

Penetrating cranial injury due to gunshot in a dog: a case report

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ABSTRACT: A ten-month old, male Black and Tan Coonhound dog was referred with ocular bleeding due to gunshot injury. His mental state was normal. A computed tomography revealed that the bullet was planted in the left cranium. It was presumed that the trajectory of the bullet penetrated from the right medial angle of the eye to the orbit, and changed its track to caudo-dorsal by penetrating the cranium, ending up at the left cranium. The bullet was removed by lateral rostrotentorial craniectomy. No complications were observed during a one-year follow-up except the blindness in the right eye. This is a rare case of gunshot-induced traumatic brain injury featuring a bullet which went through the orbit into the cranium. The damaged frontal lobe seemed to show no neurological signs at the time of first examination in this case. In conclusion, a less aggressive surgical approach is recommended to remove bullets when they are accessible.

Keywords: craniectomy; gunshot; traumatic brain injury; dog

List of abbreviations:

TBI = traumatic brain injury; **GCS** = Glasgow Coma Scale; **ICP** = intracranial pressure

A head injury refers to an obvious external wound to the head including the face, calvarium, and scalp, such as cerebral contusion, concussion, laceration, abrasion, epidural hematoma, subdural hematoma, and fracture (Bruns and Hauser, 2003; Bruns and Jagoda, 2009). It may or may not be related to traumatic brain injury (TBI). TBI is further defined as a damage done to the brain by external force, such as blunt or penetrating force, in contrast to a head injury. TBI can cause brain dysfunction including effects on physical, behavioral, or cognitive functions.

A gunshot-induced TBI is uncommon in dogs. A penetrating head injury induced by a gunshot has a high mortality rate both in humans and animals. A damaged forebrain and cerebral cortex in a dog can cause seizure, drooping heads, altered character, contralateral blindness, contralateral ataxia, contralateral deficit of proprioception, contralateral facial paralysis, and pneumocephalus (Bebchuk and Harari, 1995; Shimura et al., 1997;

Haley and Abramson, 2009). Generally speaking, acute neuroinflammatory responses and other additional damages develop within 72 hours according to an animal model report (Williams et al., 2007; Sulejczak et al., 2008).

The most common complications caused by an orbital foreign body include proptosis of the eye, development of a chronic fistula, orbital abscess or cellulitis, and injury to the extraocular muscles or optic nerves (Gonzalez-Cruz et al., 2007). In humans, the incidence of cerebral abscess associated with intracranial expansion of the orbitocranial foreign body is estimated at 48%, and mortality at 25% (Robaei et al., 2004; Shahpurkar and Agrawal, 2008).

There are several human cases of lead poisoning owing to gunshot bullets (Coon et al., 2006; de Madureira et al., 2009). Lead poisoning mostly results when the lead bullet is put into contact with cerebrospinal fluid or joint fluid. It is approximately three months before initial symptoms associated with retained lead fragments manifest themselves.

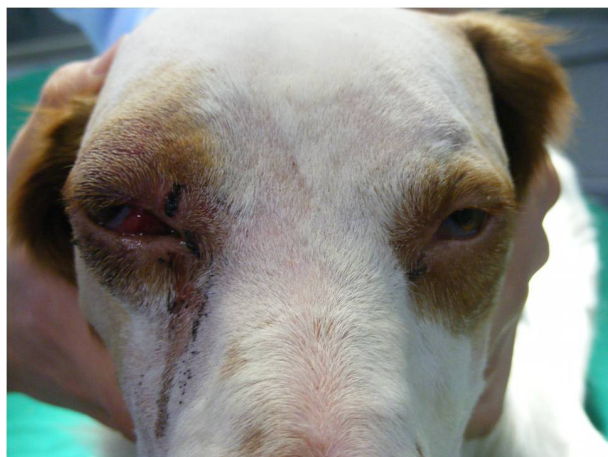


Figure 1. Ocular bleeding and swelling on the circumferential area of the right eye are observed

In some human cases, the patients have undergone surgery to remove residual fragments of the bullet and/or treatment with chelation therapy.

The objective of our treatment was to prevent further damage to brain tissue from developing due to the bullet implanted in the head. This study proposed to diagnose the gunshot-induced TBI and treat it successfully by craniectomy through removal of the bullet from the cranium.

