Case Report

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Air Bag Associated Posterior Segment Ocular Trauma

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Airbags indeed reduce the risk of injury and death in motor vehicle accidents, however, ocular injury induced by airbag deployment has been reported. From 1999 to 2001, medical records were retrospectively reviewed for patients with severe ocular injury related to airbag inflation at Taipei Veterans General Hospital. The ocular presentation, clinical course, management and visual outcome were recorded and studied in detail. Three cases of ocular posterior segment injury associated with airbag inflation were identified. Mean age was 37.3 years old (range 34-39 years). None of the patients was wearing a seat belt. All patients had periocular contusion, corneal edema, and hyphema. Vitreous hemorrhage was found in 3 cases, and there were 2 cases with severe macular injury, including traumatic maculopathy and hypotony maculopathy. Retinal detachment developed in 1 case. One patient presented with traumatic macular hole 6 weeks after injury. The initial visual acuity was hand motion only in all patients, the final visual outcomes recovered to 6/20, 1/60 and 2/60, respectively. The airbag-associated posterior segment ocular trauma was induced by impact with fully deployed airbag. Severe ocular posterior segment trauma with devastating visual sequelae might occur in drivers and passengers who have not fastened their seat belt.

Air bags are inflatable devices that are designed to decrease mortality and morbidity resulting from motor vehicle accidents.[1-5] However, ocular injuries associated with air bag deployment have been reported in recent years.[6-22] Severity of air bag-associated injury ranged from mild to severe, and location ranged from anterior segment to posterior segment.[22-23] The reported injuries include corneal abrasion, eyelid ecchymosis, periorbital contusion and fracture, subconjunctivital hemorrhage, chemical keratitis, hyphema, subluxated lens, cataract, iridodialysis and angle recession, corneal endothelial cell loss, vitreous and subretinal hemorrhage, choroidal rupture, retinal detachment, and eyeball rupture.[6-25] Here, we review a series of 3 patients with severe air bag-associated posterior segment ocular injuries. The ocular presentation, clinical course, management and visual outcome of these patients are described.

CASE REPORT

We retrospectively reviewed the records of air bag-associated ocular injuries at our Hospital from 1999 through 2001. Patients with initial vision in injured eye worse than 3/60 were included in this study. There were 3 patients enrolled in this report, 2 males and 1 female. None of the patients was wearing a seat belt. Two patients were drivers, and 1 patient was a front-seat passenger. The initial best-corrected visual acuity was hand motion in all patients. The initial intraocular pressure was less than 7 mmHg in 2 patients (case 1 and 2). There was no preexisting ocular disease or surgery history in any of the patients.

All patients had anterior segment injuries on initial examination, including periocular contusion, subconjunctival hemorrhage, and hyphema. One patient had traumatic cataract. Vitreous hemorrhage was present in all 3 patients, but the other posterior segment trauma was variable. Two patients (cases 1 and 3) had choroidal rupture. Case 1 had hypotonic maculopathy. Case 2 suffered from retinal detachment. Traumatic maculopathy and macular hole formation developed in case 3.

Cases 2 and 3 had to receive vitrectomy treatment for retinal disorder. Case 2 underwent pars plana vitrectomy,

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lensectomy, endolaser photocoagulation and intraocular gas tamponade. Case 3 (macular hole) underwent pars plana vitrectomy, internal limiting membrane peeling, usage of autologous patient serum, and gas tamponade. The final best corrected visual acuities in all 3 patients improved to 6/20, 1/60 and 2/60 respectively.

In addition, 2 patients also suffered from concomitant systemic trauma. Case 2 had a severe left arm fracture and received left arm amputation. Case 3 had initial loss of consciousness and brain contusion, fortunately the computed tomography brain scan was normal. The detailed histories of the 3 patients are shown below.

Case 1

A 34-year-old female was in the front passenger seat, with an unfastened seat belt, when her car impacted by another car in the front at a speed of 60 km/hr. The passenger's side air bag deployed, and struck the patient on her face. However, she had no systemic injuries.

On initial ophthalmologic examination, her visual acuity was 20/40 in the right eye, and hand motion in the left eye. There was bilateral periorbital ecchymosis and swelling. The orbital computed tomography (CT) revealed a left orbital floor fracture, and the movement of the left eye showed limited upper gaze. The intraocular pressure was 11 mmHg in the right eye and 5 mmHg in the left. Slit-lamp examination of the left eye revealed a large corneal abrasion with descement membrane folding, and diffuse stromal edema. There were 4+ cells and 5-10% hyphema in the anterior chamber. Fundus examination showed no clear view of the posterior pole due to vitreous hemorrhage.

