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## EXPERIENCE OF SURGICAL TREATMENT OF VERTEBRAL ARTERY INJURIES

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♦ **The aim** of the study was to analyze the results of spinal artery damage treatment of the injured.

**Materials and methods.** An 2-year analysis of treating 7 patients with vertebral artery injuries admitted to the City Hospital (GB) No. 26 of St. Petersburg was carried out. The problems of diagnosing and treating these injuries have been identified. The solutions to these problems have been suggested. Two clinical cases of successful treatment of injured patients with spinal artery damage have been presented.

**Results.** There's a possibility of damaging vertebral arteries in neck injuries thus defining the need for introducing high-informative methods of inspection (a spiral computer tomography contrast angiography, a Magnetic Resonance Imaging) and low-invasive (X-ray endovascular) interventions in urgent surgery. The implementation of complex instrumental examinations, their nature, the number of them and urgency should be determined by a surgeon individually considering the recommendations of related specialists.

**Conclusions.** Regardless of the wound size and the patient's condition, examination and treatment of patients with neck injuries should be carried out in large hospitals with angiosurgeon and other narrow specialists in the panel of doctors with the 24-hour surveillance, as well as access to full examination and high-tech urgent operational interventions.

♦ **Keywords:** spinal artery injuries; neck injuries; treatment experience.

## ОПЫТ ХИРУРГИЧЕСКОГО ЛЕЧЕНИЯ РАНЕНИЙ ПОЗВОНОЧНОЙ АРТЕРИИ

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♦ **Целью** исследования был анализ результатов лечения пострадавших с повреждением позвоночной артерии.

**Материалы и методы.** Проведен анализ лечения 7 пострадавших с повреждением позвоночной артерии, поступивших в Городскую больницу № 26 Санкт-Петербурга за два года. Определены проблемы диа-

гностики и лечения данных повреждений. Предложены пути их решения. Представлено два клинических случая успешного лечения пострадавших с повреждением позвоночной артерии.

**Результаты.** При ранениях шеи существует вероятность повреждения позвоночных артерий, в связи с этим необходимо использовать в неотложной хирургии высокоинформативные методы обследования (спиральную компьютерную томографию с ангиоконтрастированием, магнитно-резонансную томографию) и малоинвазивные (рентгенэндоваскулярные) процедуры. Решение о выполнении сложных инструментальных исследований должен принимать хирург, он также определяет их характер, объем и срочность с учетом рекомендаций смежных специалистов.

**Выводы.** Независимо от размеров раны и состояния пострадавших с ранениями шеи их обследование и лечение необходимо осуществлять в крупных стационарах, где в состав дежурной бригады входят ангиохирурги и другие специалисты узкого профиля и где есть возможность для круглосуточного полноценного обследования и выполнения высокотехнологичных оперативных вмешательств в экстренном порядке.

♦ **Ключевые слова:** повреждения позвоночной артерии; ранения шеи; опыт лечения.

## Introduction

The treatment of victims with neck wounds is one of the complex topical problems of modern emergency surgery. In wartime, the frequency of neck injuries reaches 1.5%–2% of the total injuries. Neck injuries are accompanied by damage to large blood vessels in 4.6%–9% of cases [1–4]. Approximately 95% of wounded patients with injuries of the major neck vessels die at the injury site or during transportation [3, 5, 6]. Most of such patients are transported by an ambulance to the nearest surgical hospital on duty, which in most cases does not have a vascular surgeon on duty in its team. In summary statistics, the frequency of diagnostic errors in the wounds of this area ranges from 7%–38% even in specialized surgical hospitals [7–9]. As a result, mortality after surgical treatment reaches 14%–40% [3, 10, 11]. Patients with spinal artery injuries constitute a separate group. Aspects of the arterial topography, which cause difficulties of surgical access, a low amount of external bleeding, and simultaneous damage to other structures of the neck, complicate the diagnosis and leads to unsatisfactory treatment results for these injuries.

**The study aimed** to analyze the treatment outcomes of patients with vertebral artery injuries.

## Materials and methods

We analyzed the treatment outcomes of seven patients with vertebral artery injury admitted to the City Hospital No. 26 of St. Petersburg within two years. The age of the patients ranged from 18–56 years, and five of them were men. Three patients were admitted in an extremely serious condition and had concomitant injuries, two

patients had a severe condition, and two patients had moderately severe injuries. Three patients had a closed injury of the vertebral artery, two patients had gunshot wounds to the neck, one patient had a stab wound, and one patient had an avulsive wound of the neck. The causes of the injuries were as follows: road traffic accidents in two cases, catatrauma in one case, gunshot wounds in two patients, occupational injury in one case, and a suicide attempt in one case. In five patients, the vertebral artery injury was accompanied by a cervical spine fracture, and in three of them, fatal injuries were recorded. The vertebral artery injury was more frequently localized at the level of segment II (four patients), while the injury was localized in segment I of the artery in two other cases, and at the level of segment III in one case.