Case description

A ten-month old, male Black and Tan Coonhound dog with ocular bleeding from a gunshot was referred to our veterinary medical centre. At that time, his mental state was normal, but he was bleeding with sharp pains in the right eye (Figure 1). He

was reported to have fallen down on the ground while hunting supposedly due to a gunshot injury. Several tests were conducted that included physical, neurological, laboratory examinations and radiography. A physical examination indicated that he had another wound on the back which was characteristic of a wound by a gunshot. While the menace reflex was absent and the pupillary reflex was extremely low in the right eye, the palpebral reflex remained normal with a modified Glasgow Coma Scale (GCS) standing at 16. Laboratory results showed that he had leukocytosis ($21\,100/\mu\text{l}$), mild anemia ($\text{PCV} = 30.9$), while the other results turned out normal. Radiographs found radiopaque materials in the head (Figure 2) and the back. A computed tomography was performed to identify the lesion and position of the material, measuring 5 mm in diameter and the radiopaque on radiographs was suspected to be a bullet (Figure 3). Computed tomographs revealed that the bullet was fragmented into two parts planted in the cranium. The bigger fragment was found in lateral parts of the frontal lobe of the left hemisphere, while the smaller fragment (diameter, 2 mm) in ventro-lateral parts of the frontal lobe of the right hemisphere. No cerebral edema and cerebrovascular hemorrhage was confirmed in cerebral parenchyma. It was presumed that the trajectory of the bullet took it from the right medial angle of the eye to the caudal part of orbit, and changed its track to caudo-dorsal by penetrating the cranium, ending up next to the left cranium. The bigger fragment was removed by lateral rostral craniectomy three days after the gunshot injury. However, the smaller fragment which was placed in the opposite

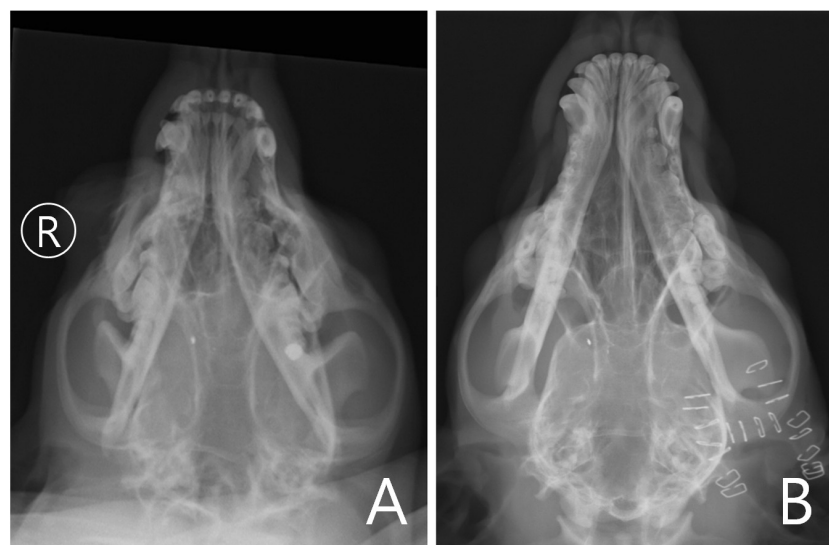


Figure 2. Preoperative (A) and post-operative (B) dorsoventral view of radiographs. Radiopaque material measuring 5 mm in diameter was removed during surgery

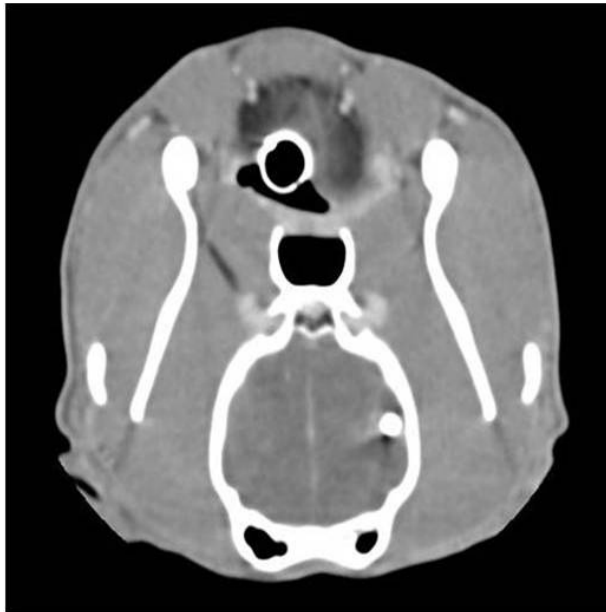


Figure 3. Postcontrast computed tomographs reveal radiopaque material measuring 5 mm in diameter in lateral parts of the frontal lobe of the left hemisphere. Cerebral oedema and cerebrovascular haemorrhage are not observed in the cerebral parenchyma