Two weeks later, the corneal abrasion of the left eye had healed, but corneal striated edema persisted. The hyphema had resolved completely, and the anterior chamber was shallow. The left eye remained hypotonic, the intraocular pressure was 6 mmHg. The fundus of the left eye revealed vitreous hemorrhage absorbed, peripapillary edema, subretinal hemorrhage, macular folding, and retinal pigment epithelium depigmentation over the macula. The diagnosis was hypotonic maculopathy and choroidal rupture. The patient received cycloplegics and non-steroid anti-inflammatory drug medical treatment.

Four months after trauma, the fundus of the left eye revealed hemorrhage absorbed and mild macula edema and folding. The intraocular pressure stabilized to 10 mmHg, and the best-corrected visual acuity recovered to 6/20 in the left eye.

Case 2

A 39-year-old male was not wearing a seat belt in the driver's seat when his automobile was struck in the front at a speed of 70 km/hr. He suffered from left upper arm fracture, and underwent amputation of his left arm.

On initial ophthalmologic examination, his best-corrected visual acuity was 6/8.6 in the right eye, and hand motion in the left. The intraocular pressure was 11 mmHg in the right eye and 5 mmHg in the left. There was bilateral periocular ecchymosis and subconjunctivital hemorrhage. Slit-lamp examination of the left eye revealed 4+ cells and 50%-60% hyphema in the anterior chamber. The cornea was diffuse striated edema. The iris showed traumatic irdodialysis inferotemporally. There was no view of the posterior pole due to hyphema and vitreous hemorrhage. B-scan ultrasonography showed vitreous hemorrhage.

Three months later, hyphema had completely resolved, and secondary traumatic cataract with lens subluxation in the left eye was found. However, there was no view of the posterior pole due to persistent vitreous hemorrhage. B-scan ultrasonography revealed retinal detachment at this time. Then the patient underwent pars plana vitrectomy treatment, endolaser photocoagulation and long-acting gas tamponade. During operation, indirect fundoscopic examination showed a retinal dialysis (1 clock hour in extent) at the inferotemporal periphery of the left eye, related to the location of iridodialysis. A phacoemulsification cataract operation with PC intraocular lens (IOL) implantation was also performed at the same time.

Two months after surgery, the retina was well-attached, with residual fine retina folding at the macula. The intraocular pressure was 12 mmHg, and the best-corrected visual acuity of the left eye had improved to 1/60 at the 5-month post-operative follow-up.

Case 3

This 38-year-old male was driving at a speed of 70 km/hr when his car was struck in the front. He was not wearing a seat belt, and the driver's side air bag deployed immediately and struck the patient on his face. He lost

consciousness briefly after the accident, but spontaneously recovered later. The subsequent computed tomography brain scan was negative.

On initial ophthalmologic examination, his best-corrected visual acuity was 6/5 in the right eye and only hand motion in the left eye. External eye examination revealed left periorbital ecchymosis, lid abrasion and swelling. Slit-lamp examination of the left eye showed subconjunctivital hemorrhage at the temporal side (Fig. 1). The cornea showed small punctate erosion and edema. The lens appeared clear and the pupil demonstrated no relative afferent papillary defect. However, there were 3+ red blood cells and 5% - 10% hyphema in the anterior chamber. The initial intraocular pressure was 14 mmHg in both eyes. Fundus examination of the left eye revealed no clear view of the retina because of vitreous hemorrhage.

Three days later, when the patient returned to our clinic, the hyphema had resolved, the vitreous hemorrhage had become less, and the fundus of the left eye showed diffuse whitening macular edema involving the posterior pole, and subretinal and retinal hemorrhage (choroidal rupture) at the temporal aspect of the macula (Fig. 1). The fluorescein angiography showed multiple pinpoint dye leakage from the retinal pigment epithelial (RPE) layer in the early phase, and diffuse dye pooling within the subretinal space at the posterior pole in the late phase (Fig. 2).

