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Case from practice

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Penetrating diametrical wounds of the head by an arrow

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Penetrating crossbow head wounds are rare. However, such patients commonly belong to the most severe category of injured persons, with a high mortality rate among these ones. Such wounds are characterized by complex damage patterns with significant destruction of brain matter by an arrow as well as frequent damages of paranasal sinuses. Currently, there is no complete consensus about treatment of such patients. Two clinical cases of patients with head penetrating wounds because of an arrow are presented in this article.

Keywods: penetrating head wound, crossbow wound, sealing the skull base, endoscopic plastic surgery of skull base, rare clinical case

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BACKGROUND

The penetrating crossbow wounds of the head are rare, but patients suffered from such wound usually belong to the most severe category of injured persons with a high mortality rate among ones. The peculiarity of such wounds is the significant destruction of the brain tissue by the arrow as well as frequent damage of paranasal sinuses. It should be noted that at present there is no complete consensus about treatments strategy for such patients.

We present 2 clinical cases of patients suffered from penetrating arrow wound of the head.

CLINICAL CASE 1

Male patient N., *40 years old, was admitted to N.I. Pirogov City Hospital No. 1 (Sevastopol) 6 hours after being wounded. The circumstances of the injury are unknown.*

The patient's condition upon admission is moderate, hemodynamics is stable, breathing is independent. The assessment of neurological status is the following: fully conscious (15 scores according to Glasgow Coma Scale (GCS)), self-criticism is depressed, the patient hides the circumstances of the injury; cranial nerves functions are normal; tendon reflexes are increased without difference between sides; Kernig's sign is positive; finger-nose test – with intention on both sides.

The local status is the following: there is a foreign body (crossbow arrow) in the right temporal region, protruding from the head by 12 cm; there is no bleeding from the wound (Fig. 1). The wound is blind, the skin on the opposite side is not damaged.

According to computed tomography (CT) of the head (Fig. 2) the diametrical wound in the frontotemporal region by a foreign body with a metal tip (arrowhead with a diameter of 4.5 mm) is revealed; the entry wound is located in the right temporal region with the bone fragments and small areas of hemorrhage with air inclusions in the area of arrow entry; the arrowhead

Fig. 1. *Patient N. at admission. Crossbow arrow in the right temporal region*

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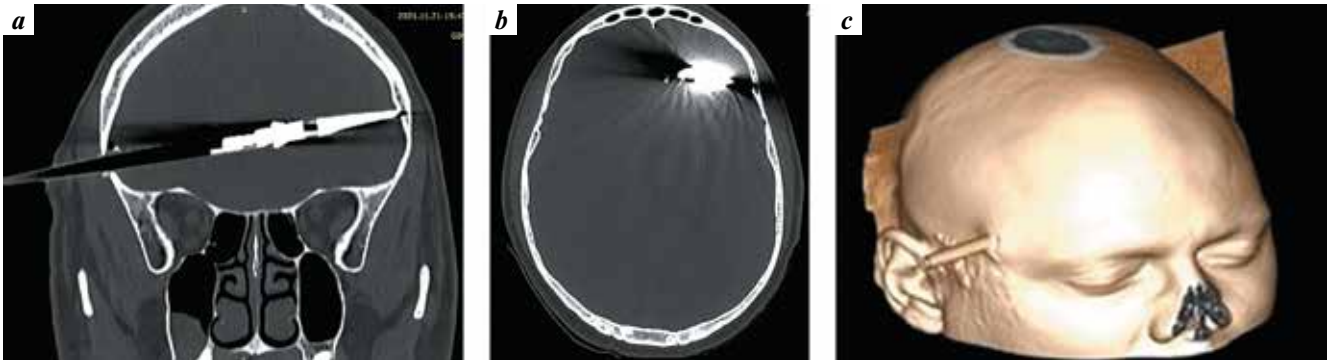

Fig. 2. *Computed tomography of patient N. at admission: a – frontal projection: arrowhead at the inner plate of the frontal bone; b – axial projection; c – 3D reconstruction*

is located in the area of the inner plate of the left temporal bone (length of the metal tip is 8 cm, diameter is up to 8.5 mm); there are also artifacts from the metal foreign body and no midline brain shift.

