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# Review of Airbag Injuries: A Sri Lankan Case Series

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## ABSTRACT

The deployment of airbags in vehicles has significantly contributed to occupant safety during accidents. This review article discusses their history, evolution, types, chemical composition, mechanisms, defects, safety issues and hazardous practices by vehicle occupants. The evolution of airbags, from early designs to advanced designs is presented highlighting their life-saving impact and defects. The article addresses common hazardous practices by vehicle occupants that could lead to airbag-related injuries such as resting hands or feet on the dashboard. A series of typical and atypical airbag-related injuries from Sri Lanka is given in the latter part of the article. These cases include incidents of metal objects detaching from airbags causing fatal injuries, fractures resulting from improper hand placement during airbag deployment, burns, cranio-facial and dental injuries and so on.

*Keywords: Airbag; deployment; road safety; vehicle occupants; atypical injuries.*

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# 1. INTRODUCTION

## 1.1 History and Evolution of Airbags

Airbags are an essential safety device in modern vehicles. Modern airbags are much more advanced than the original designs. They continue to save lives every day. The concept started in 1941 with no notable success for more than a decade. John W. Hetrick was the first person to claim a patent in 1953, though Walter Linderer too had patented his airbag design in the same year [1]. However, those airbags were mere safety cushions which were nothing more than pre-deployed air-filled bags. Modern Airbag Prototype (the deployable airbags) became a reality in 1963. A Japanese named Yasuzaburou Kobori invented the deployable air-bag.[1] Deployable airbags were massively improved after Allen Breed invented a sensor and safety system in 1968. This inexpensive crash sensing device with an accelerometer and a pressure sensor allowed a more accurate deployment of the airbags. In the late 1980s, airbags became a standard feature in almost all cars primarily due to government safety regulations. Airbags continued to evolve with new designs and technologies. In the late 1990s, many countries required that all new cars be equipped with side-impact airbags. Since the early 2000s, automakers started adding more advanced technology including Mercedes Benz's pre-crash deployment system which predicts when a crash was likely to occur and deploys the airbags and fastens seatbelts. Today's cars are equipped with even more advanced technology. They continue to evolve and become more advanced every day.

## 1.2 Types of Airbags

In a modern vehicle air bags prevent occupants from ricocheting around during an accident. Therefore, they may be placed anywhere a passenger can experience an impact against a cabin compartment [2]. These include:

- Frontal airbags in the dashboard and steering wheel
- Side airbags ('curtain' or 'torpedo')
- Seatbelt airbags (in the safety belt itself)
- Knee level airbags for leg protection
- Seat airbags (to reduce pelvic damage)
- Pedestrian airbags (to protect pedestrians during a crash)
- Roof/sunroof airbags (to protect the head)

## 1.3 Chemical Composition and Mechanisms of Air Bags

The first widespread deployment systems used sodium azide as a chemical agent to inflate airbags [3]. Sodium azide (NaN3) is ignited by a spark to release nitrogen gas and sodium metal. The Nitrogen gas causes the bag to inflate fully in 40ms. They also added potassium nitrate and silicon dioxide to react with the resulting sodium metal. That reaction produces potassium silicate and sodium silicate, both of which stop the sodium from reacting with moisture in the air to form corrosive sodium hydroxide.

In the late 1990s, the airbag maker Takata introduced a system that replaced sodium azide with ammonium nitrate [4]. Over time, the ammonium nitrate detonated uncontrollably when the airbag was deployed. This reaction destroyed the container, which include ammonium nitrate sending metal shrapnel into the vehicle. The problem was exacerbated by high temperatures. When the airbag deployed, hot gas from combustion comes through the channels quickly and burnt through the material in just 3 to 5 ms, rather than the 30 ms. This defect caused 23 deaths and at least 400 injuries in the US alone, leading to recalls of 67 million airbags in tens of millions of automobiles [4].

Today's airbags use guanidinium nitrate plus a copper nitrate oxidizer. When ignited, guanidinium nitrate produces nitrogen gas, water and carbon.

For an airbag to deploy, a combination of the following requirements/conditions may be necessary. They include the axis of sensory activation, impact severity, vehicle movement, presence of occupants, seatbelt engagement, seat belt pre-tensioners and etc [5].