The severity of the condition, critical time pressure, need for urgent hemostasis, and blood loss replacement are extremely difficult tasks facing the surgeon in case of neck wounds with injury to the vertebral artery.

Diagnostic procedures were performed in resuscitation conditions on the surgical table, where intensive preoperative preparation continued, consisting of bringing the patient out of a state of shock and blood loss replacement. In addition to the surgeon and anesthesiologist, the patients were examined by interdisciplinary specialists depending on the clinical manifestations. Consultation with a neurologist or neurosurgeon has always been an integral part of the examination of an unconscious patient. Chest X-ray and electrocardiography were mandatory. Based on hemograms, it was decided to perform an erythrocyte concentrate transfusion.

In case of non-critical parameters (hemoglobin 80–90 g/l, hematocrit approx. 30%), hypovolemia was corrected intraoperatively with crystalloids and colloids. In case of neck injuries, temporary hemostasis was implemented by applying manual pressure to the injured vessel, and with a narrow and long wound channel and balloon compression using a Fogarty probe or a Foley catheter was used.

In the second stage, a wound revision was performed to the patients with open neck wounds. A typical projection approach was used more often along the anterior edge of the *Musculus sternocleidomastoideus* (V.I. Razumovsky collotomy), which provides the best view of the operating field and the possibility of expanding it by transecting the clavicle or, if necessary, doing a partial sternotomy.

In cases of injury to the vertebral artery at the level of segments I and III, the vessel wall defect was sutured or ligated. In case of vertebral artery injury in segment II, the final hemostasis was performed in two stages. Due to the fact that this part of the artery is located in the bone canal, it was necessary to provide temporary hemostasis with subsequent opening of the canal wall and revision of the artery segment injured. The final stage of the final hemostasis is largely dependent on the experience of the operating surgeon, state of hemodynamics, and presence of progressive disorders of vital functions.

There are various options for the stage 1 of hemostasis. In one case, a balloon catheter is inserted through the segment 1 of the artery (Fig. 1). Temporary hemostasis is achieved, which enables to open the canal of the vertebral artery and, after the Lexer test, to restore the integrity of the artery or to ligate it. Ligation of the vertebral artery in segment I and filling of a bone defect in segment II with a composition of wax and a hemostatic sponge have become widespread. There is also a technique in which temporary hemostasis is achieved by introducing Fogarty probes No. 3 in the distal and proximal directions. However, we used a simpler, but no less effective, original method of temporary hemostasis. Compression of the intertransverse ligaments above and below the injury site was performed with coarse forceps, which enabled to reduce bleeding quickly and significantly in order to open the bone canal and achieve final hemostasis.

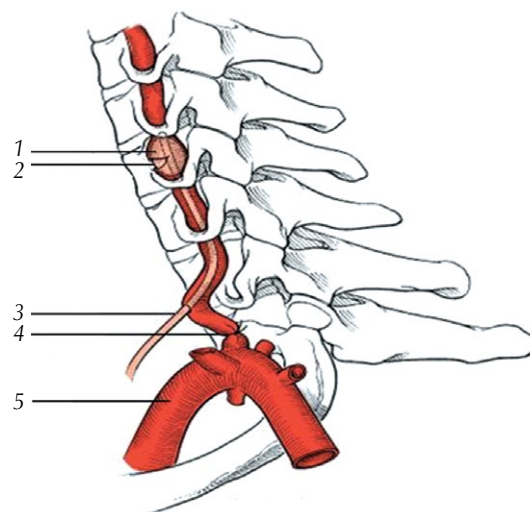


Fig. 1. Balloon obstruction of the vertebral artery II segment damage: 1 — balloon catheter; 2 — area of arterial damage; 3 — catheter; 4 — area of arterial ligation; 5 — subclavian artery [12]

Рис. 1. Баллонная обтурация повреждения II сегмента позвоночной артерии: 1 — баллон катетера; 2 — область повреждения артерии; 3 — катетер; 4 — область лигирования артерии; 5 — подключичная артерия [12]

In the presence of multisystem injury of major vessels and hollow or parenchymal organs, interventions were performed on them at the end of the surgery vascular stage. Anticoagulant therapy was prescribed to all patients without exception in the postoperative period. Heparin was injected for 6–8 days at the rate of 250–300 U/kg every 6 hours. All patients underwent transcranial Doppler sonography to assess the adequacy of the cerebral circulation after obtaining reliable hemostasis.

