

# БИОМЕДИЦИНА ВА АМАЛИЁТ ЖУРНАЛИ

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### TYPES OF ANGIODYSPLASIA IN KIMMERLE ANOMALY BY MAGNETIC RESONANCE ANGIOGRAPHY

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#### ABSTRACT

**Introduction:** Vascular diseases of the central nervous system are one of the leading causes of death in developed countries. Vertebrobasilar insufficiency (VBI), caused by compression of the vertebral artery in the atlantoaxial joint area, is considered a significant contributor. Kimmerle anomaly (KA), a congenital bony bridge of the atlas, can exacerbate this condition. This study explores the structural vascular changes associated with KA using magnetic resonance angiography (MRA).

**Methods:** We examined 106 patients diagnosed with KA from a cohort of 620 individuals presenting with headache. Patients underwent X-ray and MRA of the craniovertebral region. Vascular morphometry, anomalies in the cerebral arterial circle, and vertebral artery caliber were assessed. Special attention was given to hypoplasia, aplasia, tortuosity, and asymmetry.

**Results:** MRA revealed angiodyspasias in 96.5% of patients with KA. The most common findings included hypoplasia of the vertebral artery (17.9%), posterior cerebral circle discontinuity (40.6%), tortuosity of vessels in the vertebrobasilar region (37.7%), and internal carotid artery trifurcation (5.7%). Vertebral artery blood flow was slowed in 65.5% (right) and 87.3% (left). Symptoms were often aggravated by head movements.

**Discussion:** The study confirms a strong association between KA and structural vascular anomalies, emphasizing the role of MRA in their identification. The presence of KA combined with these angiodyspasias increases the risk of VBI, especially among young and middle-aged patients. Understanding these patterns aids in accurate diagnosis and targeted management of VBI.

**Keywords:** Kimmerle anomaly, magnetic resonance angiography, vertebrobasilar insufficiency, vertebral artery, angiodyspasia.

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## ТИПЫ АНГИОДИСПЛАЗИЙ ПРИ АНОМАЛИИ КИММЕРЛЕ МЕТОДОМ МАГНИТНО-РЕЗОНАНСНОЙ АНГИОГРАФИИ

### АННОТАЦИЯ

**Введение:** Сосудистые заболевания центральной нервной системы остаются одной из основных причин смертности в странах с высоким уровнем экономического развития. Среди множества факторов, способствующих этому, особое внимание уделяется вертебробазиллярной недостаточности, которая зачастую развивается вследствие компрессии позвоночной артерии в области атлантоаксиального сустава. Данное явление особенно актуально при наличии аномалии Киммерле, при которой наблюдаются структурные изменения артериального круга мозга. Целью исследования является оценка диагностической ценности магнитно-резонансной ангиографии для выявления дисангиогенеза и установления характерных типов ангиодисплазии у пациентов с аномалией Киммерле.

**Методы:** В исследовании использовались современные методы магнитно-резонансной ангиографии, позволяющие получать высококачественные изображения сосудистой сети мозга. Были включены пациенты с клиническими признаками вертебробазиллярной недостаточности, подтверждёнными результатами инструментальных методов обследования. Данные анализировались с использованием количественных и качественных критериев, что позволило систематизировать структурные изменения в артериальном круге мозга и центральных сосудах. Особое внимание уделялось выявлению дисангиогенеза и классификации типов ангиодисплазии на основании визуальных и морфологических характеристик.

**Результаты:** Полученные результаты свидетельствуют о высокой информативности магнитно-резонансной ангиографии при диагностике сосудистых нарушений, связанных с аномалией Киммерле. В исследуемой выборке были выявлены несколько типов ангиодисплазий, отличающихся по степени выраженности структурных изменений. Наблюдались корреляции между выраженностью дисангиогенеза и степенью компрессии позвоночной артерии, что подтверждает гипотезу о важной роли структурных аномалий в патогенезе вертебробазиллярной недостаточности. Дополнительный анализ позволил выделить подгруппы пациентов, требующих индивидуального подхода в диагностике и последующем лечении.

**Обсуждение:** Полученные данные расширяют представления о патогенетических механизмах развития сосудистых нарушений при аномалии Киммерле. Обсуждаются потенциальные клинические приложения выявленных структурных изменений, а также перспективы дальнейших исследований, направленных на оптимизацию диагностических протоколов с использованием магнитно-резонансной ангиографии. Приведённые результаты свидетельствуют о необходимости интеграции современных методов визуализации в клиническую практику для своевременной диагностики и эффективного лечения вертебробазиллярной недостаточности. Дополнительно обсуждаются ограничения проведённого исследования и предлагаются рекомендации по дальнейшему совершенствованию методик исследования сосудистой сети мозга у данной категории пациентов.