The patient underwent surgical removal of the foreign body (arrow). The arrow was cut off at the entry hole. During the first stage, the resection of the right temporal bone was performed in the area of the arrow entry with the following bone resection in the left temporal region. It was found that the arrowhead damaged the dura mater (DM) and the internal plate of the temporal bone.

The arrow was removed along the trajectory of its flight. The primary surgical debridement of the inlet and outlet holes was performed with bone fragments and fragments of damaged brain removal; the wound canal was flushed with saline. The watertight dural closure was performed using in with periosteal flap. The inflow and outflow lavage systems were placed epidurally on both sides.

The patient was fully conscious in the postoperative period. The minor hemorrhages along the wound canal with no midline brain shift and without brain edema (Fig. 3) were revealed according to the control CT scan performed on the first postoperative day.

The patient was given antibiotic therapy with the 3rd generation cephalosporins for 10 days. The drainages were removed on the 2nd postoperative day. The results of the cerebrospinal fluid analysis were the following: red blood cells were detected, cytosis 200 cells/μl, protein level is not increased.

The patient was discharged on the 11th day in a satisfactory condition. The assessment of the neurological status during discharge is the following: cranial nerves functions are normal, no limbs paresis; self-criticism is still depressed.

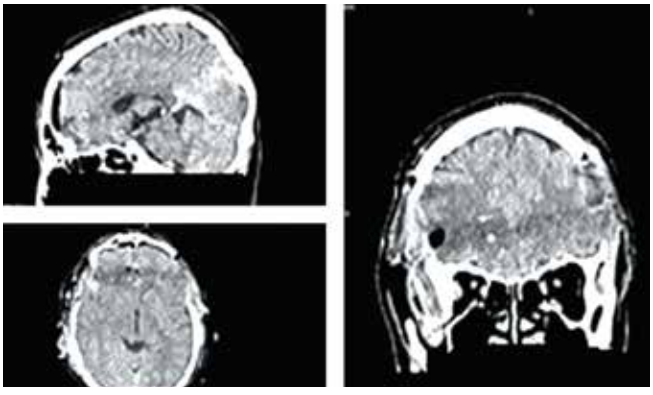

Fig. 3. *Computed tomography of patient N. after surgery: hemorrhages along the wound canal; no midline brain shift; no brain edema*

CLINICAL CASE 2

Male patient G., *36 years old, was moved N.V. Sklifosovsky Research Institute for Emergency Medicine from another hospital in 12 hours after accidentally injuring himself with an arrow from a harpoon gun.*

The patient's condition upon admission was severe, with depression of consciousness to moderate stupor as well as photophobia and moderate Kernig's symptom in his neurological status.

The local status was the following: a metal arrow (harpoon) protrudes 15 cm from the entrance hole in the mandible area; the arrowhead is palpated under the skin in the frontal parasagittal area with no signs of cerebrospinal fluid leakage.

According to head CT there was the diametrical arrow wound with the arrow entering between the branches of the mandible and passing through the oral cavity, ethmoid sinus as well as skull base and frontal lobe with the perforation of the frontal bone; there was also an intracerebral hematoma with a volume of 50 cm^3 in the left frontal lobe (Fig. 4).

The patient underwent the following surgical treatment: bifrontal trepanation was performed, the tip of the harpoon penetrated the dura mater 1 cm to the left of the superior sagittal sinus was revealed. After opening the dura mater, an intracerebral hematoma of the left frontal lobe with a volume of 25 cm^3 was revealed (the source of the hematoma was a vein damaged by the arrow).