side could not be removed at that time (Pascual et al., 2009). As a premedication for surgery, atropine sulfate 0.02 mg/kg, *s.c.* (JE IL Atropine Sulfate®, JE IL Pharm., Korea), cefotaxime sodium 30 mg/kg, *i.v.* (Cefotaxime Sodium KUKJE®, KUKJE Pharm., Korea) and tramadol hydrochloride 4 mg/kg, *i.v.* (Tamadol®, Dongkwang Pharm., Korea) were ad-

ministered. Methylprednisolone sodium succinate 30 mg/kg, *i.v.* (SALON®, HANLIM Pharm., Korea) was administered to prevent complications from traumatic cerebral edema and surgical manipulation-induced cerebral edema, and to reduce nervous tissue deconstruction and ischemia before surgery. Anesthesia was induced with thiopental sodium 10 mg/kg, *i.v.* (THIOTAL®, CJ Pharm., Korea) and maintained with isoflurane 1~1.5% (Ifiran®, Hana Pharm., Korea). During anesthesia, hyperventilation (End tidal CO₂ 30~32 mmHg) was performed, and the head was kept slightly elevated to prevent intracranial pressure (ICP) from increasing (Zweckberger et al., 2008). The cranium was exposed by incising the skin and temporalis muscle 2 cm apart in the left from median line. Four holes were drilled after a rectangular fashion over the area concerned with a round burr. Then the four holes were connected with an oscillating saw. The bullet was located by means of fluoroscopy during surgery. The bullet was removed by a hemostatic forceps after durotomy. After an incision on dura mater, cerebral parenchyma mildly protruded from a dural incision. Instead of suturing, the dural incision was covered with autogenous subcutaneous adipose tissues (Figure 4) to prevent complications most likely accompanied by an increase in ICP (Bagley et al., 1996). The bone fragment was not reduced due to a potential decompression effect. The temporalis muscle and skin were sutured. After surgery, dexamethasone initial dose 0.3 mg/kg, *s.c.*,