**Ключевые слова:** вертебробазиллярная недостаточность, позвоночная артерия, магнитно-резонансная ангиография, аномалия Киммерле, дисангиогенез, ангиодисплазия.

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## MAGNIT-REZONANS ANGIOGRAFIYA YORDAMIDA KIMMERLE ANOMALIYASIDA ANGIODISPLAZIYA TURLARI

### ANNOTATSIYA

**Kirish:** Markaziy asab tizimi qon-tomir kasalliklari rivojlangan mamlakatlarda o'limning yetakchi sababi hisoblanadi. Vertebro bazilyar yetishmovchilik (VBY) ko'pincha atlantoaksial bo'g'im sohasida umurtqa arteriyasining siqilishi tufayli yuzaga keladi. Kimmerle anomaliyasi (KA) bu holatni yanada kuchaytirishi mumkin. Ushbu tadqiqot MRA yordamida KA bilan bog'liq angiодisplaziyalarni baholashga qaratilgan.

**Metodlar:** 620 bemor orasidan KA aniqlangan 106 nafari tanlab olindi. Ularga rentgen va magnit-rezonans angiografiya (MRA) o'tkazildi. Suyak va qon tomirlarning morfometrik ko'rsatkichlari, arterial doira tuzilishi, umurtqa arteriyasi diametri, gipoplaziya, aplaziya va asimmetriya baholandi.

**Natijalar:** KA aniqlangan bemorlarning 96,5%ida angiодisplaziyalar kuzatildi. Umurtqa arteriyasi gipoplaziyasi (17,9%), orqa arterial doiraning uzilishi (40,6%), tomirlar izchilmasligi (37,7%) va ichki uyqu arteriyasi trifurkatsiyasi (5,7%) eng ko'p uchraydigan topilmalar edi. Umurtqa arteriyasida qon oqimi sekinlashuvi o'ng tomonda 65,5%, chap tomonda esa 87,3% holatlarda qayd etildi. Belgilar bosh harakati bilan kuchaydi.

**Muhokama:** KA va qon-tomir tuzilishidagi o'zgarishlar o'rtasida kuchli bog'liqlik borligi tasdiqlandi. MRA ushbu o'zgarishlarni aniqlashda muhim diagnostik usul hisoblanadi. KA mavjudligi bilan birga angiодisplaziyalar VBY xavfini oshiradi, ayniqsa yosh va o'rta yoshdagi bemorlarda. Ushbu ma'lumotlar VBYning erta aniqlanishi va oldini olishda muhim ahamiyatga ega.

**Kalit so'zlar:** Kimmerle anomaliyasi, magnit-rezonans angiografiya, vertebro bazilyar yetishmovchilik, umurtqa arteriyasi, angiодisplaziya.

### Introduction

It is known that officially today more than 30 million inhabitants of the planet with vascular diseases of the central nervous system are registered. An analysis of mortality causes in economically developed countries reveals that cardiovascular diseases hold a leading position, accounting for 45.6% of all cases. Statistical data indicate that circulatory system diseases are the primary cause of death in over half of all fatalities, making up 54.7% [3, 4].

The vertebrobasilar region holds a unique position, as more than 50% of head rotation occurs at the atlantoaxial joint, where the most vulnerable segment of the vertebral artery (AV) is located. At this level, the artery undergoes compression and stretching during rotational movements. Restricting these movements can contribute to the development of vertebrobasilar insufficiency, which is most prevalent among young and middle-aged individuals, accounting for 47.8% of cases. Extravasal compression of the vertebral artery, caused by osteophytes, herniated discs, or spasmodic cervical muscles, can lead to vertebral artery syndrome. Additionally, the presence of an extra bony canal, such as an arched foramen, may further restrict vessel mobility by compressing the V3 segment, increasing the risk of injury [5].

Vertebrobasilar anomalies refer to structural deformations within the region bounded by the occipital bone, atlas, and axis, which arise due to various pathological conditions. Reports in the literature regarding the prevalence of these anomalies are inconsistent [1, 6, 7]. Advances in central nervous system imaging have significantly increased the detection rate of craniovertebral anomalies, shifting them from being considered rare to more frequently observed conditions [2, 12]. In cases where neuroimaging, surgical procedures, and pathological studies do not reveal compression of cerebral nervous structures or disruptions in cerebrospinal fluid dynamics, vascular mechanisms of nervous system impairment are often suspected. One such extravasal factor is the Atlas bone bridge, also known as the Kimmerle anomaly.

