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Quadriplegia As A Result Of Airbag-Related Trauma

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Abstract

Airbags are known to significantly reduce mortality and morbidity of road-related trauma. Yet since the 1990s, with increasing use of these safety devices, there has been an increase in the number of minor facial soft tissue and bony injuries related to them. More worrying is the increase in the number of cases of cervical fracture and death reported. This report describes one such case that has resulted in quadriplegia and a review of the literature looks at other similar cases highlighting a common and disturbing trend.

INTRODUCTION

Airbags have been shown to significantly reduce the rates of morbidity and mortality from road traffic related trauma[5,6].The introduction of airbags along with three point lap-shoulder seat belts has improved safety for the occupants in the event of a frontal collision[1,10]. However, since the 1990s, as the implementation of such safety mechanisms has increased in frequency, reports related to injuries sustained from these protective devices have concurrently risen in frequency[8]. The majority of these cases have involved minor facial soft tissue and bony injuries. Yet there appears to be a growing number of incidents in which airbags have been associated with fracture of the cervical spine and death.

The majority of spinal injuries reported on, relate to hyper-flexion or hyper-extension injuries and seem to be related to the driver's position at the time of impact and whether the occupant was restrained or not.

CASE REPORT

A 37-year-old male (184cm; 80kg), was a front seat (left side) passenger in a family 4 wheel drive vehicle fitted with airbags for the driver and passenger. He was using a standard three-point seat belt with the head-rest adjusted appropriately. The driver lost control on a gravel shoulder and swerved to the right, then back to the left shoulder before rolling the vehicle with the impact on the passenger side door. The patient describes loss of consciousness and awaking hanging upside-down from his seat. He recalled the roof and passenger door were impacted but not so much as to contact the patient. The driver was uninjured (Fig. 1).

The patient remained conscious for the journey to the Royal Perth Hospital and recalled feeling paralysed from the neck down. Apart from sustaining minor bruising to the left orbit the patient had no other obvious signs of injury. Chest and pelvic radiographs were normal.

Plain film radiographs of the cervical spine showed mal-alignment of the C6/C7 junction. A CT scan revealed a bifacetal fracture-dislocation at C6/C7 level (Fig. 2) with anterior displacement of C6 on C7 and impingement of the spinal cord (Fig. 3). The patient underwent closed reduction and application of Halo vest with subsequent anterior spinal fusion and discectomy.

Figure 1

Fig. 1: Vehicle at scene of accident

Figure 2

Fig. 2: Sagittal CT of cervical spine

Figure 3

Fig. 3: Axial CT of cervical spine

MECHANISM OF INJURY

Photographic evidence of the crash scene and of the vehicle was obtained in order to identify a mechanism. The patient described his last memory of the accident was the car rolling on to the passenger side. Both passenger and driver airbags were deployed (Fig. 4).

Figure 4

Fig. 4: Driver's compartment with deployed airbag

From examination of the vehicle, evidence of impact on the driver's door and roof was consistent with that of a sideways roll. However, the bonnet and front fender showed signs of heavy impact suggesting that an end over end component may also have occurred. The main triggering factor for airbag deployment is fronto-angular impacts (see later)[7] and it is most likely that the end over end component of the roll initiated this.

While the overall damage to the car was quite extensive, the main cab where driver and passenger were positioned remained relatively intact (Fig. 5) allowing plenty of room between occupant's head and the vehicle – reducing the likelihood of an axial compression injury consistent with the imaging (Fig. 2).

Figure 5

Fig. 5: Main cab intact over driver and passenger

DISCUSSION

It has been shown experimentally and in every day use, that airbags and seatbelts help to reduce traffic related road injuries[5]. In particular, the airbag has been pivotal in reducing morbidity and mortality in such accidents by as much as 25%[6].

Airbags, originally implemented as a concept in the1920s, became universal in 1994 and were designed to be supplemental safety devices for use with three point seat belts. Since then there have been a number of reports relating to injuries caused by airbags[8]. Injuries to almost every area of the body have been described, but the majority of cases involved soft tissue and bony injuries[1] (e.g., the head and face).

