**Hypothesis:** The use of passenger compartment safety measures has not led to decreases in pediatric morbidity or mortality in our population of patients.

**Design:** Retrospective review.

**Setting:** University, tertiary care, level I trauma center.

**Patients:** All patients admitted to the Trauma Center at Louisiana State University Health Science Center School of Medicine in Shreveport between July 1, 1991, and December 31, 2000, who were younger than 16 years and involved in a motor vehicle crash.

**Main Outcome Measures:** Intensive care complications, postoperative complications, and mortality.

**Results:** We reviewed the experience of all pediatric patients involved in motor vehicle crashes and transported to the Trauma Center at Louisiana State University Health Science Center School of Medicine in Shreveport from July 1, 1991, through December 31, 2000. A total of 191 patients met these criteria. There were 8 deaths, and only 1 of these patients was restrained. There were significantly more injuries in those patients who died compared with those who survived (Modified Injury Severity Score, 29 vs 9; \( P < .001 \)). We compared the use of restraints in our cohort with the use of restraints in the US pediatric population. Only 20% of our patients were restrained vs 68% of the general pediatric population. This difference was significant (\( P < .001 \), \( \chi^2 \) test).

**Conclusions:** In our population of patients, death was a relatively infrequent occurrence. All patients who died presented in extremis. No patient died as the result of a complication. The rate of seat belt use in our population of patients was low. The exact reason for why we were unable to detect any survival benefit with seat belt use is unclear and demands further investigation.

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**METHODS**

We defined a child as any patient younger than 16 years. Patient charts were located through the trauma registry and medical records. Three charts were not complete enough to be included in this review. Only children who were physically in cars were included in this study. Patients who were hit by cars while walking or riding bicycles were excluded. Children injured while riding all-terrain vehicles were also excluded. Statistical analysis was performed using computer software (Sigma Stat 2.03; SPSS, Chicago, Ill).

All patients who presented unstable or in extremis were met by the pediatric trauma team.
RESULTS

A total of 191 patients, younger than 16 years, were admitted to the Trauma Center at Louisiana State University Health Science Center School of Medicine in Shreveport between July 1, 1991, and December 31, 2000, and met the study’s enrollment criteria. The ages ranged from 12 days to 15 years (average age, 8.9 years). The average length of the hospital stay was 5.8 days. The male-female ratio showed a slight male predominance. More than a third of the patients (73 [38.2%]) had a primary diagnosis of head injury. These injuries included skull fractures, epidural and subdural hematomas, intraparenchymal hemorrhages, and sinus and other facial fractures. Just fewer than a third of the patients (62 [32.5%]) had an orthopedic injury as their primary diagnosis; these included femur, radial, ulnar, and pelvic fractures. Abdominal injuries (liver, spleen, and renal lacerations and colon and gastric perforations) occurred in 16 (8.4%) of the patients, and chest injuries (pneumothorax and pulmonary contusion) occurred in 7 (3.7%) of the patients. Other injuries (including neck pain and soft tissue lacerations) occurred in 33 (17.3%) of the patients. (Percentages do not total 100 because of rounding.)

Eight patients (4.2%) died. Two patients presented in cardiac arrest. All patients who died had severe head injuries. One patient experienced exsanguination before arrival at the emergency department. All patients who were hemodynamically stable on presentation survived.

Seventy-four patients (38.7%) required at least 1 operation. Seventeen patients required more than 1 procedure. The subspecialty surgical procedures included 42 orthopedic, oral maxillofacial, or otolaryngology cases; 7 neurosurgical cases; and 1 ophthalmologic case. The general surgical procedures were as follows:

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair of complex lacerations</td>
<td>14</td>
</tr>
<tr>
<td>Thoracostomy tube placement</td>
<td>7</td>
</tr>
<tr>
<td>Splenectomy</td>
<td>3</td>
</tr>
<tr>
<td>Visceral repairs (gastric, bladder, or colon)</td>
<td>3</td>
</tr>
<tr>
<td>Arteriography</td>
<td>3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>6</td>
</tr>
</tbody>
</table>

Specifically, there were 2 nontherapeutic laparotomies, 1 splenorrhaphy, 1 hepatic resection, 1 thrombectomy, 1 abdominal wall repair, 1 laparotomy to control intra-abdominal bleeding, and 1 below-the-knee amputation.

Seventeen patients had liver and/or splenic injuries. Fourteen patients had splenic lacerations. Only 4 patients with splenic injuries underwent an operation for splenic hemorrhage. Of these 4 patients, 3 underwent splenectomies for grade IV or V lacerations. One patient underwent a splenorrhaphy. One patient with a hepatic laceration underwent surgery for ongoing bleeding. A nonanatomic liver resection was performed to control bleeding. In the remaining patients, there were no failures of nonoperative management.

