Airbag-induced thumb avulsion: two case reports

Anne-Marie C. C. Stoel · Jeroen Vanhaecke ·
Marleen Dezillie · Dirk Oosterlinck · Filip Stockmans

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Abstract Although airbags are designed to save lives and protect victims from serious injuries, airbag deployment can cause unwanted lesions. In this case report, two cases are presented of young women who sustained an important fracture dislocation of the first carpometacarpal joint (CMC I joint) caused by airbag deployment during a car collision.

Introduction

The airbag was introduced as a life-saving and injury-reducing device [5, 7, 9]. There are however hazards and risks associated with airbag deployment. The industry itself came to the conclusion that the overall life-saving airbag could also be life-threatening in certain circumstances [4–7, 8, 9].

A.-M. C. C. Stoel (✉)
Department of Plastic, Reconstructive and Aesthetic Surgery,
UZ Leuven, Herestraat 49, 3000 Leuven, Belgium
e-mail: annemarie.stoel@gmail.com

J. Vanhaecke · M. Dezillie
Department of Orthopedy, Hand Surgery, AZ Groeninge,
Campus Loofstraat, Loofstraat 43, 8500 Kortrijk, Belgium

J. Vanhaecke
e-mail: handgroep@azgroeninge.be

M. Dezillie
e-mail: handgroep@azgroeninge.be

D. Oosterlinck
Department of Orthopedy, AZ Groeninge, Campus Vercruysselaaan,
Burgemeester Vercruysselaan 5, 8500 Kortrijk, Belgium
e-mail: orthopedie.sm@azgroeninge.be

F. Stockmans
Subfaculty of medicine Kulak, KU Leuven Kulak,
Etienne Sabbelaan 53, 8500 Kortrijk, Belgium
e-mail: filip.stockmans@kuleuven-kortrijk.be

There is also evidence of increased risk on non-fatal injuries [1, 3]. At least one airbag-related injury occurs in 43 % of airbag deployments [8]. Among airbag-induced injuries, the upper limb is most frequently involved [7]. Most of these injuries are minor, such as abrasions, contusions, lacerations, thermal, mechanical, or chemical burns of the skin and the eyes [4, 6, 7] and were identified in 20–25 % of the airbag cases collected [6]. Only 0.2 % of all injuries are considered as serious lesions [4, 8].

According to Duma et al., upper extremity injuries during car crashes are four times more frequent with combined seat belt and deploying airbag than with seat belt alone [8]. Jernigan et al. states that 0.7 % of occupants exposed to an airbag deployment sustained a severe upper extremity injury specifically related to the airbag [7].

Injuries to the upper extremity and especially the hand can be caused directly by the airbag deployment or indirectly as the upper extremity is catapulted against the interior of the car [3, 6, 7, 8]. In their study, Jernigan et al. found that the majority of upper extremity injuries were caused directly by the airbag (27.7 %), followed by the instrument panel or glove box (20.2 %) and the steering wheel (17.8 %) [7]. This was confirmed by Chong et al. [3].

Jernigan et al. concluded that there was a shift in the fracture location depending on whether the occupant was exposed to an airbag deployment and whether the airbag was the source of the fracture. Fractures of the hand account for only 7 % of the fractures induced directly by the airbag itself. In contrast, occupants exposed to an airbag deployment who sustained fractures from other sources, were injured most often to the hand (23.7 %). There was no significant difference between males and females, between belted or unbelted passengers and between drivers and front passengers [7].

In literature, it is reported that the hands of car drivers are more frequently affected than those of passengers. This can be explained by the presence of the steering wheel [2, 4, 6].

Freedman et al. claimed that hand lesions induced by airbag deployment are minor and rare [4, 8]. The first and the fifth fingers are most frequently involved [8]. Reported hand lesions are usually associated with many other body lesions, particularly in the forearms [8]. Nevertheless, our cases sustained only an isolated lesion of the thumb.

In literature, little is mentioned about the airbag-induced avulsion of the thumb. The thumb is believed to be pushed back by the deploying airbag, the other fingers holding the steering wheel [2, 6, 8, 9].

Case reports

Case 1

In 2008, a 20-year-old right-handed woman sustained an airbag-induced avulsion of the right thumb as front passenger of a car. The cause of the accident was a burst tire when the car was driving at low speed because of glazed frost. The car slid against the crash barriers. The patient wore her seat belt and the airbag opened after she had braced herself positioning her hands against the dashboard.

