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PAPER

PATHOLOGY/BIOLOGY; ENGINEERING SCIENCES

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Plank Fence Penetration into Automobiles—Implications for Prevention Initiatives*

ABSTRACT: The wooden plank fence presents a deadly but unrecognized hazard to motorists. We hypothesize that fence plank injury is prevalent and results in significant morbidity and mortality. Databases of the University of Kentucky's Level I Trauma Center and the Fayette County Coroner were retrospectively analyzed over a 12-year period (1995–2006). One hundred and twenty-eight subjects were involved in vehicle contact with wooden plank fences. One hundred and twenty-three subjects were evaluated at the Emergency Department of our trauma center; 35 (27%) had a patient–plank interaction (PPI). Men (30/35) were more frequently involved (86%), and average age was 32.8 years. Thirty-two (91%) were drivers; 14/35 (40%) died from PPI-related injuries. The most common cause of death was blunt head trauma in 13 of these 14 fatally injured subjects (93%). This study provides new data underscoring the frequency, lethality, and economic consequences of this injury mechanism. Further research is needed to quantify the national prevalence of this problem and develop injury-mitigating strategies pertaining to roadway or fence design.

KEYWORDS: forensic science, automobile, motor vehicle collision, horse, fence, plank, injury, rural

Approximately 41,000 people die in motor vehicle collisions (MVCs) annually in the U.S. (1). Although highway engineers have made great advances in designing safer roadway signs, guard rails, and other highway "furniture," other adjacent roadway structures have not received comparable attention. This is particularly true with regard to wooden fences used for property delineation or large animal containment. Specifically, horizontally oriented wooden plank fences are notable examples of the common "horse" fences that parallel many state-maintained and rural roadways throughout America. These fences restrain large animals and are simple and inexpensive to build and maintain.

Design of these wooden plank fences is arbitrary because of the absence of a published standard. The typical wooden plank fence consists of three or four long rectangular boards affixed horizontally to intermittently spaced vertical wooden posts. These boards are usually made of oak or hickory wood and are typically 0.025–0.05 m thick, 0.1–0.15 m tall, and vary in length from 1.8–4.9 m. Such boards are nailed to wooden posts that are round (or round and flattened on one side) in cross-section, are *c.* 0.17 m in diameter, and are *c.* 1.42 m long.

Although scenic, these plank fences pose an unrecognized and deadly hazard to motorists whose vehicles deviate from the paved highway. When vehicles lose control, depart from the roadway, and collide with such fences at acute angles, the horizontally oriented boards (particularly the upper two) are prone to fracture and penetrate an automobile compartment during an MVC (Fig. 1). Development of prevention strategies via altered roadway or fence design, modified fence materials or placement, etc., are needed, but first the problem needs to become recognized and an understanding of the injury mechanisms must be obtained. Few published reports exist (2–6) and none can answer the questions that arise.

The purpose of this study was to document the occurrence of injury and mortality occurring in a single referral center with regard to MVCs involving wooden plank fences.

Methods

The databases of the University of Kentucky's American College of Surgeons verified Level I Trauma Center and the Fayette County Coroner were retrospectively analyzed for all records of motor vehicle accidents involving wooden plank fences over a 12-year period of 1995–2006 inclusive. Hospital charts and operative reports were retrospectively reviewed to confirm fence contact, injury data, and subject demographics. Motorcycle collisions, although numerous, were excluded. The University of Kentucky's hospital charges database was queried for those subjects for whom cost data were available. This study was approved by the University of Kentucky's Institutional Review Board.

Mean values of the resulting parametric data were analyzed and compared using Student's *t*-test. Contingency table analyses were

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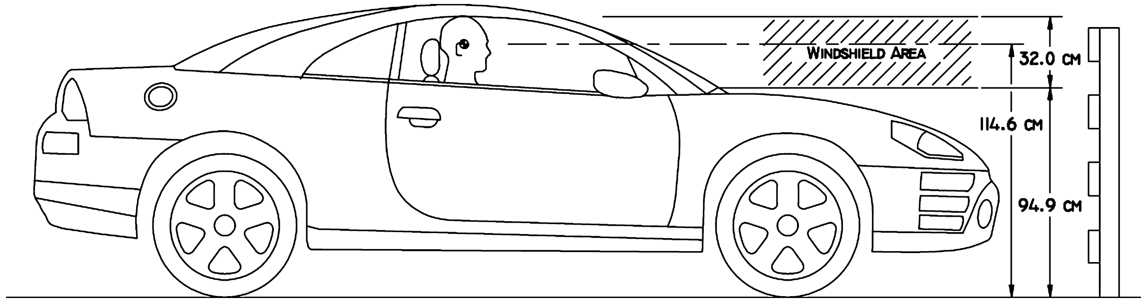

FIG. 1—*This figure illustrates a standard compact vehicle and the relationship of windshield height to current plank fence construction. The top-positioned plank is available for windshield penetration with potential for PPI.*

used to analyze relationships between nonparametric variables; the independence of selected pairs of these values was determined using a chi-square test. p-Values < 0.05 were considered indicative of significant differences.

Results

A total of 128 subjects were identified from 127 collisions involving vehicle contact with wooden plank fences. Of these 128 subjects, 123 were evaluated in the Emergency Department of our trauma center and 35 of them (27%) had a documented patient–plank interaction (PPI). Men (30/35) were more frequently (86%) represented in this population (Table 1). The average subject age was 32.8 years. Vehicle occupant position was known in all PPI subjects, 32/35 (91%) of which were drivers. Fourteen of these 35 (40%) subjects died from injuries related to PPI. The Injury Severity Score (ISS) of subjects who survived a PPI (ISS = 14.5) was less ($p < 0.05$) than those who did not survive (ISS = 27). Restraint data were available in 87/128 cases, and of these 87 subjects, 48.5% were restrained and 51.5% were unrestrained. No correlation could be established between restraint status versus level of injuries or mortality.

