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TRAUMATIC INJURY OF VERTEBRAL ARTERY COMPLICATED BY FORMATION OF A GIANT PSEUDOANEURYSM OF THE V3 SEGMENT (CLINICAL OBSERVATION AND LITERATURE REVIEW)

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Traumatic vertebral artery injury (TVAI) is a rare but severe pathology which can be associated both with penetrating injury of the neck and blunt or unclassified injury. Injury of the vertebral artery, especially due to gunshot or knife wounds, causes severe condition of the patients, development of a wide spectrum of complications including life-threatening, high rates of disabilities and mortality.

There is no consensus on the treatment tactics for this pathology. Open surgery as the first stage of surgical intervention can be used in a limited number of cases. X-ray endovascular techniques of TVAI treatment are considered to be preferable.

We present a clinical case of a 27-year-old patient with TVAI caused by a penetrating gunshot wound of the neck and complicated by formation of a giant pseudoaneurysm of the V3 segment of the vertebral artery. Two-stage combination treatment of TVAI was performed using endovascular and open surgical techniques.

Descriptions of TVAI cases are rare, and further accumulation and analysis of corresponding data and proposals on treatment of the patients with TVAI will help to formulate precise algorithms of doctors' actions and optimize treatment tactics.

Keywords: traumatic vertebral artery injury, giant pseudoaneurysm, penetrating wound of the neck, vertebral artery, X-ray endovascular treatment, combined treatment, clinical case

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INTRODUCTION

Traumatic vertebral artery injury (TVAI) is a rare but severe pathology requiring close attention and study. According to the U.S. National Trauma Data Bank (NTDB), between 2016 and 2017 6865 cases of vertebral artery (VA) damage were registered which is less than 1 % of all registered traumatic injuries. Only 9 % of them were associated with penetrating neck injury, and 91 % were associated with blunt or unclassified injury [1]. According to the Tennessee University Medical Center (Knoxville), between 2001 and 2011 TVAI comprised even less than 1 % of all registered injuries [2]. Other authors show that the frequencies of TVAI are between 0.24 and 2 % in patients with blunt trauma of various locations [3–6] and 15–46 % in more specific population groups (in patients with head injuries and blunt injuries of the cervical spine) [4, 5].

Despite low incidence, TVAI is an important medical and social problem. Injuries of the VA, especially obtained as a result of penetrating gunshot or knife wounds, cause severe condition of the patients, development of gross neurological complications, high levels of disabilities and mortality. Mortality, according to different sources, varies

between 3 and 19 %, but can be underestimated taking into account high frequency of prehospital deaths due to strokes in the vertebrobasilar system (VBS), profuse arterial hemorrhages, and other fatal complications [1, 2, 7–9].

Currently, there is no consensus on the treatment tactics for this pathology. Selection of the most appropriate method including conservative therapy, endovascular techniques, open surgery depend on a large number of factors, such as severity of the patient's condition at hospitalization; location of VA injury; condition of the contralateral VA; anatomical characteristics preventing stent installation during endovascular intervention, VA visualization and ligation in open surgery; presence of contraindications for antithrombotic therapy [10–14].

We present a case of combination treatment of a 27-year-old patient with TVAI caused by penetrating gunshot wound of the neck.

CLINICAL OBSERVATION

Patient S., *27 years, 17.06.2022 was admitted to the F.I. Inozemtsev City Clinical Hospital of the Moscow Department of Healthcare through emergency health services with a diagnosis of tense hematoma of the soft tissues of the neck on the left.*

Patient's history showed that on 04.03.2022 during a battle he received a mine-blast trauma, shrapnel wound of the external auditory canal and zygomatic area on the left with a presence of a foreign object in the projection of the spinous process of the C_2 vertebra. On 14.03.2022, the foreign body was removed from the soft tissues of the neck, the patient was discharged in satisfactory condition. Ultrasound examination of the neck on 04.04.2022 showed a posttraumatic tense hematoma, size 9 × 5 × 4.5 cm. The patient was hospitalized again. On 05.04.2022, surgical revision of the wound area was performed. Attempt of hematoma evacuation led to intense bleeding. After thorough hemostasis, a decision to stop the surgery was made. The wound was sutured, the patient was transported into the intensive care unit. On 06.04.2022, cerebral digital subtraction angiography (DSA) was performed showing formation of a giant pseudoaneurysm in the projection of the V3 segment of the left VA. On 12.04.2022, flow-diverting stents were placed into the left VA. Control cerebral DSA on 13.04.2022 did not show aneurysm filling. Approximately a month prior to the current hospitalization, the patient noted gradual growth of the swelling on the neck, decreased neck mobility, marked pain in this area, which were the reasons for him seeking repeat medical help.