Six weeks after the accident, the vitreous hemorrhage had been absorbed, and the macular edema subsided. But, the visual acuity of the left eye still remained counting finger only. The fundus revealed development of a full-thickness macular hole and surface wrinkling with diffuse fine pigmentation spot at the macula. Fluorescein angiography showed pigmentation block fluorescence in the early phase, diffuse RPE window de-

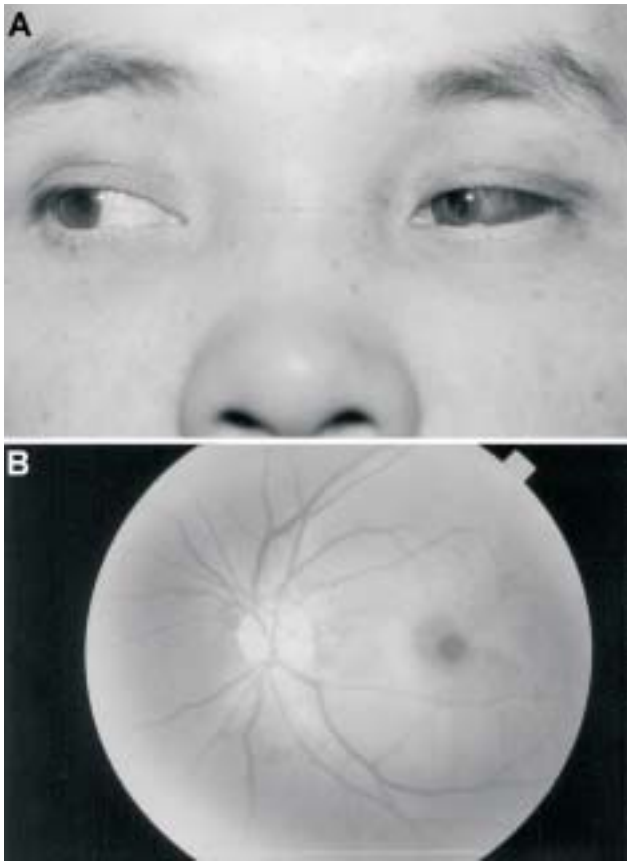

Fig. 1. The third day after air bag trauma. (**A**) Periocular contusion and subconjunctival hemorrhage. (**B**) Diffuse whitening retinal edema of the posterior pole.

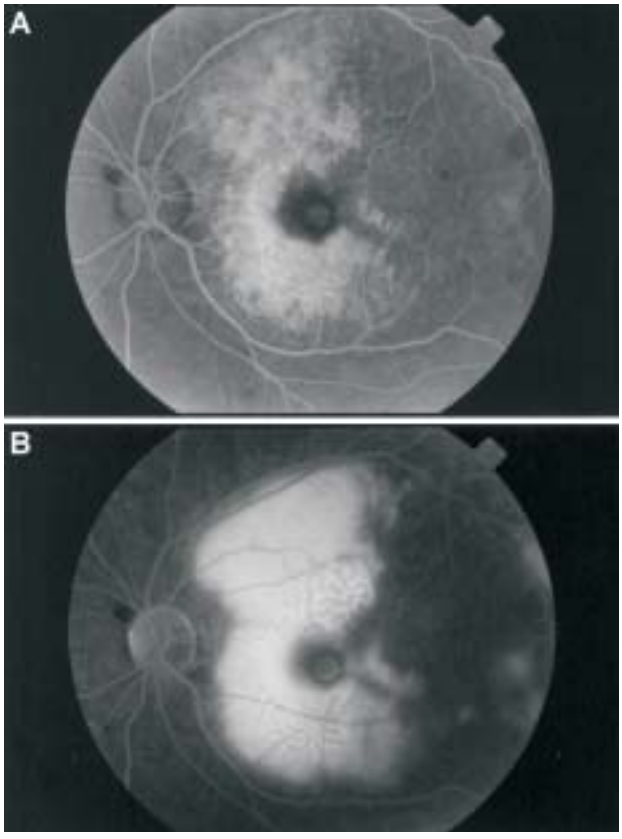

Fig. 2. Fluorescein angiography demonstrated: (**A**) Multiple pinpoint dye leakage from retinal pigment epithelium (RPE) level in the early phase. (**B**) Dye pooling within subretinal space in late phase.

fect and macular hole formation (Fig. 3). The diagnosis was air bag-related traumatic maculopathy with macular hole formation. Because there was no sign of spontaneous recovery, the patient underwent pars plana vitrectomy treatment, which included internal limiting membrane peeling around the macular hole, the use of autologous patient serum and long-acting 20% C_3F_8 gas tamponade. During operation, we observed the phenomenon of incomplete vitreous separation from the retina beginning in the periphery, but not at the macular area. The patient maintained a face-down position for 1 week postoperatively.

