How safe are the airbags? A review of literature

George Intas [1], Pantelis Stergiannis [2]

1: RN, MSc, General Hospital of West Attiki
2: RN, MSc, Oncology Hospital "Ag.Anargyroi"

Abstract

Background: The airbags can reduce even 50% of passenger injuries in a car accident. When they are not used properly, they can cause serious injuries. There have been reported several cases with fatal injuries.
Aim: The aim of this study was to review the dangers that result from the incorrect use of airbags.
Methods: A thorough review, included bibliography research from both the review and the research literature in different databases was done, such as pubmed, scopus and heallink.
Results: Many injuries from airbags have been reported in the literature. Most of them are burns from the produced gases during the development of the airbag. At the beginning of their use, airbags opened with great speed. As a result there were a lot of injuries. For this reason, it was proposed to reduce the speed of development. Often problems have the eyes and ears. Less frequent are injuries or fractures of the upper and lower extremities. Rarely, cervical spine and ribs injures from the airbag. We found one case report of placental abruption after airbag deployment in a woman driver. On contact with the airbag, passenger can also injure aorta or heart.
Conclusions: The airbags provide safety to the occupants of cars and reduce the mortality even at 50%. When not used in accordance with international standards can cause serious injuries. The airbags should always be used in conjunction with seatbelts.

Keywords: Airbag, injuries, side-airbag, seat belt

Corresponding author:

Intas George, str Olympias 15,
Egaleo, Athens, Greece,
Post code: 12243,
Tel:+306945492709,
E-mail: intasg@yahoo.gr

Introduction

Airbags decrease approximately 25% the incidence of fatalities in frontal motor vehicle crashes when compared with those where only seat belts were available.[1] Their great importance is reflected in the reduction of central nervous system injury and magnitude of facial fractures and facial lacerations.[1] The air bags should be used in conjunction with safety belts.[1] Airbags alone have an estimated effectiveness of 14% in reduction of fatalities in drivers in crashes of all types compared with 45% for lap–shoulder belts used alone. The estimated reduction in fatalities when used together is 50%.[2-4] Without the coincident use of seat belts, frontal airbags increase the risk of some injuries.[5]

The use of airbags has been responsible for reducing fatality risks by 20% to 40% for frontal crashes, and the use of lap-shoulder belts with airbags further reduces mortality risk.[6,7] Airbags are now a standard protective device in new cars. They are designed to give maximum protection when used with the belt. Safety belts help keep passengers safe distance from the airbag when they deploy.[8] Adults at the highest risk of airbag injuries are the victims who are positioned closer to the airbag at the time of deployment, particularly shorter adults and adults who ride unbelted.[9] Women are more likely to die from frontal crashes, because of their shorter body frame. Elderly women with osteoporosis are at higher risk for injury as well.[10] Drivers should be warned about the danger of full forward seat position.[11]

Nowadays all vehicles are equipped with airbags. Although airbags have reduced the incidence of fatal and severe injuries, they have been shown to increase the risk of less severe injuries, such as lacerations, facial contusions, ocular injuries, periorbital fractures, upper extremity injuries, brain and spinal injuries.[6-8,12,13] Other injuries that are less frequent are upper extremity and rib fractures, pulmonary trauma, aortic tears, atrial disruption, cardiac arrhythmias and laceration of intra-abdominal viscera.[14]

Airbag mechanic

Airbag deployment could cause several injuries. Before referring to these injuries, it is essential to understand how an airbag functions.

The airbag takes 10msec to deploy with a speed of 160 to 340 kph.[12, 17] This measure has been done by the National Highway Traffic Safety Administration. That's the reason that the force of impact causes the observed head and neck injuries. During the development of the airbag, various gases are produced. They include carbon dioxide, carbon monoxide, nitric oxide, ammonia, various hydrocarbons, sodium hydroxide, sodium carbonate and metallic oxides.[12] Two seconds after the deployment of airbag, these gases escape via exhaust ports or the back side of the airbag.[14] The airbag is designed to inflate before the moment that the restrained occupants hit the bag and the person decelerates as the bag deflates.[20] The most common of injury is burn. If the driver`s hand is in contact with the steering column or near the vent holes at the time of deflation, the setup for a chemical burn is clear. Also, the airbag chemicals may ignite by contact with the live electrical wiring, resulting in an explosion of the chemicals and a thermal injury to the driver`s hand. A combination of both chemical and thermal injury may result. One cause of burns is friction from physical contact with the surface of the airbag. Other type of burn is thermal by direct burn from high-temperature gases and indirect burn due to melting of clothing. The third cause is chemical by contact of alkaline corrosives, especially sodium hydroxide, with the skin or the mucous membranes of the eyes or by particulate materials with unknown effects. The alkaline corrosives are responsible for keratitis,[14] facial erythema [14] and contact dermal burns of the extremities.[13] The gases have high temperature, which melts causes chest and hand burns.[15] The majority of thermal burns are mainly in upper extremities because they are often pushed

forward and away from the airbag module by the force of its opening.[16]