## Results

This section comprises two cases of neck injuries that clearly show the complexity of the diagnosis and options for hemostasis of vertebral artery injuries.

Female patient M., 34 years old, was admitted to the admission department of City Hospital No. 26 after a traffic accident with a diagnosis of closed craniocerebral injury, moderate cerebral contusion, avulsive neck wound, chest contusion, closed abdominal trauma, open fracture of the right lower leg bones, and shock of the degree III. The patient was transferred to the shock room in a critical condition. Examination revealed that consciousness was soporose, and



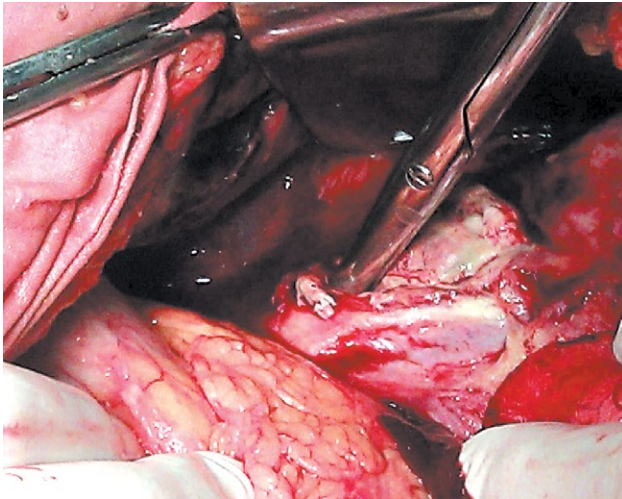


Fig. 2. Complete intersection of the left vertebral artery in segment I with 4.0 cm diastasis of the ends

Рис. 2. Полное пересечение левой позвоночной артерии в I сегменте с диастазом концов 4,0 см

the blood pressure was not determined. In the hematological analysis, leukocytes were  $12.5 \times 10^9/l$ , erythrocytes were  $2.01 \times 10^{12}/l$ , and hemoglobin was 68 g/l. The coagulogram revealed prothrombin of 74%, fibrinogen of 1890 mg/l, and international normalized ratio of 1.2. Biochemical blood test showed blood glucose of 15.2 ml/l, alanine aminotransferase of 235 U/l, amylase of 69.8, aspartate aminotransferase of 325.4 U/l, and creatinine of 82.6. On the electrocardiogram, sinus tachycardia of 120 beats/min with diffuse changes and impaired repolarization was present.



Fig. 3. Incised wound on the right side of the neck

Рис. 3. Резаная рана правой половины шеи

An open wound with intense bleeding was identified in the left half of the neck.

The patient was transferred to the emergency operating room where the neck wound was revised along with continuing anti-shock therapy. The wound was 9.0 cm long, triangular in shape, with an inwardly open angle. The complete intersection of the internal jugular vein and left vertebral artery was found in segment I (Fig. 2).

Diastasis between the distal and proximal segments of the artery was approximately 4 cm. A rupture of the inferior thyroid vein was detected, as well as a comminuted fracture of the transverse process of cervical vertebra VII with a displacement in the distal direction, fracture of ribs I–III on the left in the cervical region, crush injury of the *Musculus sternocleidomastoideus*, and complete injury to the roots of the brachial plexus. A foreign body (triangular glass with an area of approximately 1 cm<sup>2</sup>) was removed from the fragments of the transverse process of vertebra VII. Final hemostasis was performed by ligation of the injured arteries (positive Lexer test). The surgery was completed with the restoration of the *Musculus sternocleidomastoideus* and drainage of the wound. On day 19 of hospitalization, the patient was discharged for outpatient treatment with the recommendation of further hospitalization in the neurosurgical department.