In addition to the expected effects of the airbag deployment, an atypical outcome may result from inappropriate use of the product (against the prescribed guidelines by the vehicle manufacturer), the product failure/defects and activity errors etc.

Air bags have a higher success in speeds below 80kmph. At higher speeds, they are not a guaranteed lifesaver. In some vehicles they may deploy even when seat belts are not fastened, leading to serious injury and even death. In vehicles equipped with shackle sensors, deployment of airbags will depend on multiple

factors including the buckling of seatbelts. Some vehicles are equipped with occupant sensors (tactile or pressure sensors) in seats [6]. Corresponding airbags may not function if the seat is unoccupied. Smart airbags can even compensate for the person's weight.

### 1.4 Airbag Defects

There are three airbag defects mainly. They are failure of deployment, too aggressive deployment and deployment at the wrong time. Other airbag defects include faulty on-off switches, malfunctioning inflators, airbag sensor malfunctions, accidental airbag deployment, airbags that are not fitted correctly to the size of the vehicle [7].

A total of 67 million airbags have been recalled and at the end of 2022, 11 million were yet to be replaced which were made by Takata company due to the explosive deployment. The airbag's metal inflator which contains wafers of propellant, in some instances, has exploded with substantial explosive force leading to the above issue [8]. Metal fragments from the airbag may spray throughout the passenger cabin if the inflator housing ruptures during a collision [9].

### 1.5 Airbag Safety Issues

Women, children and men with short stature, unrestrained passengers, pregnant women, children in the front seat, drivers with a habit of adjusting the seat too closer to the steering wheel are more likely to suffer air bag injuries. The speed of a deploying airbag can cause abrasions or burns. The chemicals released when deployed can irritate the eyes, lungs or airways [10]. Airbags can cause severe injuries to the eyes [11]. When an airbag fails to deploy, that too can cause serious and life-threatening injuries.

### 1.6 Common Hazardous Practices done by Vehicle Occupants

Objects carried on the dashboard could act like missiles when an airbag is deployed [12]. Artificially fitted seat covers/dashboard covers will hinder the full benefit of airbags. Resting the hand through the steering wheel may lead to injuries. Resting feet on dashboard too may lead to injuries [13].

## 2. SRI LANKAN CASE EXAMPLES

### 2.1 Case 01

According to the traffic accident reports, the deceased was driving a Honda Insight hybrid car [14]. His car crashed into a pile of rubble left behind near a telecommunication manhole. According to the police statements, an iron part of the barrier placed near the manhole was found on the windscreen, but there was no damage to the windscreen. Only the bumper of the car had been damaged after the vehicle had crashed onto the rubble. The airbag had been activated.

**Fig. 1. Common hazardous practices**

Autopsy revealed that a metal object which was later identified as a part of the air pump of the airbag, had been detached and had penetrated the neck. The death was due to massive haemorrhage leading to hypovolemic shock resulting from injuries to several major neck vessels.

## 2.2 Case 02

In this case, the driver had held his right forearm and hand in the space within the steering wheel and the column. During the accident, which was a head-on collision with a lamp-post by the side of the road, the steering wheel airbag was activated resulting in fractures of both radius and ulnar. Fractures were at the distal one-thirds and were obliquely placed while displaced posteriorly. (A picture is included merely to demonstrate how the driver had positioned his forearm at the time of the deployment of airbags.)

## 2.3 Case 03

In this instance, there was a burn along the medial aspect of the left forearm. The heat generated by the deployed airbag, corrosive compounds formed during the process as well as the course nylon material of the balloon might have caused this. Erythema without blister formation and formation of a scab is evident here.

**Fig. 2. An iron part of the barrier placed near the manhole**

**Fig. 3. Broke the bones**

### 2.4 Case 04

In this photograph, singeing of hair amidst a burnt and abraded area on the left frontal scalp in this 11-year-old child due to the heat and other effects produced by the deployed airbag is evident. He was seated unrestrained on the lap of an adult in a Toyota van when suddenly it met with a head-on collision with another van. The child was thrown forward towards the dashboard and the wind-screen but escaped serious cranio-facial injuries due to the protective effect of the airbag. As the distance between the child's head and the airbag was less than what is recommended by the vehicle manufacturer, (mainly as the child was seated unrestrained on the lap of an adult) he sustained the above injuries as his impact with the deploying airbag is premature (before it is fully inflated and ready to cushion the passengers).

