHODS

This study was a 5-year retrospective review (January 1, 1992, through December 31, 1997) of pregnant trauma admissions at 13 level I and level II trauma centers. Ten trauma centers were located in urban settings and 3 in rural settings. Inclusion criteria consisted of all pregnant trauma patients whose injuries were severe enough to require admission to the hospital (International Classification of Diseases, Ninth Revision, Clinical Modification codes 800-959.9 and 648.9-68.94 or V22.2). Data were culled from the trauma registries at each individual hospital and, when necessary, corroborated by individual chart review. Data collected included trauma demographic characteristics, injury severity, admitting obstetrical examination on admission, fetal ultrasound findings, any records of cardiotrophic monitoring (CTM), fetal complications, and maternal and fetal outcome.

Data from all institutions were entered into a single database (Paradox, Boreland Inc, Scotts Valley, Calif). Cases of fetal death were compared with those of fetal survival. The effects of physiologic (maternal pH, PAO2, maternal systolic blood pressure, and fetal heart rate) and injury score (ISS1, Glasgow Coma Scale [GCS] score2, and probability of survival3) variables were evaluated separately. Continuous variables were compared using a t-test, and dichotomous variables were compared using a Fisher exact test. Differences between group means were considered significant at $P<.05$. Data are expressed as mean ± SD.

Fisher exact test). A maternal ISS of greater than 25 was associated with a 50% incidence of fetal death.

Obstetrical complications are shown in Table 2. The most common fetal complication was premature onset of labor; 22 patients (5.9%) delivered prematurely. Of these patients, 21 (95%) produced a viable child. Placental abruption was the second most frequent complication, occurring in 13 patients; 9 underwent an emergency cesarean delivery and 7 were delivered of a viable child. Other fetal complications of trauma in this series included premature rupture of the membranes (3 patients [0.8%]) and uterine injuries (3 patients [0.8%]).

Of the injured pregnant patients, 238 (64%) had an ultrasound to assess the fetus. Cardiotrophic monitoring was conducted from 0.3 hours to 228 hours; 57 patients received CTM for longer than 4 hours. Of those patients in their third trimester of pregnancy (n = 106), only 65 (61%) received CTM. Cardiotrophic monitoring detected potentially threatening fetal heart rate patterns (persistent type II decelerations, tachycardia [heart rate >160 beats/min], or deep variable decelerations) in 24 patients (37%); 7 underwent emergency cesarean delivery, with maternal and fetal survival in all cases.

Table 3 shows the injury severity and outcome of injured pregnant patients in their third trimester who had CTM monitoring vs those who did not. Of note, those who had CTM were significantly less severely injured. Those patients who did not undergo CTM had a higher rate of fetal mortality.

All the patients, except for 1 who had an emergency cesarean delivery, had either clinical evidence of abruption or CTM abnormalities. The 1 patient who had neither abnormality required a cesarean delivery for chorioamnionitis. There were several elective cesarean deliveries (n = 4) performed during the course of hospitalization in this injured pregnant population.

COMMENT

In this study as well as others,6-12 injured pregnant patients accounted for only a very small fraction of trauma admissions (<1%), yet the impact of their injuries was significant. Fourteen mothers lost their lives because of trauma and 35 lost their developing children, underscoring the fact that trauma is the leading cause of maternal death. Fildes et al13 examined the medical records of 95 pregnant women who died in Cook County, Illinois, from 1986 through 1989. Direct maternal causes of death (18.9% [n = 18]) were the result of complications of pregnancy, labor, delivery, or management. Indirect maternal causes of death (12.6% [n = 12]) occurred when pre-existing health problems were exacerbated by pregnancy. Trauma was the cause of 46.3% (n = 44) of the maternal deaths in this series, with more than half caused by homicide.