Sixteen patients required transfusions. The range of transfusion volume was from 70 mL in a toddler with a scalp laceration to 12 U in a preteen with a femur fracture. No patient undergoing nonoperative management of either a splenic injury or a hepatic injury required more than 2 U of packed red blood cells. Interestingly, one patient who presented hypothermic with a grade IV splenic laceration required 10 U of fresh frozen plasma to correct a coagulopathy. This patient did not require a splenectomy or a splenorrhaphy.

There were 15 complications (7.9%). No patient died as a result of a complication. Three patients with head trauma requiring intubation developed atelectasis. They all responded to ventilator manipulation to open collapsed airways. Two other patients with head trauma who were intubated for a prolonged period were diagnosed as having nosocomial pneumonias. Antibiotic therapy was successful. A seizure from a posttraumatic head injury was noted in 1 patient. This was a generalized tonic-clonic seizure that responded to phenytoin (Dilantin) therapy. Another patient presented with a complex contaminated thigh wound. Despite operating room débridements, the patient developed a wound infection with cellulitis. The infection responded to antibiotic therapy, and operative wound care continued. One patient, who presented with a complex liver laceration, required a resection to control hemorrhaging and subsequently developed a biloma. The biloma was percutaneously drained. The drain was removed once the output decreased to an acceptable level. Central line infections were found in 2 patients. One patient had a closed head injury and underwent mechanical ventilation. The other patient had a nonoperative splenic laceration. Both patients responded to antibiotic therapy and removal of the central line. A postoperative bowel obstruction developed in a patient who underwent primary repair of a gastric perforation. This patient had a large amount of spillage of gastric contents with peritoneal soilage at surgery. He initially did well and was discharged home. He was seen again 2 weeks later with a bowel obstruction. This complication was managed surgically. One patient had an open tibia-fibula fracture with distal vascular compromise. The patient underwent complex saphenous vein repair of the anterior tibial artery, and an external fixator was placed. This repair failed, and the patient required a below-the-knee amputation. There was 1 iatrogenic pneumothorax from a central line placement. A thoracostomy tube was placed. Last, a severely injured patient (closed head injury, cerebral edema, subarachnoid hemorrhage, and pulmonary contusion, with a Modified Injury Severity
Score [MISS] of 32) who presented in shock underwent prehospital mainstem intubation. This was recognized in the emergency department and promptly corrected. This patient died on his second hospital day. This death was thought not to be secondary to the mainstem intubation.

To compare outcomes, we used the MISS for pediatric patients, as suggested by Mayer et al. The mean MISS for this study was 9.96 (SD, 7.44). The MISS in patients with seat belts was 8.89. This was not significantly less than the mean MISS in patients who were not restrained (P = .33). The MISS was significantly higher in patients who died vs those who survived (29 vs 9; P < .001, Mann-Whitney rank sum test).

Only 1 patient who was wearing a seat belt died. Only 20% of the patients in this study were reported to be wearing a seat belt at the time of the crash. The national average for wearing seat belts is 68%. There is a statistically significant difference between our population of patients and the national average (P < .001, χ² test).

This is a retrospective chart review. It is, therefore, subject to several biases. There were several incomplete charts that fit enrollment criteria but could not be included because of inadequate information. Seat belt information was found in 1 of several locations in the chart—progress notes, nurses’ notes, or emergency medical services’ run sheets. The time from injury to the time of admission was not clearly documented in more than half of the charts. Therefore, no conclusions can be made regarding time to definitive care. Prolonged transport times could have influenced our cohort of patients. Without these data, we cannot speculate. Many researchers have commented on the child’s position in the car and its relationship to mortality. None of this was documented in the chart and, therefore, no comments can be made on this topic.

We were unable to find a statistically significant difference between patients who were restrained and those who were not restrained. There are many factors that can lead to a fatality. Child safety seats must be correctly buckled into the car to function properly. Older children need booster seats. Preteens and teenagers need lap and shoulder belts. If any of these devices are not applied correctly, injury can result. We were unable to determine if our patients were in the appropriate restraints; this is one of the limitations of a hospital-based chart review. Seat belts are only one of the factors that can influence our cohort of patients. Without these data, we cannot speculate. Many researchers have commented on the child’s position in the car and its relationship to mortality. None of this was documented in the chart and, therefore, no comments can be made on this topic.

Although the number of patients is relatively small, nonoperative management for spleen and liver trauma was effective. There were no deaths secondary to nonoperative therapy. No patient who underwent nonoperative management for a splenic or a hepatic injury required more than 2 U of blood. Nonoperative management of spleen injuries should have an 85% to 95% success rate. Nonoperative therapy will fail in fewer than 1% to 2% of children.12,13 Appropriate monitoring and adequate critical care support are essential for good outcomes.