Huelke et al.,[16] suggested that modifications of the module cover or the mechanism of airbag inflation may reduce the likelihood of these fractures.[16] To reduce injuries from airbags, the National Highway Traffic Safety Association proposed changes in national standards, and are recommended for manufacturers to reduce the force with which the airbag deploy. The model was applied to cars after 1998.[17]

Honda Motor Corporation Material Safety Data Sheet revealed important information about the ingredients of the airbag and their physical hazards. When the vehicle sensors detect a sufficiently severe crash, an electric signal ignites a primer in the airbag canister. This triggers the ignition of about 70 g of sodium azide, which converts to nitrogen gas (99.2%), water (0.6%) and hydrogen (0.1%). By products of this combustion include sodium hydroxide, sodium carbonate and other metallic oxides, which create a fine alkaline aerosol. The reaction will vary slightly, depending on which oxidizing agents are used by the manufacturer. These agents can include copper oxide, molybdenum disulfide, iron oxide or silicone dioxide. The pressure of the rapid ignition causes the inflation of the 60 L airbag to occur within about 10 milliseconds. The propellant is a class B explosive and the chemicals in the inflator module may self-ignite when temperatures reach more than 300°F. The chemicals may also be ignited by contact with live electrical equipment and circuitry if the assembly is not properly protected or by severe impact of the inflator assembly or the completed module. Azides may also react with copper, silver or heavy metals (brass, alloys) to form explosive metal azides. Strong oxidizing agents may initiate ignition. Reaction with acids will liberate hydrozoic acid (NH_3), which is highly toxic and explosive.[18,23]

Injuries from airbag deployment

The airbag is designed to inflate when the vehicle is involved in barrier impacts of 20 to 25 km per hour or greater or head on collisions of 40 to 45 km per hour or greater.[18] Huelke et al.,[16] reported the first upper extremity injuries caused by airbag deployment. They described nine patients who sustained various fractures of the radius and ulna from airbag trauma and several of these were opened. The conclusion of the study was that these are rare injuries and the module cover usually is the cause of the damage.[16] Duma et al., [23] studied 12.429.580 front-seat passengers from 25.464 cases. The occupants who were not exposed to an airbag deployment were more than twice as likely to sustain an orbital fracture. Also they showed that airbags decrease the severity of orbital fractures that occupants sustained.[17] An analysis of 25.464 cases of airbag deployment (United States 1993–2000) indicated that automobile occupants exposed to airbag deployment were statistically more likely to sustain a severe upper extremity injury (2.7%) than occupants not exposed to airbag deployment (1.6%). [19] Orthopedic injuries occur mainly in the upper and lower limbs (for side airbags). Injuries of the spine are less common.[19] Lesions appear more frequently in the wrists. [10,14,16,19,20] Fractures of the upper extremities are rare and minor [16,21,32] Duma et al.,[23] argue that the upper limb injuries from traffic accidents are four times greater when the car has an airbag.[23] Huebner et al.,[10] reported 4.4% of upper limb fractures during airbag deployment. [10]

The reported risk of airbag related eye injury is 2.5% for any eye injury and 0.4% for severe eye injury.[21] The report of the multidisciplinary expert panel of 17 physicians at the 1997 National Conference on Medical Indications for Airbag Disconnection concluded that “persons with various types of ophthalmologic surgery may be at unreasonable risk of injury because of the fragility of their ocular structures,” but “most eye injuries that occur after airbag deployment are minor and lead to full recovery”. [22]

In the review of the literature found one study that reported injury in the first and fifth finger. But the results of this study

challenged and have not yet been established. [21]

Seat belts used alone have not been found to significantly reduce the number of chest injuries in motor vehicle crashes.[25] An estimated 1500 lives have been saved since the introduction of airbags in 1987 through 1995.[26] Front airbags have been shown to reduce the occurrence of cervical spine and maxillofacial injuries considerably.[24] Hansen et al.,[25] reported two drivers with fatal spinal cervical spine because of the violent hyperextension of the neck from the airbag pressure to the chin and/or mandible.[25] Hart et al., [26] reported subaxial cervical cord injury secondary to a hyperextension mechanism, with preexisting severe cervical spondylosis from C3-4 to C6-7 and cord compression.[26]

Automobile crashes are the most common cause of blunt traumatic tricuspid valve regurgitation.[15] The first cases of airbag related cardiac trauma were reported in 1993.[15]