Reported rates of fetal death following maternal injury have ranged from 4% to 61% depending on injury severity and length of follow-up.4 Many authors have attempted to examine maternal factors that would predict fetal demise following pregnancy.5-11 Kissinger et al,3 in a multicenter trial involving 3 level I trauma centers with 93 injured pregnant patients, found that ISS and GCS score were the only factors that were significantly different between viable (n = 79) and nonviable (n = 14) pregnancies. All other maternal physiologic and laboratory parameters failed to predict pregnancy outcome. Ali and colleagues,6 in a 5-year study of 20 severely injured pregnant patients (ISS ≥12) at a single institution, found a 65% (13/20) incidence of fetal mortality. The most significant predictor of fetal mortality in that study was the presence of maternal disseminated intravascular coagulation. The authors hypothesized that disseminated intravascular coagulation may result from placental products entering the maternal circulation as a marker of intrauterine injury. Drost et al17 looked at 25 hospitalized pregnant trauma patients over a 5-year period and found a significantly higher ISS (mean, 30) and lower trauma score (mean, 12) in patients with nonsurviving fetuses vs those whose fetuses survived (mean ISS, 9; trauma score, 16). Hoff et al,18 in a database involving 4 trauma centers and 30,000 patients, identified 9 instances of fetal death among 73 pregnant patients. Using logistic regression, fetal death was found to be associated with increasing ISS, increasing face and abdominal Abbrevi-
In the present series of those patients with potentially viable fetuses in an extrauterine environment (third trimester), only 65 (61%) of 106 patients had CTM employed, and only 57 patients (54%) had CTM for at least 4 hours, the minimum recommended period. This may be because of a lack of proper documentation in the medical record in this retrospective series, but it may also represent a failure of major trauma centers to recognize the need to implement CTM even in patients with relatively minor trauma.

**CONCLUSIONS**

Trauma in the pregnant patient is a significant event, with a 3.8% maternal mortality rate and a 9.4% fetal mortality rate in the present series. Factors associated with increased fetal mortality were increasing ISS, decreasing GCS, maternal shock, acidosis, and a decrease in fetal heart rate. An ISS of greater than 25 was associated with a 50% fetal mortality rate in this study. Although placental abruption was rare, it was associated with a 70% fetal mortality rate. This may be related to the fact that only 61% of major trauma

---

### Table 1. Injury and Physiologic Profile of Those Mothers Who Did and Did Not Suffer Fetal Death

<table>
<thead>
<tr>
<th></th>
<th>Fetal Death</th>
<th>Fetal Survival</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>35</td>
<td>337</td>
<td></td>
</tr>
<tr>
<td>Injury Severity Score*</td>
<td>25.6 ± 14.9 (n = 25)</td>
<td>7.4 ± 8.2 (n = 236)</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Revised Trauma Score*</td>
<td>5.86 ± 2.70 (n = 21)</td>
<td>7.72 ± .68 (n = 183)</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Glasgow Coma Scale score*</td>
<td>10.0 ± 5.5 (n = 34)</td>
<td>14.5 ± 2.0 (n = 307)</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>pH*</td>
<td>7.31 ± 0.16 (n = 19)</td>
<td>7.41 ± .09 (n = 105)</td>
<td>&lt;.001†</td>
</tr>
<tr>
<td>Systolic blood pressure &lt;90 mm Hg, No.</td>
<td>8</td>
<td>7</td>
<td>&lt;.001‡</td>
</tr>
<tr>
<td>Fetal heart rate &lt;110 beats/min at any time, No.</td>
<td>17</td>
<td>3</td>
<td>&lt;.001‡</td>
</tr>
</tbody>
</table>

*Values are mean ± SD.
†By t test.
‡By Fisher exact test.

### Table 2. Obstetrical Complications in the Pregnant Population

<table>
<thead>
<tr>
<th></th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset of labor with delivery</td>
<td>22 (5.9)*</td>
</tr>
<tr>
<td>Placental abruption</td>
<td>13 (3.5)†</td>
</tr>
<tr>
<td>Premature rupture of membranes</td>
<td>3 (0.8)</td>
</tr>
<tr>
<td>Uterine perforation, rupture, or avulsion</td>
<td>3 (0.8)</td>
</tr>
<tr>
<td>Placenta previa</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Amniotic fluid embolism</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Elective abortion</td>
<td>5 (1.3)</td>
</tr>
<tr>
<td>Others</td>
<td>7 (1.8)</td>
</tr>
<tr>
<td>No complications</td>
<td>269 (72.3)</td>
</tr>
<tr>
<td>Total</td>
<td>372 (100)</td>
</tr>
</tbody>
</table>

*Twenty-one live neonates.
†Nine patients had a cesarean delivery; 4 live neonates were born.

