CASE REPORT

Driver's side curtain air bag-related globe rupture

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SUMMARY

A 35-year-old man presented after a high-speed motor vehicle accident and the driver's side curtain air bag causing blunt force trauma rupturing his right globe. The tangential force of the air bag resulted in an unusual arcuate horseshoe-shaped rupture through the lateral rectus insertion, causing avulsion of the muscle and tearing the sclera, with the apices of the tear extending anteriorly towards the limbus. Repair of the globe rupture was undertaken, and secondary vitrectomy revealed that the scleral tear had not involved the retina abutting the ora serrata. Silicone oil tamponade was used to fill the globe and the postoperative best corrected vision was 6/9. This is the first reported case of a ruptured globe caused by a side curtain air bag, resulting in a uniquely shaped arcuate scleral wound combined with lateral rectus avulsion, not associated with rhegmatogenous retinal damage, and is the first air bag-related globe rupture with scleral involvement to report a final best-corrected visual acuity better than 6/60.

BACKGROUND

Motor vehicle accidents can have a significant impact on victims, in terms of physical, psychological and financial burden.¹ The first air bag patents in 1953 saw the development of these systems and they were introduced into Australian cars in the 1980s.¹ It is estimated that air bags have reduced fatalities by 31% and have reduced the rate of ocular injuries by a factor of 2.5 times.^{1,2}

Globe rupture is a devastating complication that can occur as a result of sudden air bag inflation. We present a case of air bag-related globe rupture involving a uniquely arcuate tear through the temporal sclera over the lateral rectus insertion, requiring primary closure and secondary repair with lensectomy and vitrectomy for vitreous haemorrhage and assessment of the underlying retina. The side curtain air bag as the causative mechanism was consistent with the pattern of injury and is to our knowledge the first case of a side curtain air bag causing globe rupture. This is also the first report of an air bag-related globe rupture producing an unusual horseshoe-shaped scleral wound without tearing the retina and resulting in a visual outcome better than 6/60.

CASE PRESENTATION

A 35-year-old male driver of a sports utility vehicle presented after a high-speed collision (100 km/hour) with a horse. Air bags were deployed at the time of the accident and the patient specifically recalls initial contact with the driver's side curtain air bag.

At the time of the accident, the patient was wearing a seat belt and not using any eyewear. Prior to the accident, he was emmetropic and had no previous ophthalmic history.

On presentation, he had a best-corrected visual acuity (BCVA) of perception of light in the right eye (OD) and 6/5 in the left eye (OS). Intraocular pressures were 6 mm Hg OD and 14 mm Hg OS. Ocular examination was limited by intense pain. A CT scan of the orbits revealed a grossly deformed right globe, with significant distortion of the lateral rectus and no foreign material (figure 1). His ocular trauma raw score sum was 47, predictive of a 28% chance of final BCVA better than 6/60.³

Preoperative intravenous vancomycin 1.5 g twice daily and gentamicin 450 mg were administered, and an oral course of ciprofloxacin 750 mg twice daily was started for endophthalmitis prophylaxis. Intraoperatively, a temporal horseshoe scleral rupture was identified in the right globe with the apices of the tear extending anteriorly towards the limbus. The rupture extended through the insertion of the lateral rectus causing avulsion, and a primary repair was undertaken to close the scleral wound with interrupted 8/0 nylon sutures and reattach the lateral rectus with 6/0 vicryl. Intracameral cephazolin 1 mg/0.1 mL and intravitreal vancomycin 2 mg/0.1 mL and ceftazidime 2 mg/0.1 mL with subconjunctival dexamethasone 4 mg/1 mL were administered intraoperatively.

Postoperative topical ciprofloxacin 0.3% four times a day and prednisolone acetate with phenylephrine HCl 1/0.12% were continued every 2 hours. Postoperatively the right eye demonstrated significant angle recession with a choroidal haemorrhagic effusion temporally underlying the scleral wound. There was no relative afferent pupillary defect (RAPD), intraocular pressure OD was 25 mm Hg, and postoperative B-scan OD revealed no retinal detachment, with a dense vitreous haemorrhage obstructing fundal examination.

Intraocular pressure spikes complicated the postoperative period and were attributed to severe angle recession. The patient was started on oral acetazolamide 250 mg three times a day, and topical bimatoprost/timololol 0.3/0.5% every night with brinzolamide/brimonidine 1/0.2% twice daily after 11 days to control the IOP.

OUTCOME AND FOLLOW-UP

Secondary repair was undertaken 2 weeks later (after cataract developing), with right lensectomy and vitrectomy revealing the scleral rupture extending posteriorly to the edge of the ora serrata but not involving the retina (figure 2). Silicone oil

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Figure 1 Presenting CT of the orbits showed the right-sided globe rupture with deformity around the lateral rectus.

tamponade was used to fill the globe and the 3-month postoperative BCVA OD was 6/9. Silicone oil removal and secondary lens insertion are planned for 6–12 months following the repair.