Visual examination showed significant change of neck configuration due to marked swelling of the posterior and left lateral surfaces (Fig. 1). The skin color above this area was normal, palpation was accompanied by acute pain, fluctuation was not determined. In the left postauricular area, a linear normotrophic scar, 10 × 0.5 cm, without signs of inflammation was observed.

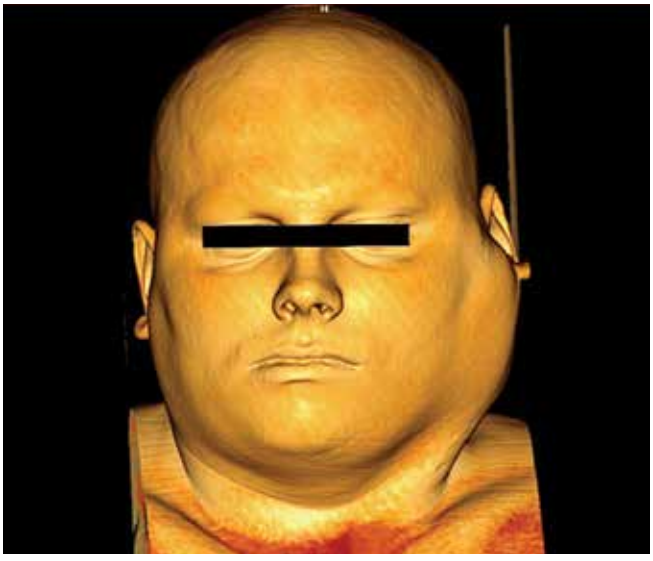

Fig. 1. *Computed tomography. 3D reconstruction of the appearance of patient S., 27 years. Marked swelling on the left lateral surface of the neck*

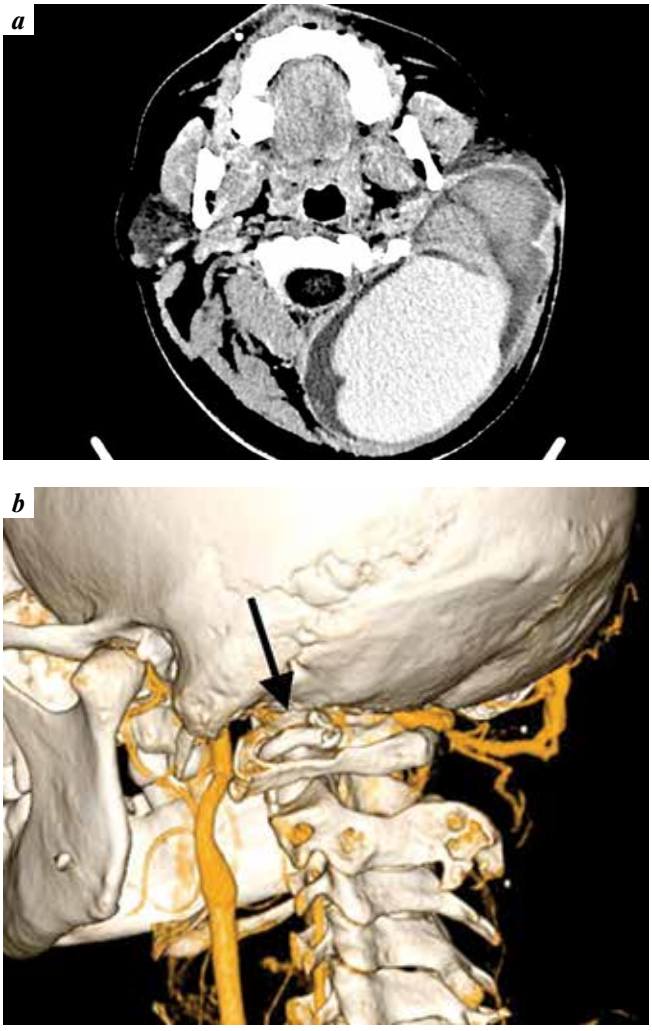

Fig. 2. *Computed angiography of patient S., 27 years: a – giant pseudoaneurysm of the V3 segment of the left vertebral artery with signs of extravasation of the contrast agent and surrounded by partially lysed hematoma; b – near the V3 segment a stent with signs of deformation is visualized (arrow)*