Kimmerle's anomaly (KA) is characterized by both clinical and radiological manifestations. Clinically, it may present with symptoms resembling cervical osteochondrosis, such as neck pain, cranialgia, dizziness, and tinnitus. Since vertebral arteries are not visible on conventional radiography, changes in their blood flow can only be inferred indirectly—for instance, by identifying a bony ring in Kimmerle's anomaly, along with its type and diameter, through X-ray imaging, which

may suggest a potential reduction in blood flow. Some researchers argue that this anomaly can lead to vertebral artery compression stenosis, disrupting laminar vertebrobasilar circulation [11]. However, it is also recognized that the degree of arterial narrowing does not always correlate with stroke incidence, as it largely depends on the efficiency of the central nervous system’s adaptive blood flow mechanisms.

**Purpose of the study** was to evaluate the arterial bed by magnetic resonance angiography in the vertebrobasilar region in the presence of Kimmerle's anomaly.

**Materials and methods:** An X-ray examination of the vertebrobasilar region of the spine was conducted using an HF-51-5 device (China) in the X-ray Radiology Department of the Multidisciplinary Clinic of SamSMU. The procedure was performed under the following technical conditions: tube voltage of 95-115 kV, current of 100-150 mA, and an exposure time of 0.2-0.4 seconds. Radiation exposure during X-ray of the cervical spine was 0.5 mSv.

Magnetic resonance angiography (MRA) of the craniovertebral region was performed using a MAGNETOM ESSENZA Tim+DOT tomograph (Siemens) with a field strength of 1.5 T, utilizing the 3D TOF ("time-of-flight") angiography technique. A comprehensive multimodal analysis was conducted to assess vascular parameters and alignment. Particular attention was given to the closure of collateral vessels in the Willis circle, arterial structural anomalies, their connections, and blood flow characteristics from the internal carotid arteries. Visualization of the neck vessels was achieved through MRA, which enhances the blood flow signal while simultaneously reducing signals from surrounding stationary structures. The acquired images were reconstructed using a 3D technique for better visualization.

**Results**

At the first stage of the examination, the X-ray data of 620 patients were analyzed. The main complaint of which was headache. The indicators for exclusion from the study were individuals with decompensated pathological processes. 106 of the examined patients were diagnosed with Kimmerli anomaly. To assess the architectonics of the arterial bed in these patients, an MRA examination of the vessels of the craniovertebral zone was performed.

The study included 52 male and 54 female patients, ranging in age from 12 to 85 years. The average age among men was 41.12±17.25 years, while for women, it was 42.34±15.45 years. Based on the WHO age classification and gender, all patients diagnosed with Kimmerle's anomaly were categorized into groups, as presented in Table 1. The age distribution analysis indicates that the majority of cases were observed in young individuals.

Table. 1

**Age classification of patients with Kimmerle's anomaly**

Age range	Gender	
	men	women
<18 (children)	4	1
18-44 (young age)	29	29
45-59 (middle age)	14	15
60-74 (old age)	4	7
75-89 (senile age)	1	2
Total:	52	54

An analysis of the gender and age distribution of patients reveals an absence of significant gender predominance across all age groups, a trend also observed in other studies [10]. As shown in the table below, Kimmerle's anomaly was detected in men and women at nearly equal rates, with a prevalence of 17.1%. Additionally, the majority of cases were recorded among residents of rural areas, accounting for 60 patients (63.6%). than urban (46 patients, 36.4%).

**Clinical Characteristics of the Examined Patients.** The clinical symptoms observed in the examined patients varied and included headaches of different intensities, tinnitus, dizziness, transient hearing and visual disturbances, fatigue, sleep disorders, unsteady gait, falling episodes, panic attacks, anxiety, shortness of breath, hand numbness, and seizures. These symptoms are most likely of vertebrogenic origin, primarily associated with peripheral etiology [14].

It is important to note that, according to the literature, even the presence of a partial bony bridge—an incomplete arched opening (ponticulus posticus) on the upper surface of the atlas—may, based on both clinical and radiological data, suggest a potential link between Kimmerle's anomaly and the development of chronic tension headaches and sensorineural hearing loss [9].