### 2.5 Case 05

In this case, there were chip fractures involving the central incisors of the upper jaw. He also has a sutured laceration on the inner aspect of the lower lip.

### 2.6 Case 06

In this incident there were multiple brush-burns on the front of the chest and upper abdomen following the deployment of air bags.

**Fig. 4. A burn along the medial aspect of the left forearm**

**Fig. 5. Singeing of hair amidst a burnt**

**Fig 6. Chip fractures involving the central incisors of the upper jaw**

**Fig. 7. Multiple brush-burns on the front of the chest and upper abdomen**

**Fig. 8. Extensive burns involving the left side of the face**

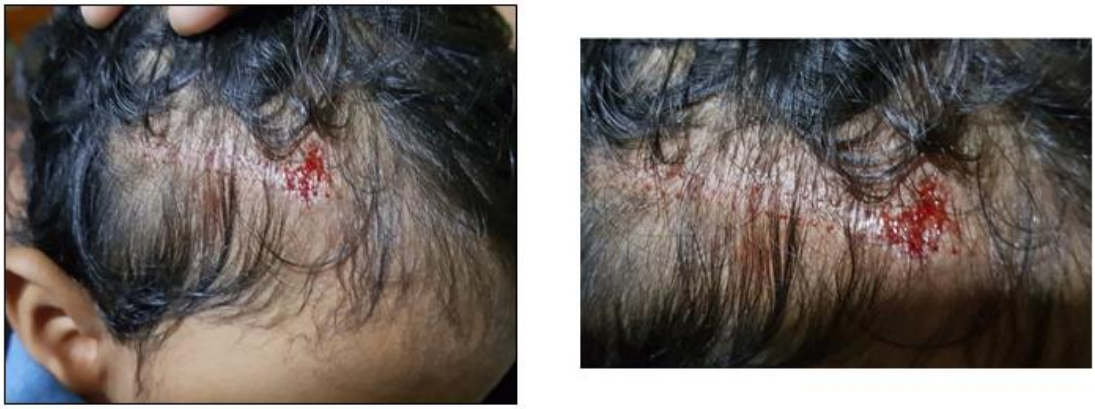

**Fig. 9. Abrasions, superficial laceration and an underline scalp haematoma**

### 2.7 Case 07

In this case, rather extensive burns involving the left side of the face and outer angle of the eye and ear-lobe are evident. These are more in favour with chemical burns not impossible to occur following airbag deployment. (Photograph: with the kind permission from Prof. Dhammika Ariyarathne)

### 2.8 Case 08

In this incident, there were pattern abrasions, superficial laceration and an underline scalp haematoma (evident on CT scan) following airbag deployment.

## 3. DISCUSSION

The review article provides an overview of airbag-related issues, history, and safety concerns. The article discuss the evolution of airbags from their inception in the early 1940s to the advanced systems we have today. It is fascinating to see how they evolved from basic safety cushions to advanced, life-saving features, thanks to innovations like crash sensors and improved technology. The chemical composition of airbags is also discussed, highlighting how changes in the propellant chemicals used have led to improvements in their safety and functionality over time. The article highlights the importance of adhering to vehicle manufacturers' guidelines and not engaging in hazardous practices while in a car. The examples of airbag-related injuries from Sri Lanka, such as metal objects detaching from airbags, fractures due to improper hand placement during deployment, and burns, illustrate the potential risks and the need for proper safety measures.

## 4. CONCLUSION

Airbags provide an enormous protection to cabin occupants of a vehicle during collisions. Rarely due to technical problems and more commonly due to inadvertent use of airbags and not complying with guidelines laid down by the vehicle manufacturers, there can be injuries due to airbags themselves. Such injuries mostly are of minor forms while rarely more serious and even lethal injuries could occur due to airbags. In the above case series, brush burns, chemical burns (involving eyes), abrasions, contusions, fractures, lacerations, haematomas and perforating/puncture wounds have been identified as caused by deployed airbags. Most such injuries could be avoided by adhering to manufacturer’s guidelines.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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