The issues of hemostasis in the event of injury to the vertebral artery segment II protected by the bone canal are of particular interest. The implementation of hemostasis in this area is

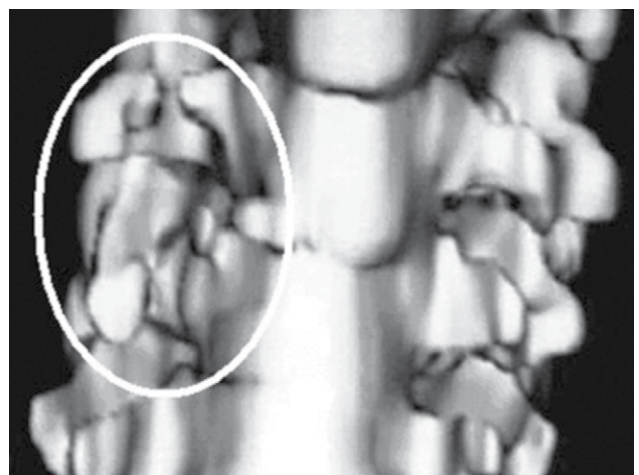


Fig. 4. Partly lacerated canal of the right vertebral artery

Рис. 4. Частично вскрытый канал правой позвоночной артерии

also impeded by the proximity of the nerve roots of the cervical plexus.

Male patient B., 48 years old, was admitted to City Hospital No. 26 with a diagnosis of incised wound on the right half of the face with a transition to the anterolateral surface of the neck. The wound was caused by the fragment of a cutter during plumbing work (Fig. 3).

In this case, hemostasis was caused by a foreign body, namely a fragment of an abrasive disc which, having pierced the structures between the transverse processes of vertebrae C<sub>5</sub>-C<sub>6</sub>, was stuck firmly in the body of vertebra C<sub>5</sub>. When the foreign body was removed, major bleeding from the wound channel occurred. Temporary hemostasis was achieved by an original method, namely compression of segment II of the right vertebral artery with rigid branches through the intertransverse ligaments. Revision revealed a complete traumatic transection of the right vertebral artery in segment II, injury to the oropharynx, upper third of the esophagus, vertebral body of C<sub>5</sub>, and nerve roots of C<sub>5</sub>-C<sub>6</sub>. After ligation of the vertebral artery in segment I, the canal of segment II of the artery was partially opened (Fig. 4) and the bone defect was filled with a composition of wax and a hemostatic sponge.

The postoperative period was uneventful. The patient was discharged for outpatient treatment with a minor neurological impairment of the cervical plexus on the right.

## Discussion

When major vessels of the neck are injured, a large wound hiatus is almost never observed, but a narrow wound channel is more common; otherwise, such an injury is fatal due to blood loss. Under favorable conditions, even if major vessels such as the carotid artery or jugular vein are injured, bleeding can stop independently. This occurs when blood flows through the wound opening in the vessel wall into the vascular sheath, and a perivascular hematoma develops, which compresses the vessel, thereby helping to stop the bleeding. In such cases, even a computed tomography study does not always enable to rule out injury to the major vessels, which necessitates a surgical revision of the wound. In addition, the surgical access should be economical, with minimal injury to the neck structures, while on the other hand, it should be sufficient to perform

a full revision of the artery and, if necessary, to implement hemostasis under conditions of profuse bleeding.

The examples presented demonstrate once again the difficulties of the complete diagnosis and treatment of patients with neck wounds. However, only the possibility of round-the-clock use of contemporary research methods, such as spiral computed tomography, Doppler sonography, the availability of an angiosurgeon in the team, and active surgical approach, enabled to provide timely full-fledged qualified assistance to these patients.

## Conclusion

Due to the topographic and anatomical aspects, depth of location, profuse bleeding, and frequent injury to the surrounding internal structures of the neck, injuries of the vertebral arteries are characterized by increased difficulty for diagnosis and treatment. Since neck injuries can be accompanied by vertebral artery injuries, highly informative examination methods (spiral computed tomography with angio-contrast enhancement, magnetic resonance imaging) and minimally invasive (X-ray endovascular) procedures should be used in the emergency surgery. The decision to perform complex instrumental examinations must be made by the surgeon, and he also determines their nature, volume, and urgency, taking into account the recommendations of the interdisciplinary specialists.

## Insights

Regardless of the wound size and the condition of patients with neck wounds, their examination and treatment must be conducted in large hospitals, where the team on duty includes angiosurgeons and other highly specialized personnel, and with an opportunity for round-the-clock complete examination and performing of high-tech emergency surgical interventions. Injuries to the artery segment II covered by the bone sheath cause particular difficulties.

## References

1. Орлов В.П. Лечение огнестрельных ранений черепа и позвоночника в условиях локальных войн и военных конфликтов. – СПб.: ВМедА, 2003. – 35 с. [Orlov VP.