Adapted Injury Scores, increasing fluid requirements, maternal acidosis, and maternal hypoxia. Hematocrit, oxygen saturation, systolic blood pressure, heart rate, and trauma score were not predictive of fetal death. Esposito et al9 examined data on 79 pregnant patients admitted to a single institution over 9 years and showed a 34% (18/53 known pregnancy outcomes) rate of fetal loss. They found that the rate of fetal death was not related to the presence or absence of maternal shock or hypoxia. In a similar study, Scorpio et al10 found that in 59 pregnant patients over 10 years, found that higher ISS or higher abdominal Abbreviated Injury Score, lower systolic blood pressure at admission, and placenta abruption were correlated with fetal death.

The study reported herein is by far the largest series of injured pregnant patients reported to date, and our findings confirm those of other studies in that ISS, GCS, and probability of survival predicted fetal death. In our study, an ISS of 25 or greater represented the lethal dose, which will kill 50% of patients for fetal survival. We also found with univariate analysis that maternal acidosis and decreased fetal heart rate (<110 beats/min) were more common in women who lost their developing child after trauma.

In those patients whose pregnancies have progressed to the point at which extrauterine viability of the fetus is a possibility, CTM is generally recommended as a check for signs of fetal distress. The major concern is that fetal distress on CTM may be a sign of placental abruption, which is the most common cause of fetal death after trauma.14 Clinical findings of vaginal bleeding, abdominal cramps, uterine tenderness, amniotic fluid leakage, or maternal hypovolemia may or may not be present.15 Ultrasound12 is not as reliable as CTM; hence, most authors recommend routine CTM for a period of 4 to 48 hours.13 If the fetus is in distress and of viable age, emergency cesarean delivery may be warranted. Of concern in the present series of those patients with potentially viable fetuses in an extrauterine environment (third trimester), only 65 (61%) of 106 patients had CTM employed, and only 57 patients (54%) had CTM for at least 4 hours, the minimum recommended period.16 This may be because of a lack of proper documentation in the medical record in this retrospective series, but it may also represent a failure of major trauma centers to recognize the need to implement CTM even in patients with relatively minor trauma.
centers used CTM for pregnant trauma patients who were in the third trimester of their pregnancy.

Increased awareness of the importance of routine CTM in the pregnant trauma patient may help decrease the incidence of fetal mortality associated with abruption in this population.

From the Departments of Surgery, Fletcher Allen Health Care, Burlington, Vt (Drs Rogers, Osler, and Shackford, and Ms Jalbert); Hartford Hospital, Hartford, Conn (Dr Kinton); Cooper Health System, Camden, NJ (Dr Ross); LeHigh Valley Hospital, Allentown, Pa (Dr Cippolle); University Medical Center, Las Vegas, Nev (Dr Fildes); Gundersons Lutheran Medical Center, LaCrosse, Wis (Dr Coggill); West Virginia University School of Medicine, Morgantown (Dr Bergstein); Maine Medical Center, Portland (Dr Clark); The Trauma Center at Penn, Philadelphia, Pa (Drs Frankel and Kauder); University of South Carolina, Columbia (Drs Bell and Bynoe); and Emory University School of Medicine, Atlanta, Ga (Dr Rozycki); the R. Adams Cowley Shock Trauma Center, University of Maryland School of Medicine, Baltimore (Dr Scalea); Trauma Patient Care Center, Vanderbilt University Medical Center, Nashville, Tenn (Dr Morris); the University School of Medicine Program in Trauma, University of Maryland Medical Systems, Baltimore (Dr Gens); and the Mayo Clinic, Rochester, Minn (Dr Cullinane).

Corresponding author: Frederick B. Rogers, MD, University of Vermont, Fletcher Allen Health Care, 111 Colchester Ave, FL 4, MCHV Campus, Burlington, VT 05401 (e-mail: frederick.rogers@vtmednet.org).

REFERENCES