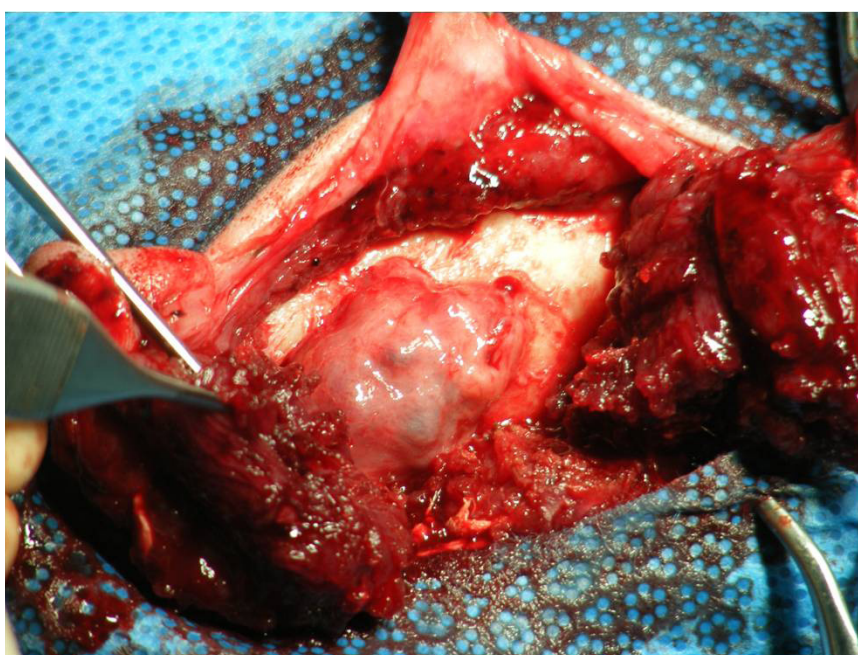


Figure 4. Incised dura mater was not sutured but covered with adipose tissues

bid (JE IL Dexamethasone[®], JE IL Pharm., Korea) was administered with the dose reduced by half each day for three days to prevent an increase in ICP caused by cerebral edema (Gocer et al., 1996). Cefotaxime sodium 30 mg/kg, *i.v.* tid (Cefotaxime Sodium KUKJE[®], KUKJE Pharm., Korea) was administered to prevent infection caused by the penetrated bullet and tramadol hydrochloride 4 mg/kg, *i.v.* tid (Tamadol[®], Dongkwang Pharm., Korea) to relieve postoperative pain for seven days. The dog remained stable after surgery and neurologic deficits were not observed except for a menace reflex in the right eye. Ocular ultrasonography was performed on the second day after surgery. Ocular ultrasonography identified a mixed echogenic material in the vitreal body of the right eye. On the third day after surgery, the appetite and vital force of the dog were improving with no sign of complications associated with craniectomy. The patient was discharged from the hospital with a prescription of antibiotics and analgesics for seven days after surgery. There were no complications during a one-year follow-up except for the blindness in the right eye.

DISCUSSION AND CONCLUSIONS

In humans, GCS is used to estimate the prognosis of a TBI patient (Gonul et al., 2005). Modified MGCS which is adapted from a human GCS is used to suggest prognosis of a canine TBI patient (Platt et al., 2001). A patient with an MGCS of 3 to 8 (score category I) indicates a grave prognosis, 9 to 14 (score category II) guarded prognosis, and 15 to 18 (score category III) a good prognosis. Patients with a MGCS of more than five need urgent surgery as soon as possible. When foreign bodies are accessible, removal of bullets or bone fragments are necessary and do not require an approach through uninjured cerebral tissues (Kim et al., 2007). Moreover, a patient who has a damaged frontal pole does not immediately manifest neurological signs, nor does he or she usually show any localizing signs (Agrawal et al., 2008). Surgical removal of bullets was decided on in this case, because the bullet was placed in an accessible position and the MGCS was high.

Craniectomy is generally applied to the ablation of intracranial neoplasia or cephalhematoma and to decompression of increased ICP. It is accompanied by durotomy if the lesion is located in the inside of the dura mater such as the cerebral parenchyma, subdural part, or subarachnoidal part.

The complications caused by craniectomy generally include uncontrolled cerebral swelling, deterioration of neurological signs, an increase in ICP, seizures, cerebral herniation, hemorrhage, infection, pneumocephalus, and pneumonia (Cavanaugh et al., 2008; Jadhav and Zhang, 2008).

The bigger fragment located in lateral parts of the frontal lobe of the left hemisphere was surgically removed. If the lead bullet had not been removed, it might have caused continuous irritations, persistent inflammatory responses, lead poisoning, neurological disorders and abscesses ultimately leading to death. However, the smaller fragment located in the ventro-lateral parts of the frontal lobe of the right hemisphere was still retained. A surgical procedure to remove the small fragment could cause an excessive surgical brain injury because of its extraordinarily complicated position and thus the difficulty in approaching it.

The affected frontal bone was fractured with an opening between the orbit and the brain. Mixed echogenic material, which was observed in the vitreal body of the right eye, was suspected to be vitreal hematoma or an abscess caused by the penetrated bullet. If it had been vitreal hematoma, it would have spontaneously been absorbed. However, if it had been an abscess, the dog would have suffered from continuous pain, and the circumference of the right eye would have swollen. And if the medical treatment including the prescription of antibiotics to prevent the abscess were not efficacious an additional surgical procedure or debridement may have been considered to remove the material, to debride necrotic tissues and to drain off any abscesses (Bhatoe, 2001).

After one year of surgery, no abnormality associated with lead poisoning and TBI due to a penetrated bullet or brain surgery was identified. In addition, no abnormalities while hunting had been observed, to the satisfaction of the owner.

In conclusion, in a case of gunshot-induced TBI containing a bullet that passed through the orbit into the cranium, the damaged frontal pole showed limited neurological signs. The removal of bullets or bone fragments in the cranium in cases with a high MGCS figure is recommended, provided they are accessible.

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