Airbags are triggered by frontal or fronto-angular crashes, which comprise around 65% of all fatalities associated with motor vehicle accidents. They are deployed rapidly (generally within 35 milliseconds after the sensors in the car detect initial contact) and require gas generators, which are akin to explosives. Most airbags use sodium azide for deployment. Even though the mass of the bag is rather low, the bag fabric accelerates rapidly during deployment to reach a speed of 225 to 320 km/h (140 to 200 mph)[7]. Thus, the force of impact against a human torso is hazardous should the airbag impact with the occupant in that period.

Of the injuries previously identified, a few have caused serious cervical spinal injuries and death. Most of the more serious injuries described are caused by the act of deployment[9,11]. One way to explain this type of injury would involve the unrestrained occupant accelerating towards a deploying airbag, sustaining a thoracic impact and leading to a cervical hyper-flexion. Alternatively in a restrained person who is sub-optimally positioned, a hyperextension injury to the neck may result as the bag expands from below causing impact to the face and chin from below[2].

Airbags have been shown to become dangerous in collision situations when the occupant is out-of-position or is of short stature. Maxeiner et al. described the case of a short restrained female passenger who sustained a hyper-flexion injury secondary to airbag deployment during a head-on collision[11]. The postmortem findings included widening of the C1–C2 intervertebral joint with associated deep pre-vertebral muscle rupture and occipital condyle avulsion as a cause of her death.

Similar occipital condyle injuries were described in two cases of unrestrained drivers in Denmark[3]. Common to all three cases was the identification of submental bruising implying a blunt force to the base of the chin.

A more recent report involved a driver who survived an occipital condyle fracture after a head-on collision with a tree. In this case the driver had been restrained but had been purportedly sitting unusually close to the steering column[13].

Evidence suggests that basilar skull fracture is an airbag-specific injury caused by hyper-flexion or extension of the neck and may be explained by the victim being within the airbag deployment zone.

In a rollover accident, airbags cannot prevent neck injuries, including fracture-dislocations of the cervical spine from a combined compression and bending load applied to the spine. This can only occur if the occupant's neck just happens to be lined up with the direction of roof crush during the rollover. The probability of this happening is less than that of ejection[7].

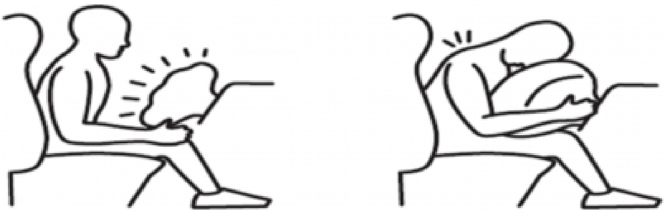
In conjunction with a three point seat belt, airbags reduce the fatality rate by more than 45% (18% with airbag alone), provided the driver is sitting at an optimal distance from the steering wheel (25cm gap between the sternum and the steering wheel)[1,10].

CONCLUSION

In this case, the patient was the passenger. It appears that the mechanism of injury was related to a combination of side roll and end over end roll, which led to airbag deployment. There was minimal intrusion in to the cab from the passenger door and the roof, neither of which was great enough to explain the injury. The type of injury sustained is consistent with hyper-flexion of the neck (Fig. 6).

Figure 6

Fig. 6: Suggested mechanism of injury – hyperextension/flexion over airbag



The complex nature of the impact and roll may lead one to argue against a case of airbag related injury. However, if this was the case one would expect the driver to have at least similar injuries to the passenger. In a review of 53 fatal crashes in Canada since 1993, 17 of the crashes involved side-on collisions. In one of these cases the driver who was reportedly "out of position" sustained a radiographically confirmed C_1–C_2 dislocation in a minimally intruded vehicle[12]. Although rare, this event is similar to the case we present here.

I propose that due to the height differences between passenger and driver, when the airbags deployed the passenger's chest received the force of the expanding airbag. If the patient were to have been moving forward at the time, the deceleration to his torso would have caused his head and neck to forcefully flex over the top of the bag, ultimately resulting in a fracture-dislocation (Fig. 6). This mechanism again reiterates the problems that may occur when occupants are "out of position". In this case the patient's height put him at increased risk that may have been avoided if the airbag were to have contacted his face and chest.

Neck injuries have in the past been associated with upper cervical injuries. In this report we present a patient who became quadriplegic from a low cervical injury following a car crash. While airbags and seat belts undisputedly reduce the toll of trauma on vehicle occupants, this report aims to further highlight the hazards associated with airbags when the occupants are out of position.

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