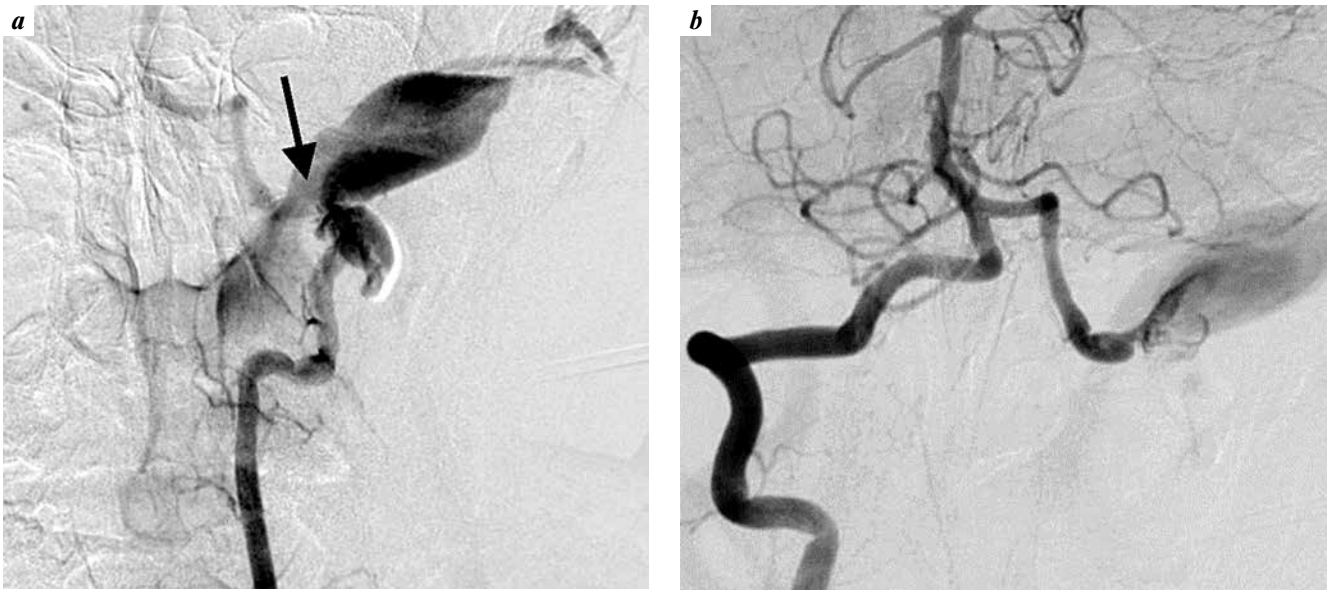

Fig. 3. *Cerebral DSA of patient S., 27 years: a – anterograde contrast of the giant pseudoaneurysm of the left vertebral artery; in the projection of the V3 segment, previously implanted flow-diverging stents are visible (arrow); b – retrograde contrast of the pseudoaneurysm from the system of the right vertebral artery*

Computed tomography-angiography (CTA) of the brachycephalic arteries performed on 17.06.2022 showed: giant pseudoaneurysm of the V3 segment of the left VA with signs of extravasation of the contrast agent into the lumen of the previously installed stents and surrounded by partially lysed hematoma; intramuscular hematomas of the parotid area on the left (Fig. 2).

Due to high risk of intraoperative bleeding, it was decided to abstain from emergency evacuation of hematoma of the soft tissues of the neck. At stage 1 (on the same day), to detail the anatomy of the injury and determine possibility of reconstructive endovascular intervention, selective cerebral DSA was performed. Under local anesthesia, the right common femoral artery was punctured. Introducer 6F was installed. Using a diagnostic catheter, the left and right VAs, left common carotid artery, left external carotid artery were sequentially catheterized. Multi-projection angiography of the corresponding vascular systems showed a giant pseudoaneurysm with wide neck of the V3 segment of the left VA and 2 previously implanted flow-diverting stents with signs of deformation and dislocation of one of them into the lumen of the pseudoaneurysm (Fig. 3, a); the lumen of the latter was intensely contrasted anterogradely and retrogradely (from the system of the right VA) (Fig. 3, b).