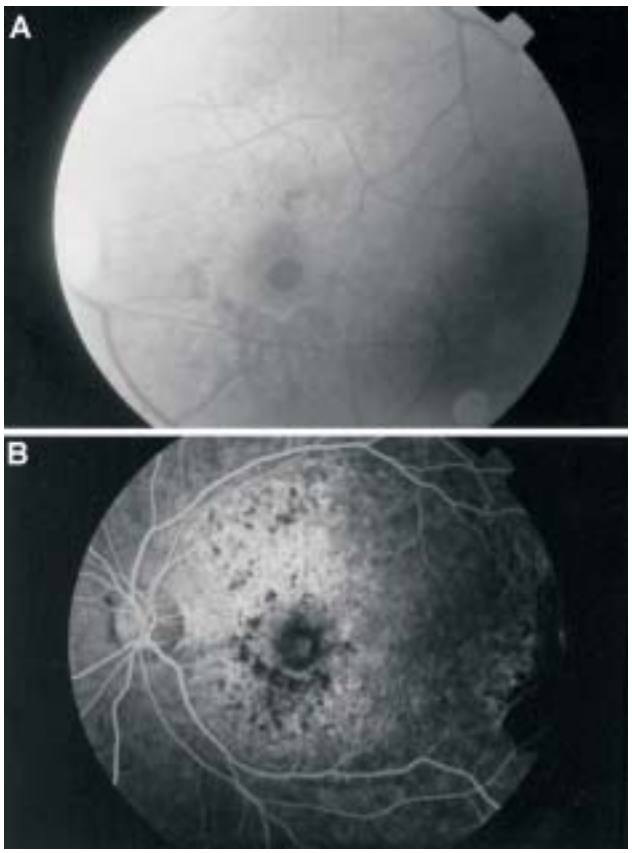

Fig. 3. Six weeks after trauma. (**A**) A full-thickness macular hole and diffuse pigmented spots were noted. (**B**) Pigment blocking hypofluorescence over the macula in early phase. Macular hole with halo, and surrounding diffuse RPE window defect noted in late phase.

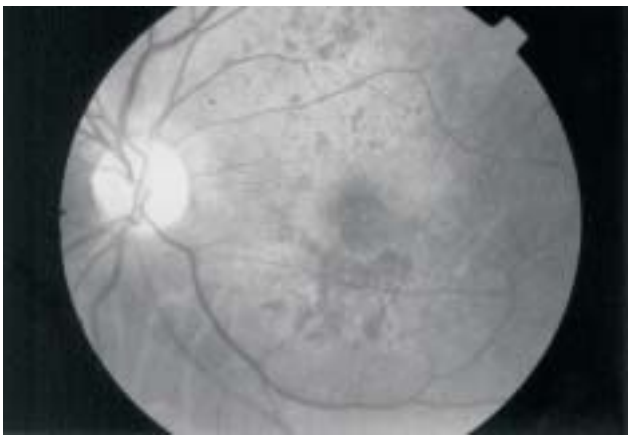

Fig. 4. Post-operative 1 month, the previous macular hole healed with residual hyperpigmentation over macula.

One month after surgery, the macular hole had healed completely. However, residual pigmentation over the macula persisted (Fig. 4). The best-corrected visual acuity of the left eye had improved to the 2/60 at the 6-month post-operative follow-up.

DISCUSSION

When a motor vehicle accident occurs, the sensors which detect the rapid deceleration will activate the air bags immediately. Then, the combustion of sodium azide is triggered, which produces nitrogen gas, inflating the air bag rapidly.[6] The air bag provides a cushion between the occupants and the steering column or dashboard.[6,23] However, the inflation is very forceful, and the face is often the point of air bag impact.[20] Recently, there have been reports of air bag associated ocular injuries after motor vehicle accidents.[6-25]

The main mechanisms of air bag-associated ocular injuries include blunt ocular trauma from impact with the inflating air bag, and chemical keratitis resulting from exposure to alkaline sodium azide gas after the air bag is deflated.[6,16,21,23,24] The most commonly reported ocular injuries are anterior segment periorbital contusion and hyphema,[7,20] which were present in all our cases. The anterior segment manifestations usually resolve spontaneously without serious sequelae. However, ocular injuries involving the posterior segment are more severe, and may lead to devastating visual sequelae. In this study, we present 3 cases, all with severe injuries of the posterior segment, including hypotonic maculopathy, retinal detachment and macular hole formation. Two of the 3 patients underwent vitrectomy treatment, and their final visual acuity recovered to a range from 2/60 to 1/60.

In the acute phase of case 3, the fluorescein angi-

ography on the third day after trauma showed multiple pinpoint leakage in the early phase, and dye pooling within the subretinal space in the late phase. Pigmentation (RPE) proliferation over the macula was found 1 month later. We hypothesize that the fundus change represented the initial contusion of retinal pigment epithelial cells and subsequent disruption of the barrier of retinal pigment epithelium, resulting in pigment epithelial cell edema and overlying serous retinal detachment.[26-28] Finally, the retinal pigment epithelium degenerated and proliferated, causing hyperpigmented change of the macula.[28] Fluorescein angiography is a very helpful tool in the pathogenic diagnosis and assessing the visual prognosis in patients with air bag-related traumatic retinal opacification and edema, as seen in our case 3. The visual prognosis of pure commotio retinae is usually good. However, the vision recovery is limited by the associated macular pigment epitheliopathy and macular hole formation.