DISCUSSION

A previous review of air bag-related injuries in serious or fatal motor vehicle accidents showed a 2.5% risk of ocular injury and 0.5% risk of severe ocular injury in fatal and severe motor vehicle accidents.⁴ Pearlman *et al*, Duma *et al* and Lehto *et al* have reported case series of 101, 62 and 25 air bag-related ocular injuries, respectively.^{1 4 5} As not all air bag-related ocular trauma cases are reported, the true rate and perceived impact of air bag-related ocular injury are potentially under-reported.

Air bag-related globe rupture in the literature has been reported in 14 cases, and is commonly associated with severe blunt trauma or laceration injury from the seams of the air bag or other projectile foreign bodies (eg, spectacle lenses).^{5–17}

There was no overlying laceration of the cornea or conjunctiva associated with the blunt trauma in this case. The mechanism of globe rupture in these injuries is attributed to anteroposterior compression followed by equatorial distension.¹⁸ Anterior chamber compression results in lateral aqueous displacement with potential angle recession and iris root dissection.¹⁸ The corneoscleral limbus is the most common site of air bag-related open globe injuries, with seven cases reporting corneoscleral rupture.^{6–10 15 16}

Where scleral rupture occurs, it usually extends radially past the equator to the posterior pole.^{6 11} The scleral rupture in

this case was unusual, forming an arcuate pattern with dissection through the lateral rectus insertion over the ora serrata in a horseshoe pattern. This may reflect the oblique direction of the force applied by the side curtain air bag. The avulsion of a rectus muscle off the sclera in air bag-related ocular injuries has not been reported previously and was attributed to the force of impact on the globe.

Overall, the benefit of air bags in the prevention of both life-threatening and sight-threatening injuries is well established; however, unfortunately ocular injuries still occur.² The rate of open globe injuries has been shown to be three times greater in patients wearing spectacles while driving⁴; not wearing a seat belt has also been shown to increase the rate of open globe injuries.^{4 19} Prior corneal surgery was reported in two cases and previous ocular surgery may predispose to air bag-related open globe injuries.^{17 20}

Interestingly, air bag-related open globe injuries were more highly correlated with speeds less than 30 mph (~50 km/hour) than faster speeds, although so far the number of cases is small.¹ Simulation models of air bag deployment have identified that a speed of >40 m/s results in corneoscleral rupture.²¹ As this exceeds the speed limit of reported cases, it would suggest that the force of air bag inflation is required in addition to the motor vehicle speed to result in globe rupture.^{1 17 20}

The simulations also found that transsclerally fixated posterior chamber intraocular lenses secured with 10–0 propylene could rupture at high-velocity impacts (>60 m/s), while eyes with a long axial length underwent greater deformity with air bag impact across all velocities, attributable to a thinner globe wall.²¹

Air bag-related globe rupture is associated with poor visual prognosis, with only two patients (14%) achieving a BCVA better than 6/60 and both these cases occurring in patients with corneal lacerations only.^{12 14} In patients with scleral involvement up until now, no patients reported a BCVA better than 6/60.^{5–10 12 15}

The association of air bags with bilateral blindness has also been reported and has serious implications for victims and automobile companies.²² The issue of grievous morbidity should be addressed in crash test protocols and detailed in vehicle insurances, sales and maintenance, in a transparent and comprehensive manner to the public.²²

In summary, globe rupture can occur as a side curtain air bag-related injury. The underlying mechanisms, including the oblique tangent of force, may produce arcuate tearing of the sclera and subsequent lateral rectus avulsion. The better visual outcome in this case was attributed to the fact that the scleral rupture did not involve the retina. This is the first reported case of a side curtain air bag-related open globe trauma and the only air bag-related globe injury with scleral involvement obtaining a BCVA better than 6/60.

Figure 2 The scleral rupture. (A) The scleral rupture was closed with 8/0 vicryl and is highlighted by the broken line. (B) The indented view of the scleral rupture shows that the retina was not involved in the injury. The broken line highlights the edge of the rupture.

Learning points

- Globe rupture can occur as a result of side curtain air bag blunt trauma.
- The arcuate scleral rupture is unique to this case and may be attributed to the tangential force of the side air bag.
- Good visual outcomes may be achieved, with urgent primary surgical repair necessary while subsequent vitrectomy may be required.

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drafting and revising the manuscript, final approval and accountability for the manuscript. RH: contributed to the concept and design, drafting and revising the manuscript, final approval and accountability for the manuscript. LL: contributed to the concept and design, drafting and revising the manuscript, final approval and accountability for the manuscript. SO'H: contributed to the concept and design, drafting and revising the manuscript, final approval and accountability for the manuscript.

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