The opening of the airbag caused an open fracture luxation of the right thumb (Figs. 1 and 2). At the level of the CMC I joint, there was avulsion of the digital nerves, the thenar musculature as well as the volar beak ligament. Vascularisation was preserved (Fig. 3) and radiography showed an avulsion fracture of the trapezium (Fig. 4).

The same day, an operation was planned. Suturing of the volar beak ligament was carried out, as well as a carpal tunnel release, suturing of the thenar muscles and suturing of the digital nerves back to the median nerve end to side. The patient was put on intravenous antibiotics and a scaphoid cast was applied. Radiographic controls demonstrated a good alignment of the fracture. Clinical control after 1.5 months

Fig. 2 Peri-operative view: visualization of the trapezium bone

revealed a lack of opposition with quite good flexion and extension of the thumb.

Clinical control after 2 years showed some morning stiffness in the joint and difficulty in opening bottles. There was only partial thumb numbness. There were no further restrictions in daily life and there was a good recuperation of the mobilization, including opposition. On radiography, there were no signs of early arthrosis.

Case 2

In 2009, a 25-year-old right-handed woman sustained an open fracture luxation of the right thumb caused by the deployment of an airbag. She was the driver of a car that was hit at the left front side, driving at a speed of 60–70 km/h. The other car was driving at a speed of 30 km/h. In anticipation of the crash, she braced herself to the steering wheel with the hands in the ten to two position. She was wearing her seat belt. There were no associated lesions. Primary care was carried out elsewhere: skin suturing under local anesthesia and application of a plaster cast.

Fig. 1 Avulsion injury of the right thumb of a car passenger by the deployment of an airbag

Fig. 3 Peri-operative view: preserved vascularisation and injured nerve of the avulsed thumb

Fig. 4 Pre-operative radiography: avulsion fracture of the trapezium bone

She was transferred to our hospital after 11 days. A scan was carried out which revealed a multifragmentary fracture of the os trapezium and the os trapezoideum, as well as a non-displaced fracture of the os hamatum.

The displaced fracture of the trapezium was not acceptable, and open reduction was attempted under general anesthesia, 25 days after the car accident. Exploration showed an anterior luxation of metacarpal 1 at the junction with the os trapezium. The surface of the trapezium was fractured (multifragmentary, Fig. 5). The os trapezium was filled with bone grafts to create a bone stock in order to keep open the option of an arthroplasty at a later time.

Stabilization of the cartilaginous surface was undertaken by means of K-wires, but the pieces of cartilage were small and an Iselin pinning was carried out to unload the CMC I joint and to keep the first web space open (Fig. 6).

Six days after the intervention, there were signs of superficial infection. Intravenous and later on oral antibiotics were administered. A removable cast was measured 1 week later

Fig. 5 Open avulsion of the thumb caused by the deployment of an airbag. Peri-operative view of the multifragmentary fractured os trapezium

and progressive mobilization was allowed. The K-wires were removed 6 weeks post-operatively and total mobilization was allowed.

2.5 months post-operatively there was a good mobilization, but still a big loss of force. The patient sustained some pain at the CMC I joint. She restarted her work as a secretary after 4 months. A check-up showed no contraction of the first webspace and a smooth scar. Mobilization of the thumb reached a Kapandji score of 8 and there were certain difficulties in positioning the thumb for key pinch. Decreased pronation caused a loss of power. There was also a persistent pain of the CMC I joint after pressure.

Two years after the injury, the patient complained about more pain on the thumb, as well as in the area of the triangular fibrocartilage complex (TFCC). Radiography showed arthrosis of the CMC I joint and no evidence of ulnar pathology. Enough bone stock was left at the trapezium bone (Fig. 7).

Control at 2.5 years after the injury showed persistent pain on the CMC I joint. NMR showed bone edema of the

Fig. 6 An Iselin pinning was carried out to unload the first carpometacarpal joint and to keep the first web space open

Fig. 7 Two years after the injury, radiography shows arthrosis of the CMC I joint at the right side, but there is still enough bone stock: **(a)** right side, **(b)** left side

trapezium. There was no evidence of ulnar impaction syndrome. There was also a minimal carpal tunnel syndrome confirmed on EMG. An infiltration of the carpal tunnel was carried out.

Discussion

The presence of airbag-induced injuries is a reality [6, 9]. The energy and especially the speed of an airbag deployment is sufficient to cause injury to the occupant, particularly to body areas that are close to the airbag module at the time of deployment [5]. The production of serious and fatal injuries secondary to airbag deployment, although relatively small in overall numbers, is increasing [9].