Blunt aortic injury is most commonly caused by sudden deceleration caused by a high-speed motor vehicle crash. Although the use of seat belts in conjunction with automobile airbags has significantly reduced the fatality rate associated with high-speed collisions, severe thoracic injuries have been attributed to airbag deployment alone.[9,15,19]

In the National Highway Traffic Safety Administration's report to Congress,[27] the estimated effectiveness of an airbag alone reduced the risk of moderate head injury by 46%, but was less effective in preventing serious head injury, with a non significant 16%. A recent study conducted by Pintar et al.,[28] also found that for serious head injuries, an airbag alone was only slightly more effective in preventing head injuries than being unrestrained, but it was the restraint system, seat belt or combination of belt and airbag, that produced very low percentages of head-injured occupants.

A report by Kramer et al.,[29] has documented otologic symptoms involved in airbag deployments such as tinnitus, hearing loss and disequilibrium. These references are in adults and rarely in children. The deployment of the airbags leads to an intense impulse noise from two sources. The first one is from the rapid expansion which creates an impulse noise of high amplitude and low frequency. The second one is the noise caused from the gases and the unfolding of the bag. These noises are greater than 170dB and last less than 100 milliseconds.[30] This volume is enough to cause hearing loss.[31] Kramer et al., [29]showed a case study of an adult who had hearing loss 10 weeks after the accident. It is not known yet, whether the hearing loss from airbags is temporary or permanent.

One case report of placental abruption after airbag deployment,[32] and one case of uterine rupture have been reported.[33] If the seat belt is worn properly reduces the mortality of pregnant women and protects the fetus. The suitable manner is low over the anterior pelvis with the shoulder strap between the breasts and above the uterine fundus.[34] One to three women does not wear the seat belt properly.[35] In pregnant women has not been explored yet the protection offered by airbags. There have been several reports about potential obstetrical complications, including placental abruption, uterine rupture, and direct fetal injury, have been raised. This is higher in the second half of pregnancy, when the uterus is a leading point of impact and the baby is potentially viable.[32-34] The placental attachment is likely a complication from violent contact with the belly bag. The forces deployed have been studied in the laboratory using pregnancy crash test dummies and computer modelling. Pearlman et al.,[36] showed that the risk of placental or injury to the fetus increases when the pregnancy was not the right place or not wearing seat belt. The driver`s side airbag provides an additional 9% effectiveness in reducing fatalities and a 25% to 29% decreased incidence of serious injuries when seat belts are used. The combination of airbags and lap and shoulders belts is thought to have saved thousands of lives.[18] Dalmotas et al., [19] suggested that passengers, who are too closed to airbags, are at high risk during airbag deployment.

Drivers should have a distanced about 25 cm from the airbag and 45 cm the other occupants.[20,25] They are encouraged to maintain a safe distance from the steering wheel and to use seat belt restraints or to obtain a manual cutoff to their airbags.[34] Because of their small body type, children younger than 10 years have a 36% increased risk of dying in a car accident than adults.[37] The distance between the wheel and the driver in an accident, which may be affected by short height, low weight or unbelted passengers,[33,32] increases the risk of injury to the upper extremities.[19,19,23] The main factor for this seems to be the hand position during the airbag deployment. Lot of studies showed to increase the risk when the forearm crosses the middle of the steering wheel, just in front of the deploying area.[10,22,23] This occurs when the left hand turn right hand drive and vice versa. That's why experts suggest that the correct driving position (distance from the driver's steering wheel) when the wrists are resting on top of the steering wheel.

Side collisions, collisions to the side of the vehicle where the occupant is seated, are more lethal than the frontal one, because the lateral aspect of most vehicles offers less opportunity for energy dissipation when compared with the front that include the bumpers, the fenders and the engine compartment.[38] In side collisions the seat belts are not as effective in reducing injury risk. Side airbags are designed to protect specific occupant body regions namely the head and thorax by 75% and 68% respectively.[5] They deploy from the door, seat and door frame. Side airbags are increased after the finding of increased risk of death in side collisions in relation to the frontal. Bedard et al.,[38] found that mortality in side impact collisions is double compared with frontal ones. The NHTSA has also issued an advisory regarding the potential for serious injury to children associated with side airbags deployment.[39]

Unrestrained patients with airbag deployment have increased Injury Severity Score, hospitalizations, thoracoabdominal procedures, rehabilitation, and a higher mortality rate compared with restrained patients with deployed airbags.[40]

Conclusions

The airbags provide safety to the occupants of cars and reduce the mortality even at 50%. When not used in accordance with international standards can cause serious injuries. The airbags should always be used in conjunction with seatbelts.

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