The medical team made a decision to endovascularly close the defect of the left VA through implantation of a stent graft. A guiding catheter Fubuki was inserted into the left VA. Guidewire Avigo with significant technical difficulties was inserted into the left posterior cerebral artery through the previously implanted stents. At the position of previously installed stents, a series of balloon predilations was performed with subsequent implantation of a stent graft Papyrus 4.0 × 20 mm. Control angiographs showed that aneurysm lumen was not excluded from the blood flow: its intense anterograde contrast had remained (Fig. 4).

Fig. 4. *Control anterograde DSA of the left vertebral artery after balloon angioplasty and implantation of a stent graft: intense contrast of the pseudoaneurysm remains*

Due to the absence of the effect of stenting and satisfactory retrograde blood flow, a decision to perform total embolization of the left VA distally and proximally relative to the defect was made. to evaluate the adequacy of collateral blood flow, preliminary balloon occlusion test of the left VA for 30 minutes was performed. As a result, no new signs of neurological deficit appeared, collateral blood flow was considered satisfactory.

Fig. 5. *Control DSA: a – in antegrade contrast, the left vertebral artery (VA) is occluded at the V3 segment level, implanted microcoils are also visible here (arrow), pseudoaneurysm is totally excluded from the blood flow; b – in contralateral contrast, retrograde filling of the pseudoaneurysm of the left VA is absent; в – cerebral DSA after embolization of the left VA: intracranial blood flow in the vertebrobasilar system at the preoperative level*

For control contralateral contrast of the cerebral arteries, the left common femoral artery was punctured, introducer 6F was installed, diagnostic catheter was inserted into the right VA. Using the previously left in the left anterior cerebral artery Avigo guidewire, microcatheter Echelon 14 was inserted distally from the defect area, after which the guidewire was removed, and 6 microcoils Axium were sequentially implanted into the target areas through the microcatheter lumen. Anterograde control contrast showed total occlusion of the V3 segment of the left VA, pseudoaneurysm lumen fully excluded from the blood flow (Fig. 5, a). Control contralateral DSA (from the right VA) showed retrograde contrast of the aneurysm lumen, distal intracranial blood flow at the preoperative level (Fig. 5, b, c).

At the end of the endovascular stage: neurological status without negative dynamics. Instruments were removed, at the puncture points of the common femoral arteries hemostasis using the Angio-Seal device was performed.

Considering compensated condition of the patient, after short-term postoperative observation the 2nd stage of surgical treatment in the form of open revision of the wound area was performed. The access was performed through the old postoperative scar in the parotid area on the left. After dissection of the subcutaneous muscle, a large number of thrombotic masses was evacuated, the pseudoaneurysm lumen was dissected, aneurysm walls were resected. At the floor of the pseudoaneurysm, one of the previously installed flow-diverting stents was visualized. After hemostasis, the wound was sequentially sutured leaving a silicone drain (Fig. 6).

After the surgical intervention, the patient was transferred into the intensive care unit for patients with acute cerebrovascular disorders where intensive therapy, dynamic observation for somatic and neurological condition were performed. Extubation was performed 3 hours after the surgery.

Control computed tomography of the brain from 17.06.2022 did not show signs of ischemic changes in the vertebrobasilar system (VBS). On 18.06.2022, the patient was transferred to the ward for further treatment. The postoperative period did not have complications, the volume of hematomas of the soft tissues of the neck significantly regressed (Fig. 7), neurological deficit during observation did not progress. On 24.06.2022, day 7 after surgical intervention, the patient was discharged in satisfactory condition with recommendations for rehabilitation treatment at the place of residence.

DISCUSSION

Traumatic injuries of the VA can manifest differently. For example, according to some authors, formation of stenoses, occlusions, pseudoaneurysms, arteriovenous fistulas (AVF), VA dissections can occur. Incidence of the listed forms per K. Piper et al. is presented in the Table [11]. The risk of ischemic stroke in the VBS due to TVAI is, according to various authors, between 6 and 37 % [1, 3, 15, 16].