In most articles, quite a lot is written on predisposing factors for airbag-induced upper extremity injuries [1–3, 5–7, 8, 9].

Several authors thought that the fragility of women's bones, especially those with osteoporosis, was the cause [5, 8]. However, Duma et al. stated that in wrist injuries caused by the deployment of side airbags with entrapment of the arm in the handgrip, the risk of injury was found not to be dependent on subject bone mineral density, age, mass, and stature [7]. Jernigan et al. also stated that occupant height, age, and crash delta V were not significant variables [7].

Other authors however stated that the distance between the patient and the steering wheel during the impact - which can be affected by short height, low weight, or unbelted patients - increases the risk of upper limb injuries [8, 9]. For hand injuries caused directly by the deploying airbag this distance should not be a factor as the driver's hands are usually in close proximity to the steering wheel [9]. In fact, the main predisposing factor seems to be the hand position during the airbag deployment, particularly for the steering wheel airbag [1, 6, 8]. When the hand is strongly held in position, for example by the steering wheel or a lateral door handle, an indirect mechanism can bring about traction injuries [8].

Furthermore, we cannot neglect the instinctive protective action: victims brace themselves against the steering-wheel or dashboard [2]. At initial deployment, the airbag fabric can reach a velocity in the range of 160–320 km/h [6]. Because of the proximity of the driver's upper extremities to the steering wheel airbag module and the necessity to deploy the airbag rapidly, it may not be possible to completely eliminate these more common superficial extremity injuries [6, 9].

Further research is needed to determine the optimal design to reduce the incidence and severity of hand, wrist, and forearm injuries within the deployment envelope, while preserving the life-saving performance of airbag systems [3, 6].

In our two cases, the open fracture luxation of the thumb, caused by an airbag deployment is described. Based upon the clinical view of our cases the mechanism of these avulsions seems to be a direct forceful wedging open of the webspace causing elongation of the soft tissues.

This involves more or less the presence of ligamentous and/or bony lesions. The ligamentous lesions are the key problem for stability, while the bony lesions are secondary to the ligamentous avulsions. Avulsion of the thenar muscles, as well as neurovascular injuries, are frequently associated soft tissue injuries. Little has been written on the approach and treatment of these specific lesions.

The main goals of the treatment are the reconstruction of the stability of the CMC I joint and to keep the first webspace open. When there are associated fractures in the carpal bones, these have to be reduced and a bone stock should be provided when necessary (second case). The latter is carried out to keep all options open for later treatment of the anticipated arthrosis.

Despite the bad-looking aspect of this kind of lesions and the associated dire prognosis, the follow-up clinical examination (cfr. clinical photos) of our cases shows that the outcome is better than commonly expected. The important associated neurovascular lesions tend to heal without implications on daily life. There were no problems of insensibility and cold intolerance, which results in a better outcome compared to replantation of the thumb. Furthermore, the post-operative

mobility is better than expected. However, the greatest long-term morbidity of these lesions - especially when the os trapezium has a multifragmentary fracture - will be the mobility of the CMC I joint. A long-term follow-up is therefore warranted to allow intervention in early stadia of arthrosis.

Conclusion

Airbag utility cannot be questioned due to its life-saving advantages. However, as the use of airbags is common nowadays, the impact of airbag deployment-induced injuries becomes clear [4–7, 9].

The upper extremity is prone to injuries caused by the deployment of the airbag as it is close to the steering wheel [4]. Hands are rarely involved, but if some predisposing factors are present at the same time (e.g. unbelted patient, wrong position on the steering wheel), airbag-induced lesion can occur [8].

Creating awareness of nonlethal injury patterns related to airbag deployment is a logical first step toward potential design modifications to make automobile transportation even safer. Probably, studies on the predisposing positions of the thumb are warranted.

In this article, two cases of young females who sustained a severe dislocation of the thumb are described. None presented with devascularisation. However, in both cases all muscles of the first webspace were avulsed as well as the digital nerves. The prime goal of treatment was to restore stability in the CMC I joint. The nerve reconstruction could only be achieved in an end to side fashion.

Despite the bad-looking aspect of these lesions, the outcome concerning insensibility, cold intolerance, and mobility is better than expected, certainly when compared to results after replantation of the thumb.

Statement of human and animal rights This article does not contain any studies with human or animal subjects.

Conflict of interest Anne-Marie Stoel, Jeroen Vanhaecke, Marleen Dezillie, Dirk Oosterlinck, and Filip Stockmans declare that they have no conflicts of interest.

Statement of informed consent Anonymity of the patients can be assured.

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