Six weeks after air bag-associated trauma, a macular hole developed in case 3. Although the actual pathogenesis of traumatic macular hole formation remains unknown, we believe that the theory of tangential vitreous traction offers the most likely pathogenesis.[29] Thus, the air bag-related blunt ocular trauma induced separation of the vitreous from the retina, creating traction of macula, and eventually causing the formation of the macular hole. We also observed the occurrence of vitreous separation intraoperatively in case 3. Vitrectomy treatment can release the vitreous traction,[29,30] and successfully promote the healing of a macular hole.[31-35] There has been another case report of delayed onset of air bag-associated macular hole, 6 months after original injury.[20] We should be aware of this sequelae, and long-term follow-up of patients is essential.

There were 2 patients (cases 1 and 2) in this report with hypotony after trauma. Hypotonic maculopathy presented retinal folding at the macula, vascular engorgement and tortuosity, choroid fold, and optic disc edema. The ciliary body injury, or cyclodialysis induced by ocular trauma, results in a decrease of aqueous humor production and ocular hypotony. The causes of hypotonic maculopathy include trauma and ocular surgery, especially after glaucoma filtering surgery with mitomycin-C soaking. The medical treatment of hypotony maculopathy includes argon laser photocoagulation, cycloplegics, corticosteroids and non-steroid anti-inflammatory drugs.[36-38] In our series, the hypotony lasted for 6 to 8 weeks. However, severe cases of hypotony may result in phthisis bulbi.[39]

Blunt ocular trauma induced by air bag impact may produce retinal tears and retinal detachment.[9] When the eyeball is rapidly compressed along its anterior-posterior axis, it becomes stretched in the equatorial region and vitreous base. Retinal dialysis, as seen in our case 2, is the most common type of retinal tear associated with traumatic retinal detachment.[20,26] Dialysis is usually located at the posterior border of the vitreous base, which may be as small as 1 oral bay or extend 90° or more. Another sequelae of air bag trauma is choroidal rupture (cases 1 and 3), which is due to Bruch's membrane tearing along the adjacent RPE and underlying choriocapillaris.[26] Choroidal rupture is usually located concentric to the optic nerve, and the associated subretinal hemorrhage is commonly seen. The location of choroidal rupture will determine the visual outcome; permanent visual deficit might occur if there is choroidal rupture occurs across the fovea.

In our series, none of the patients was wearing seat belt, and all had severe ocular injuries of the posterior segment. The concomitant use of a seat belt is essential for an air bag device to adequately protect the passengers and lessen the severity of injuries from motor vehicle accidents. There have been reports that unfastened seat belts in air bag-associated trauma may cause death due to severe injuries,[40] particularly for unrestrained children.[21,23,41] We assumed the mechanism is that unrestrained occupants sit closer to the air bag and therefore are injured more severely by the rapidly inflating air bag. However, because of limitation in sample size, we can't compare with patients with seat belt fastened. A further large-scale study is necessary to confirm our hypothesis.

All 3 patients in our series were Asian. Asians seem to be at increased risk for air bag-associated ocular injuries.[20] This may be related to differences in orbital anatomy, since Asians have a shallow orbital socket and a less prominent superior orbital rim compared to Caucasians. Asian also tend to be shorter, causing them to sit closer to the steering wheel,[20,42-44] and causing more violent contact with the rapidly inflating air bag. It is impor-

tant for automobile manufacturers to continue to improve the design of air bags. A recent modification of air bags has been made to allow the bag to fill more radially rather than anterior-posteriorly. A tethered bag extends 10-13 inches towards occupants, as opposed to 15-20 inches in an untethered bag, thus distributing the explosive force more evenly.[45]

In conclusion, air bags substantially reduce the mortality and morbidity associated with motor vehicle accidents. However, there have been a number of ocular injuries caused by air bag deployment. Air bag-associated ocular trauma is induced by impact with the inflating air bag, and severe ocular injuries might occur in occupants with an unfastened seat belt. The presentation of ocular injury is variable. The anterior segment manifestations of periorbital contusion and hyphema were the most common finding, which was usually self-limited with good vision recovery. However, there is the potential for devastating visual sequelae of air bag-associated posterior segment ocular injuries. Therefore, patients should be informed and physicians are aware that careful follow-up is essential.

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