PPI is associated with significant morbidity and mortality (Table 2). Approximately two-thirds (64%) of the impacts occurred on the right side of the subjects. The most common body region of plank contact was the head and as might be expected, brain injury was the most common (13/14) cause of death (93%) in that PPI group (Fig. 2). Blunt injury predominated over penetrating injury; only one subject suffered a mortal penetrating head injury from PPI (as specified by the coroner's database of those who were dead at the scene). The next most common body region of injury was the upper torso (chest and shoulder) where PPI was associated with significant soft tissue and bone injuries, tissue loss, and vascular injuries (Fig. 3). All vehicles except one (a pickup truck) were passenger automobiles. The occupant of the truck suffered blunt chest trauma from a PPI.

PPI involving the upper extremity was also associated with significant bone and soft tissue loss as well as neurovascular compromise. Upper extremity injuries frequently required operative interventions for salvage or repair. Near complete amputation of the involved extremity after plank contact was not uncommon. Neck injuries were uncommon but when they occurred, they were associated with significant vascular and soft tissue injuries. A single penetrating abdominal injury occurred in this group of 35 subjects; this injury caused the subject's demise.

TABLE 1—*ISS was available for 27/35 PPI subjects. Parametric values are mean ± standard error.*

Demographics and Injury Severity in Patient–Plank Interaction	
Age (mean)	32.8 ± 2.6, range 14–84, (N = 35)
Male	30/35 (86%)
Female	5/35 (14%)
ISS (survivor)	14.5 ± 3.03 (n = 21)
ISS (nonsurvivor)	27 ± 11.02 (n = 6)

TABLE 2—*Concomitant injuries were not uncommon among patients that were struck by wooden planks entering the vehicle's cabin. Totals do not sum to 35 secondary to multiple injury patterns on each patient.*

Injury Data by Body Region	
Head	24/35
Upper torso (chest + shoulder[s])	7/35 and 9/35, respectively
Upper extremity (shoulder to fingers)	9/35 and 3/35, respectively
Neck	3/35
Abdomen	1/35
Right-sided injuries	64% (16/25)
Left-sided injuries	36% (9/25)

FIG. 2—*Severe head and maxillofacial trauma were common after PPI. This image demonstrates a mortal injury after PPI. The fence plank acted as a blunt battering ram resulting in a severe open mandibular fracture with failure to attain a definitive airway in the prehospital environment resulting in death. The plank contact left an impressive skin imprint superior and inferior to the laterally oriented mandibular soft tissue defect. Although severe maxillofacial trauma is present, this was the patients' only injury, and if PPI could have been avoided, it is expected this death would have been obviated.*

FIG. 3—*Penetrating injury as a result of PPI is rare in our series. This patient suffered a penetrating plank injury to the right chest, entirely extra-thoracic. Significant soft tissue injury such as this is not uncommon during PPI involving the upper torso or upper extremities.*

Hospital cost data were available for 13 of these 35 subjects. Total hospital incurred costs for PPI-related injuries averaged \$50,530.31 (n = 6) for those requiring surgery. Mean total hospital incurred costs for PPI subjects not requiring surgery was \$34,255.83 (n = 7) but this value was skewed by the fact that four of seven who did not receive surgery died shortly after arrival at the hospital.

Discussion

Although there are isolated reports documenting impalement by various foreign objects in general (4,6–12), motor vehicle encounters with wooden plank fences pose a greater risk to motorists than the literature would suggest. Injury resulting from vehicular interactions with adjacent roadway wooden fence planks is a particular but unappreciated event that has been only sporadically described in isolated case reports (2–6,10–18). The extent of this problem is unknown because of the haphazard reporting of such events and lack of standardized databases with enabling links to this specific mechanism. The present study is significant because it provides new data underscoring the frequency, lethality, and economic consequences of this particular injury mechanism.

The severity of the injuries noted in this study is similar to those noted by others (3–6,8,10–14); however, our study demonstrated a large incidence of head injury. As would be expected from the "right-hand" driving orientation of American roadways, the majority of the injuries observed in the present study were right sided, particularly when involving the thorax; this is in agreement with a recent case report (13).

Mitigation of this injury potential is also hampered by the lack of standards for wood plank fence design and construction. As a result, there exist a variety of designs, materials, as well as fence placements with respect to rural roadways. Modifications to roadway design, wood species, plank fixation, post arrangement, or construction technique may mitigate the injuries suffered by roadway errant motorists who have a PPI accompanying a vehicular impact, but ameliorating steps cannot be accomplished until the mechanism of fence penetration is understood. Other initiatives for mitigating this risk include roadway surface modification (to increase friction coefficients during inclement weather), increasing driver awareness regarding the importance of posted speed limits for specific roadway contours, and the increasing driver awareness of the dangers of driving while under the influence or text-messaging. Development of penetration-resistant windshields seems unlikely given current initiatives for lightweight and low-cost vehicular components. Efforts to create more aerodynamically efficient vehicles, however, result in more sharply inclined windshields, and this may aid wood plank deflection and thereby prevent passenger cabin intrusion and occupant injury. Restraint use does not appear to be an effective prophylaxis.

The conclusions presented are based upon a limited time and region sample. The present study will motivate further research to: provide an accurate accounting of PPI accompanying a vehicular impact and the resulting injury patterns that occur on a national basis, increase awareness, and motivate implementation of established highway engineering techniques to develop injury-mitigating traffic safety strategies.

Conflict of interest: The authors have no relevant conflicts of interest to declare.

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