This study clearly points out the multisystem nature of pediatric trauma. There were multiple specialties required to adequately care for these patients. The number of operative general surgery cases was relatively small when compared with the overall number of patients. Depending on an individual hospital’s dynamics, a trauma surgeon, a pediatric surgeon, a neurosurgeon, an orthopedic surgeon, and a pediatric intensivist are some of the physicians required to care for these patients with complex injuries. Some physicians believe, because more and more pediatric trauma is nonoperative, that these patients can and should be cared for by pediatricians or internists. Although this data set was not specifically designed to address this issue, more than a third of these patients required surgery. Collaboration, not exclusion, is the best way to care for these patients.

There were no preventable deaths. We believe that this statistic points to our comprehensive team approach to patients experiencing trauma. This is not “trauma by committee”; instead, everyone knows their part in the trauma team. Although the trauma attending physicians are board certified in critical care, we ask the pediatric intensivists to help us with the care of these patients with complex injuries. Their insights on fluid management, line placement, drug dosing, and family issues are invaluable. The trauma surgeon remains the only physician responsible for the whole patient. The contribution of the pediatric intensive care nursing staff cannot be overestimated. They are familiar with sick children and are usually the first people on the trauma team to notice small changes in the child that can be the first signs of a complication.

Although our complication rate is rather low at 8%, it is the duty of a trauma center to review complications and look for ways to reduce the complication rate even further. Atelectasis is a disease process that is preventable. Diligent pulmonary maneuvers, including incentive spirometry, effective pain control, prophylactic intubation, and attainment of adequate tidal volumes and appropriate drive pressures, need to be performed to prevent atelectasis. We had only 2 central line infections during this study period. We do not know what percentage of our patients received central lines. These data were not collected. Therefore, the significance of having only 2 infections is not clear. We use antibiotic-coated catheters and have done so for the past 5 years. We also try to feed our patients enterally if at all possible. Total parenteral nutrition is avoided because of its associated complications (bacterial and fungal sepsis, central vein thrombosis, and a malpositioned catheter). All central venous catheter insertion sites are inspected daily. Lines are changed every 7 to 10 days. We do try to use catheters that are appropriate for the patient’s size, believing that large catheters in small central veins can lead to thrombosis. We try to avoid prolonged central line use. We did experience 1 pneumothorax from a central line placement. Avoiding pneumothoraces is usually done with experience and good technique. All of our central line...
placements are supervised by attending physicians or upper-level residents. Our other complications were infrequent and thought not to be avoidable. The Injury Severity Score (ISS) is an accurate predictor of outcome in adults.\textsuperscript{10} The ISS tends to be less accurate in children. Children have a greater tendency to have multiple organs injured. Head injuries are also more prevalent in children than in adults. In 1981, Mayer and associates\textsuperscript{2} developed the MISS. They added the Glasgow Coma Scale to the ISS to give more weight or importance to head injuries that are more commonly seen in pediatric patients. The MISS tends to be a better predictor of mortality and morbidity in children than the ISS. For this reason, we used the MISS in this study.

The most statistically significant result from our study is lack of seat belt use in our population of patients. Seat belts reduce the likelihood of morbidity and mortality.\textsuperscript{1,2,4} A recent study by Tyroch et al\textsuperscript{3} revealed 53% restraint use in their population. They found a significant reduction in injuries in those patients who were restrained. The mortality rate for those patients who were restrained was significantly less than for those who were not restrained ($P<.001$). In our study, there was a trend toward significance when comparing the injuries of the restrained vs the nonrestrained patients.

Louisiana does not have a statewide trauma system. Trauma systems attempt to shunt patients experiencing trauma to 1 or 2 regional trauma centers. This may not be happening in Louisiana. It could be argued that less severely injured patients may be taken to outside hospitals. These patients should be the ones who have fewer injuries and may be the ones who wear seat belts. Of course, the opposite could be argued. Severely injured patients may be taken to the closest hospital whether that hospital is a trauma center or not. This prehospital selection bias may skew the data one way or the other. The children in northwestern Louisiana may actually wear their seat belts at a higher rate than our patient population indicates. We cannot comment on this. This is an area that needs further study. We can conclude that our patients had an appallingly low rate of seat belt use.

In the coming years, we will continue to study our population of children involved in motor vehicle crashes. Working with law enforcement, we should be able to gather better prehospital information. We will study the much larger population of northwestern Louisiana. This prospective investigation should help us delineate the seat belt issue.