Table 2

**Main complaints of the examined patients**

	Complaints	Number of patients	
		Abs.	%
1	pain in the neck	56	52,8
2	pain in the occipital region	87	82,1
3	dizziness	59	55,7
4	hearing loss	23	21,7
5	tinnitus	15	14,2
6	memory loss	40	37,7
7	photopsia and blurred vision	29	27,4
8	short-term loss of consciousness	3	2,8

In patients diagnosed with KA, the main complaint (82.1%) was headache. Speaking about vestibulocerebellar and cochlear disorders in the examined patients, dizziness, nystagmus, decreased muscle tone and blurred vision were mainly observed (Table 2), which was also noted by other authors [12, 13].

Often, a special role in the occurrence of vertebrobasilar insufficiency (VBI) is played by painful spasm of the vessel, including AV, due to irritation of the sympathetic nerve plexus. The majority of those examined complained of pain in the cervical region, which was probably provoked by degenerative-dystrophic changes in the ligament-articular apparatus and contributed to the occurrence of a pathological vegetative reflex. As a result, painful irritation of the spinal structures led to excessive irritation of the sympathetic nerves of the perivascular plexus of the AV, and as a result, to a long-term and persistent spasm.

According to the subjects, taking anesthetics and nonsteroidal anti-inflammatory drugs often did not relieve headaches or was short-lived, which was also noted by some authors [13]. Cervicalgia was complained of by 56 (52.8%) patients, with muscle hypertonicity of the cervical spine, often asymmetrical. Moderate pain in the upper cervical paravertebral points and points in the scalp area was noted during palpation by 28 (26.4%) patients. Patients also complained of moderate non-systemic dizziness - 59 (55.7%), general weakness was noted in 61 (57.5%), rapid fatigue - 41 (38.7%), a marked decrease in performance - 35 (33%), sleep disturbance in 29 (24.5%) patients.

Some patients with KA (27.3%), with concomitant VBI, had complaints of ophthalmological pathologies. A third of those examined showed a feeling of lethargy and fatigue, decreased performance, pathological drowsiness, and also absent-mindedness [14].

After diagnosing Kimmerle's anomaly, it was found that the aforementioned symptoms were most pronounced in patients with this condition and became particularly severe during head rotations. In 16% of cases, patient complaints were directly related to head position, such as turning or tilting to the side. The onset and worsening of these symptoms were often linked to various types of cervical spine strain.

The clinical presentation, along with frequently observed radiographic changes in the cervical spine, suggests a potential association between Kimmerle's anomaly and the development of chronic tension-type headaches [9]. According to the literature, bilateral KA is more frequently associated with clinical symptoms [8, 10]. Additionally, studies indicate that the prevalence of acute headaches

is significantly higher in individuals with bilateral KA compared to those without the anomaly, with no substantial gender differences [10].

**X-ray examination of patients.** Images of the craniovertebral junction in the frontal projection did not always provide a clear visualization of the atlas bone bridges due to overlapping structures. Therefore, for more accurate diagnosis and comparison, imaging was primarily performed in lateral projections.

X-ray visualization of the cervical spine was performed with the patient in a standing position in the lateral projection. A cassette measuring 18 cm x 24 cm was used. The distance from the focus of the X-ray tube to the cassette when performing X-ray of the neck in the lateral projection was standardly 100 cm, which gave the true anatomical dimensions of the bone structures being examined.

In lateral projection images, the lateral parts of the atlas were well visualized; however, overlapping of the lateral sections made it difficult to accurately determine the exact localization of the bony bridge (left, right, or both sides). This limitation arises because X-rays in this projection pass through both atlas arches, resulting in a summation of shadows. Although this method does not provide a fully detailed radiographic assessment of atlas abnormalities, its diagnostic value remains significant, as it allows for the detection or exclusion of Kimmerle’s anomaly. Given its low radiation exposure, radiography is highly beneficial as a screening tool.

**Magnetic resonance imaging.** Magnetic resonance angiography (MRA) of the brain vessels was performed with coverage of the craniovertebral region, and MR angiograms were analyzed in all planes. MRA is recognized as a highly informative diagnostic standard, particularly valuable for comprehensive evaluation and comparison of data obtained from various radiological diagnostic methods.

However, MRA has certain limitations, including the potential for "dropout" of the blood flow signal due to artifacts, turbulence, small vessel caliber, or slow blood flow, which can complicate result interpretation.