Under visual control and control of the localization in the oral cavity, the arrow was removed retrogradely. There was dura mater defect sized 1.5 × 1.5 cm at the skull base. The step-by-step closure of the base of the anterior cranial fossa was performed with a free autograft from the fascia lata, which was fixed with Durasil biological glue and a periosteal

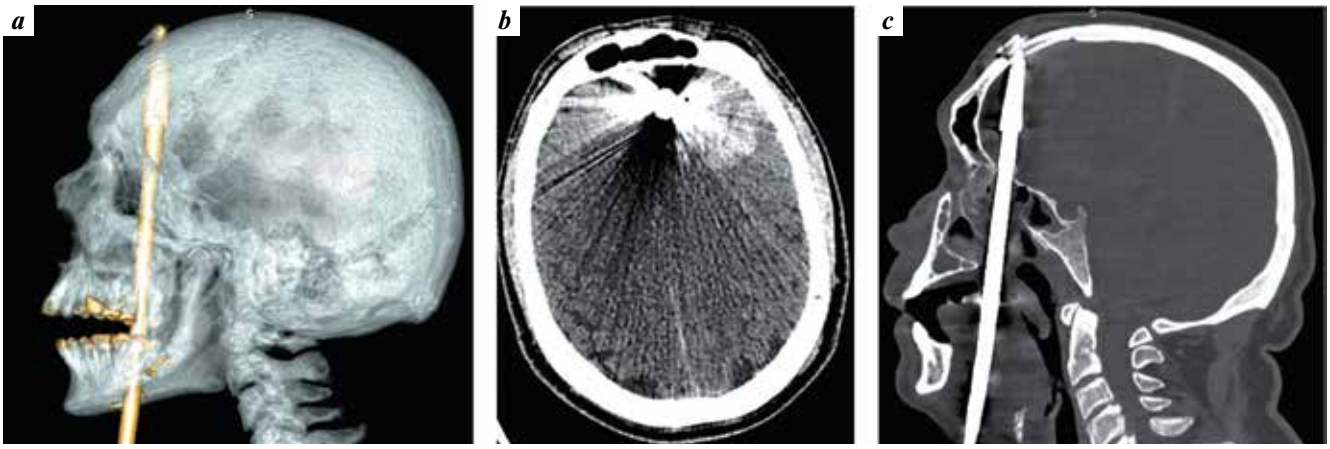

Fig. 4. *Computed tomography of patient G. at admission: a – 3D reconstruction: the massive harpoon tip with anti-passage "flags" is noteworthy; b – axial projection: intracerebral hematoma in the left frontal lobe; c – sagittal projection*

flap. Then the transnasal endoscopic revision of the nasal cavity with water-tight closure of the ethmoid cells defect were performed. The primary surgical debridement of the tongue wound was performed. Lumbar drainage was placed in the operating room.

The patient was fully conscious in postoperative period, there was a mild meningeal syndrome with no signs of liquorrhea. According to the control head CT there was hemorrhagic infiltration with perifocal edema with total volume 52 cm^3 in the left frontal lobe as well as brain and midline brain shift up to 4 mm.

The patient underwent antibacterial therapy with meronem – 3 g/day, vancomycin – 1.5 g/day. In 3 days after operation, an increase of neutrophilic cytosis in the cerebrospinal fluid was noted, that is why the intrathecal administration of antibiotics was started. The depression of consciousness level to sopor was observed in 12 days after operation, the head CT revealed an increase of the ischemic area in the left frontal lobe as well as the increase in midline and craniocaudal brain shift (Fig. 5).

The patient underwent the repeated surgery consisted of bifrontal decompressive craniotomy. The patient died 1 month after the surgery. The cause of death was purulent meningitis and ventriculitis.

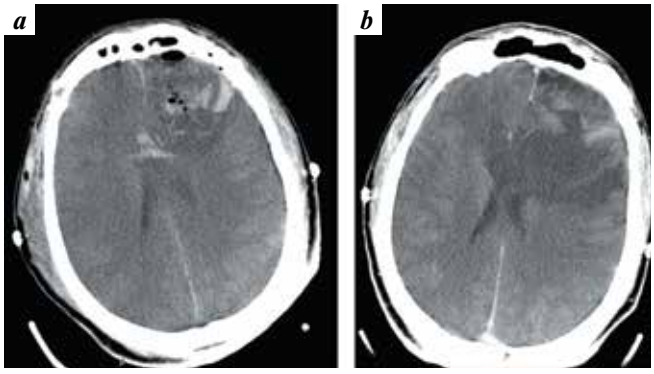

Fig. 5. *Computed tomography of patient G. (axial projection): a – 12 hours after the surgery; b – 12 days after the surgery: increased area of edema and ischemia in the left frontal lobe*