Arteriovenous fistulas in TVAI in 30 % of cases develop asymptomatically, but almost always are diagnosed during auscultation of neck hematoma [17]. This points to the importance of physical diagnostic methods even if instrumental methods are available. Among the latter, currently the most common method of TVAI verification is CTA. Studies show that invisible during CTA types of VA pathology, such as AVF and pseudoaneurysms, can be detected by

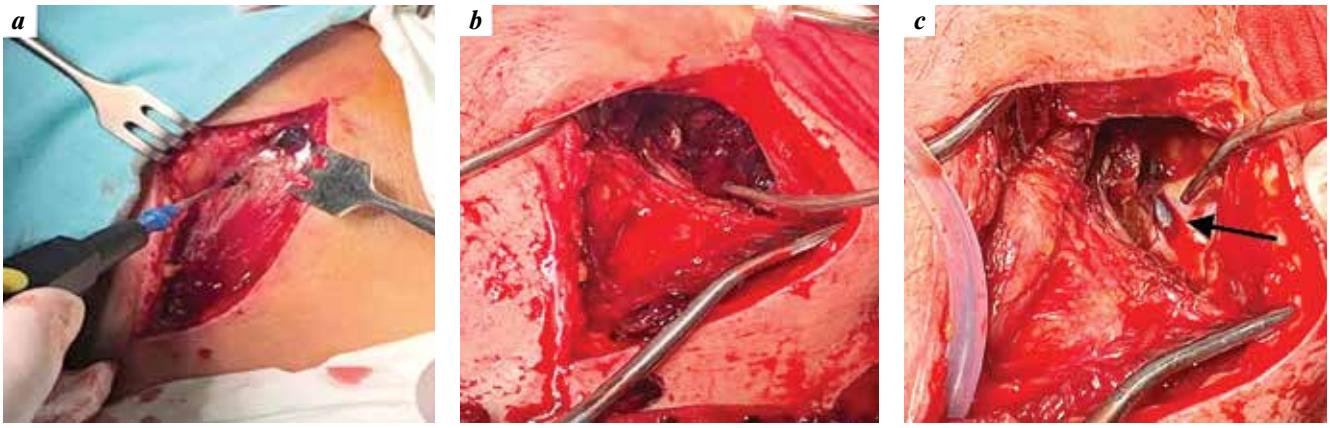

Fig. 6. *Stages of surgical intervention: a – skin dissection following the old postoperative scar, dissection of the subcutaneous neck muscle; b – removal of thrombotic masses from the pseudoaneurysm cavity; c – previously implanted stent is visible near the floor of the pseudoaneurysm (arrow)*

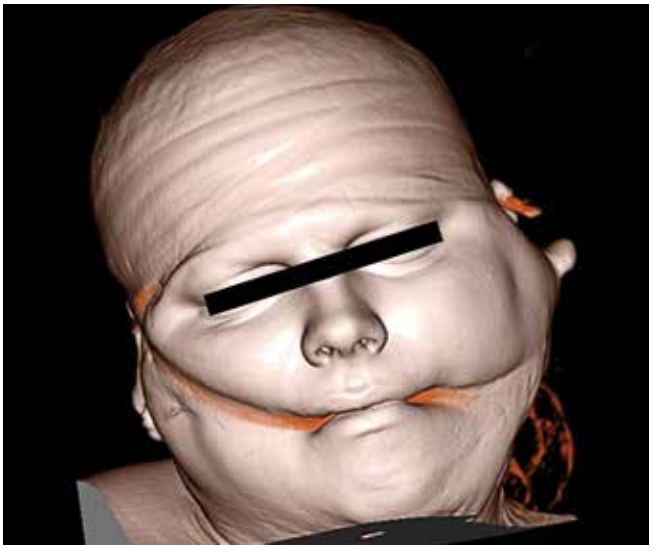

Fig. 7. *Computed tomography. 3D reconstruction of the patient's appearance after open surgical intervention. The volume of soft tissue hematomas on the neck decreased significantly*

Frequency of clinical forms of traumatic vertebral artery injury (TVAI) per K. Piper et al. [11]

Clinical form	Number of cases, *n*	Percentage of all TVAI, %
Occlusion	61	37.6
Pseudoaneurysm	37	22.8
Arteriovenous fistulas	32	19.8
Dissection	14	8.6
Other	18	11.1
Total	*162*	*100*

DSA [11, 18, 19]. Therefore, DSA should be considered as an additional diagnostic method when CTA results are dubious or uninformative, for example in the presence of artefacts or metallic foreign bodies, large hematomas, or in other contentious situations.