- Lechenie ognestrel'nykh raneniy cherepa i pozvonochnika v usloviyakh lokal'nykh voyn i voennykh konfliktov. Saint Petersburg: VMedA; 2003. 35 p. (In Russ.)]
2. Гофман В.П. Результаты лечения ранений ЛОР-органов // Военно-медицинский журнал. – 1992. – Т. 313. – № 6. – С. 21–24. [Gofman VR. Rezul'taty lecheniya raneniy LOR-organov. *Voen Med Zh.* 1992;313(6):21-24. (In Russ.)]
  3. Бисенков Л.Н., Ляшенко В.Г. Успешное лечение ранений общей сонной артерии // Вестник хирургии им. И.И. Грекова. – 1982. – Т. 129. – № 7. – С. 97–98. [Bisenkov LN, Lyashenko VG. Uspeshnoe lechenie raneniy obshchey sonnoy arterii. *Vestn Khir Im I I Grek.* 1982;129(7):97-98. (In Russ.)]
  4. Белевитин А.Б., Шелепов А.М., Ишутин О.С., Леоник С.И. Организация оказания медицинской помощи и лечения легкораненых и легкобольных в военном полевом эвакуационном госпитале // Вестник Российской военно-медицинской академии. – 2011. – № 1. – С. 232–240. [Belevitin AB, Shelepov AM, Ishutin OS, Leonik SI. Organisation of medical care and treatment of slightly wounded and slightly sick in a field evacuation military hospital. *Vestnik Rossiiskoi voenno-meditsinskoi akademii.* 2011;(1):232-240. (In Russ.)]
  5. Белевитин А.Б., Синопальников И.В. Организация розыска, сбора, выноса (вывоза) с поля боя и эвакуации раненых из районов боевых действий в вооруженных конфликтах // Вестник Российской военно-медицинской академии. – 2010. – № 4. – С. 177–179. [Belevitin AB, Sinopal'nikov IV. The organization search, gathering, and medical evacuations injured from battle-ground armed conflict. *Vestnik Rossiiskoi voenno-meditsinskoi akademii.* 2010;(4):177-179. (In Russ.)]
  6. Каншин, Н.Н., Воленко А.В., Николаев А.В. Аспирационные методы профилактики нагноения-послеоперационных ран: методические рекомендации. – М., 1985. – 14 с. [Kanshin NN, Volenko AV, Nikolaev AV. Aspiratsionnye metody profilaktiki nagnoeniya posleoperatsionnykh ran. Metodicheskie rekomendatsii. Moscow; 1985. P. 14. (In Russ.)]
  7. Дуданов, И.П., Ижиков Ю.А, Мячин Ю.А. Лечение ранений с повреждением сосудов шеи // Актуальные проблемы современной тяжелой травмы: материалы всероссийской научной конференции. – СПб., 2001. – С. 40–41. [Dudanov IP, Izhikov YA, Myachin YA. Lechenie raneniy s povrezhdeniem sududov shei. In: Aktual'nye problemy sovremennoy tyazhely travmy: Materialy vserossiyskoy nauchnoy konferentsii. Saint Petersburg; 2001. P. 40-41. (In Russ.)]
  8. Fogelman MJ, Stewart RD. Penetrating wounds of the neck. *Am J Surg.* 1956;91(4):581-593. [https://doi.org/10.1016/0002-9610\(56\)90289-6](https://doi.org/10.1016/0002-9610(56)90289-6).
  9. Fry WR, Dort JA, Smith RS, et al. Duplex scanning replaces arteriography and operative exploration in the diagnosis of potential cervical vascular injury. *Am J Surg.* 1994;168(6):693-696. [https://doi.org/10.1016/s0002-9610\(05\)80147-3](https://doi.org/10.1016/s0002-9610(05)80147-3).
  10. Landreneau RJ, Weigelt JI, Magison SM, et al. Combined carotid-vertebral arterial trauma. *Arch Surg.* 1992;127(3):301-304. <https://doi.org/10.1001/archsurg.1992.01420030067012>.
  11. Lourencao JL, Nahas SC, Margarido NF, et al. Penetrating trauma of the neck: prospective study of 53 cases. *Rev Hosp Clin Fac Med Sao Paulo.* 1998;53(5):234-241.
  12. Kaiser LR, Pearce WH. ACS Surgery: Principles & Practice. 7<sup>th</sup> ed. WebMD Professional Pub.; 2007.

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