DISCUSSION

The head penetrating gunshot wounds have been studied and described quite well in the medical literature. The penetrating crossbow wounds of the head are rare and pose a problem due to the complexity of its nature. A feature of crossbow wounds is causing injury with a large wounding object moving at low speed [1–3].

Opposite to gunshot wounds, when the foreign body is either absent in the cranial cavity (in case of perforating head wound) or the small size of the wounding objects does not require surgical removal, the crossbow wounds are characterized with the large wounding object (arrow) remaining in the cranial cavity. An arrow of about 25 g released from a modern crossbow has a speed from 50 to 120 m/s and an energy of up to 190 J.

The such crossbows are considered as a weapon and required registration. For example, bullet from a Makarov pistol weighing 5 g at a speed of 350 m/s has an energy of 180 J. However, even less powerful crossbows have a shot energy of up to 50 J, which is almost a third of the energy of a 9 mm bullet and is enough to cause severe damage of the skull and brain [4].

The energy of the arrow (harpoon) fired from a pneumatic underwater gun is also quite high. As a rule, injuries from crossbows or underwater guns are received at close range due to careless handling with the weapon or during suicidal attempts, and the arrow has maximum speed and energy.

The severity of head injuries caused by a crossbow arrow depends on such factors such as the distance of the shot, the entry and exit points, the trajectory, the material and shape of the arrow and the arrowhead. In some patients, the arrow damages the paranasal sinuses or passes through the oral or nasal cavity. Therefore, it is extremely important to determine the sequence of diagnostic measures and surgical actions.

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The problem of crossbow wounds, given the large length of the wound canal and damage to several head areas, is interdisciplinary in most cases. The main treatment goals in such patients with penetrating crossbow wounds are stabilization of the patient's condition, safe removal of the foreign body (arrow), and prevention of potential complications [5, 6].

The experimental studies of the arrow wounds ballistics conducted by B. Karger et al. [7] showed that the mechanism of arrow penetration differs from a gunshot wound by the presence of a sharp cutting edge of the tip and the low speed of the arrow. In most cases, the area of damage is limited to tissues immediately adjacent to the ip. The arrow shaft performs a tamponade function, and bleeding from the wound, as a rule, does not occur.

Thus, it is necessary to prevent the possibility of arrow displacement and admit the patient to f specialized multidisciplinary hospital. In clinical case 1 the patient had the small head damage by arrow which did not lead to neurological disorders despite its diametrical nature. In clinical case 2 the harpoon damaged a cerebral vein, which led to the intracerebral hematoma formation with the following edema of the frontal lobe.

It is essential to assess and secure the airway, especially in penetrating wounds that pass through the oral cavity. Some authors recommend to trim the arrow in the oral cavity to avoid difficulties with intubation and to decrease the arrow length during anterograde removal to reduce the infection risk.

There are certain differences in the surgical technique. In case of gunshot wounds, as a rule, it is necessary to perform thorough surgical debridement of the entry and exit holes, where there is damaged brain tissue and bone fragments. During surgery of gunshot wounds the removal of foreign bodies is not the main goal of the operation. In case of crossbow wounds, it is necessary to remove a large-sized wounding objects from the cranial cavity.

The crossbow arrows or underwater harpoons often have a tip equipped with devices (anti-passage "flags" that prevent retrograde extraction of the arrow. The safe removal of a foreign body requires consideration of the movement trajectory and localization of the anatomical structures at risk. Many authors point to the possibility of damage of large intracerebral vessels and venous sinuses by the arrow – primarily (as in the clinical case 2) or during arrow extraction.