Due to low injury rate, minimal invasiveness and possibility of using local anesthesia, X-ray endovascular methods are considered preferable in treatment of TVAI. Open surgery as the first intervention stage can be used in a limited number of cases when quick revision of the neck wound is necessary to stop profuse bleeding, eliminate organ compression by tense hematoma, in cases of traumatic/hemorrhagic shock, marked arterial hypotension, iatrogenic injury during open surgical intervention [11, 14]. Additionally, endovascular interventions can be forgone (in favor of surgical operation) due to some anatomical features of VA defect. For example, if it is close to the posterior inferior cerebellar artery (PICA) or to the VA entrance, endovascular intervention can be technically difficult or associated with the risk of severe ischemic complications. As a rule, in these patients open surgical interventions are performed such as VA prosthesis, VA entrance transposition into the common carotid artery, side-to-side anastomosis PICA-PICA [20, 21].

Contemporary endovascular surgery has a wide spectrum of techniques for TVAI treatment such as installation of flow-diverting stents or stent grafts, balloon angioplasty, microcoil embolization. In this respect, stenting of the injured VA is the most physiological, organ-saving and sometimes even fully reconstructing method of vascular lumen treatment. It allows to minimize the risk of cerebral hypoperfusion and VBS stroke. However, reports on successful performance of this procedure are rare which in case of TVAI is also associated with the rareness of this pathology [11, 22, 23]. The general limitation for VA stenting is a patient having any contraindications for administration of antithrombotic drugs, long-term course of which is required after installation of most stents.

The most radical endovascular technique for treatment of posttraumatic pseudoaneurysms or VA AVF embolization of the damaged vessel using microcoils. However, this approach has a significant disadvantage in the form of possible decreased blood flow in the VBS which can lead to

ischemic stroke of the brainstem and/or occipital lobes. Currently, the safety of VA exclusion from the blood flow is discussed only in a small number of articles. In the review by K. Piper et al., 4 patients with stroke due to such interventions are mentioned, and clinically stroke manifested only in 1 of them. Notably, almost 50 % of patients included in this review did not undergo magnetic resonance imaging due to the presence of metallic foreign objects in the soft tissues of the neck which could decrease the number of verified asymptomatic cerebral strokes [11].

To decrease the risk of stroke, prior to embolization of the injured VA it is necessary to perform contralateral (from the healthy VA) angiography. In the presence of retrograde (collateral) blood flow, this procedure is relatively safe, and in some cases it can be performed through contralateral access [24]. For the same reason, prior to open VA ligation, evaluation of CTA data is necessary; during endovascular embolization, direct angiography of all 4 arterial systems of the brain to detect hypoplasia/anaplasia of the contralateral VA, posterior communicating artery mediating collateral blood flow in the VBS is necessary [25]. Additionally, to evaluate the adequacy of the collateral blood flow prior to occlusion interventions in the VA, balloon occlusion test or transient clamping of the injured vessel should be performed [26]. The literature mentions a large number of techniques for evaluation of collateral blood flow during transient VA exclusion: neurological examination, electroencephalography, transcranial Doppler ultrasound, single-photon emission computed tomography, xenon-enhanced dual-energy computed tomography, venous phase arrest during DSA. However, no significant differences in the sensitivity of the current techniques have been shown [27].

In case of selection of open surgical interventions, one or the other type of VA exclusion from the blood flow can be used. If VA is visualized well, it is ligated or clipped. If the above-mentioned manipulations are difficult and according to instrumental diagnostic data collateral blood flow is intact, V2 segment of the VA can be tamponaded in the vertebral foramens of the cervical transverse processes using bone wax [9]. In some cases, more complex revascularization surgical interventions described above are considered [24]. Sometimes open ligation/tamponade can be impossible due to multiple injuries or inaccessibility of the target VA segment. In these cases, the medical team should consider the possibility of using a combination of surgical and endovascular techniques.

CONCLUSION

Traumatic injury of the VA is a very rare but formidable complication of both perpetrating and blunt injuries of the neck. The danger of these injuries consists of possible development of a wide spectrum of complications including life-threatening: from tense hematomas of the soft tissues of the neck, VA AVF, pseudoaneurysms, stenoses and occlusions to VBS strokes, massive profuse hemorrhages.

Considering limited data in the current literature, there is no consensus on the treatment of patients with TVAI. It is not possible to formulate guidelines with a high level of evidential credibility and accuracy. However, some authors attempt to create promising but still unconfirmed proposals for management of patients with TVAI. Further accumulation and analysis of corresponding data will help to formulate strict algorithms of doctors» actions and optimize treatment tactics for this pathology.

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Authors' contribution
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