The frequency of vascular complications after penetrating head trauma varies from 5 to 40 %. Most often, they are manifested by the development of pseudoaneurysms, which usually occur in delayed period (within 2–3 weeks after injury, in some cases – after several months), therefore it is recommended to perform the digital subtraction angiography when the arrow is localized in the projection of the vessels.

CT angiography is not advisable due to its low sensitivity because of artifacts due to the massive metal tip. The risk of intracerebral hemorrhage increases with the removal of the arrow, and intraoperative ultrasound is recommended in the case of close contact of the foreign body with the vessel [8–12].

In case of a diametrical wound, if the arrowhead does not damage the skin, retrograde extraction of the arrow is possible in the absence of a large tip and anti-passage "flags" or with visual control, as in clinical case 2. If retrograde extraction is impossible, the arrow should be cut as close as possible to the entrance hole.

When an arrow passes through the paranasal sinuses, it is necessary to consider the risk of liquorrhea. The open water-tight closure of the skull base using biological glue and autotransplant is more reliable. If it is impossible, many authors recommend endoscopic closure in the area of the wound canal in all patient. The open and endoscopic methods can be combined as in the clinical case.

CONCLUSION

The penetrating crossbow wounds are complex pathology requiring multidisciplinary approach in the treatment of these patients. Our clinical cases demonstrate that, despite the severity of the injuries, these patients may have a good treatment outcome.

References

1. Non-lethal kinetic weapon injuries: a guide for physicians. Ed. by V.E. Parfenov, I.M. Samokhvalov. Saint Petersburg: ELBI-SPb, 2013. 224 p. (In Russ.).
2. Lebedev V.V., Krylov V.V., Shchegolev Yu.S. et al. Gun-related traumatic brain injuries. Moscow: RIPOL, 1997. 128 p. (In Russ.).
3. Aljuboori Z., McGrath M., Levitt M. et al. A case series of crossbow injury to the head highlighting the importance of an interdisciplinary management approach. Surg Neurol Int 2022;13:60. DOI: 10.25259/SNI_1166_2021
4. Frank M., Schikorr W., Tesch R. et al. Ballistic parameters and trauma potential of pistol crossbows. Int J Legal Med 2013;127(4):777–82. DOI: 10.1007/s00414-012-0801-8
5. Franklin G.A., Lukan J.K. Self-inflicted crossbow injury to the head. J Trauma 2002;52(5):1009. DOI: 10.1097/00005373-200205000-00034
6. Řehulka H., Čechová E., Mottlová J. et al. [Fatal head injury caused by a crossbow arrow with unusually preserved posttraumatic volitional activity – case report (In Czech)]. Soud Lek 2016;61(1):2–4.
7. Karger B., Sudhues H., Kneubuehl B.P., Brinkmann B. Experimental arrow wounds; ballistics and traumatology. J Trauma 1998;45(3):495–501. DOI: 10.1097/00005373-199809000-00011
8. Ishigami D., Ota T. Traumatic pseudoaneurysm of the distal anterior cerebral artery following penetrating brain injury caused by a crossbow bolt: a case report. NMC Case Rep J 2017;5(1):21–6. DOI: 10.2176/nmccrj.cr.2017-0083
9. Gutiérrez-González R., Boto G.R., Rivero-Garvía M. et al. Penetrating brain injury by drill bit. Clin Neurol Neurosurg 2008;110(2):207–10. DOI: 10.1016/j.clineuro.2007.09.014
10. Kazim S.F., Shamim M.S., Tahir M.Z. et al. Management of penetrating brain injury. J Emerg Trauma Shock 2011;4(3): 395–402. DOI: 10.4103/0974-2700.83871
11. Williams J.R., Aghion D.M., Doberstein C.E. et al. Penetrating brain injury after suicide attempt with speargun: case study and review of literature. Front Neurol 2014;5:113. DOI: 10.3389/fneur.2014.00113
12. Luo W., Liu H., Hao S. et al. Penetrating brain injury caused by nail guns: two case reports and a review of the literature. Brain Inj 2012;26(13–14):1756–62. DOI: 10.3109/02699052.2012.700085

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