During MRA, we assessed vascular morphology, with special attention to stenotic areas, vessel deformities, deviations in vessel course, blood flow obstructions, malformations, and trifurcations. The caliber of the vertebral artery (VA) was analyzed, and cases of hypoplasia were identified, predominantly at the V3 and V4 segment levels.

The analysis of MR angiograms allowed for a detailed evaluation of the major brain arteries and the arterial circle of the brain, including the integrity of the communicating arteries and the role of the AV in brainstem blood supply. The diameter of the artery at the posterior arch of the atlas was precisely measured, considering that Kimmerle’s anomaly (KA) may contribute to AV compression within the foramen arcuale.

In KA, the symptoms of the nosology are mainly determined by the specific nature of changes in the biomechanics of the cervical vertebrae and the manifested disorders of the physiological processes of maintaining autoregulation of general cerebral hemodynamics, while the degree of manifestations of the severity of the semiotics of VBI does not correlate with the severity of degenerative-dystrophic changes in the cervical vertebrae.

We have found that a combination of changes in the architectonics abnormalities in the main arteries and the arterial circle of the brain were identified in 96.5% of patients with Kimmerle’s anomaly. In the prevailing number of patients examined by us, changes in the architectonics of the arterial circle of the brain were detected, which related to one of the possible options most often noted in our study:

1. variants of the unusual beginning of the cerebral arteries;
2. open variant of the circle - the anterior and posterior semicircle;
3. asymmetric diameter of the arteries of the right and left sections of the circle.

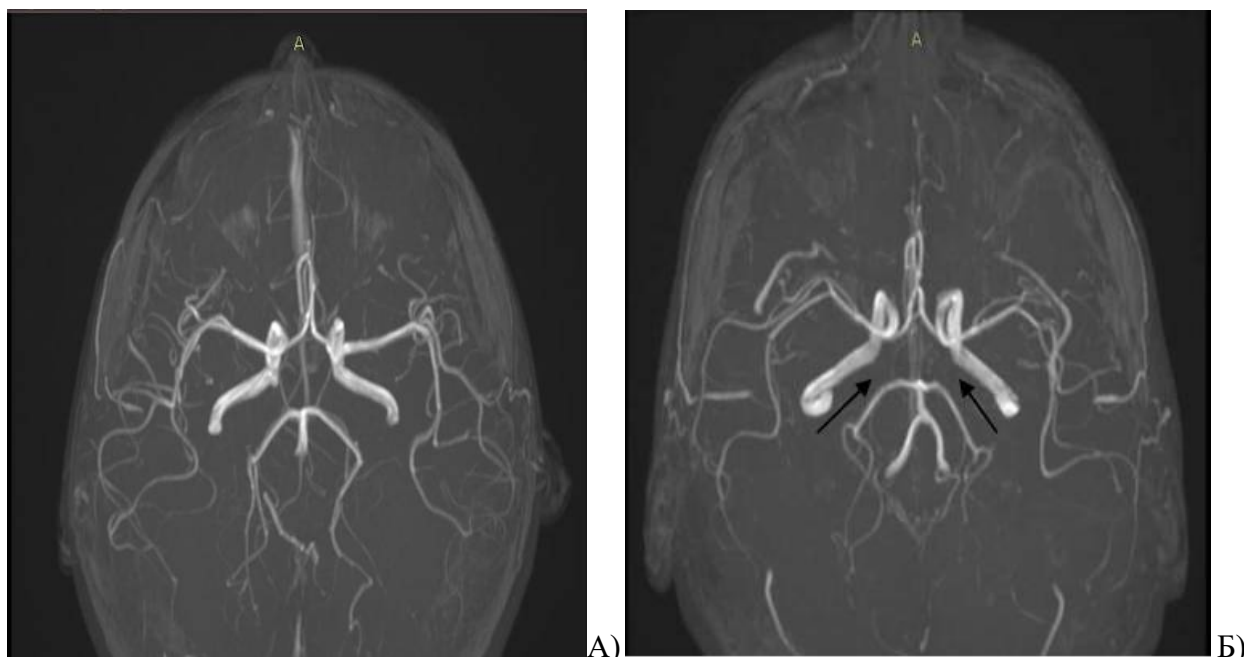
In addition, the magnetic resonance angiography technique made it possible to study the caliber, the level of origin and the correctness of the course of the arterial vessels (Table 3).

Table 3

**MRA data in examined patients with Kimmerle anomaly**

Сосудистые изменения	Right	Left	On both sides
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	Абс.	%	Абс.	%	Абс.	%
Hypoplasia of the AV	7	6,6	9	8,5	3	2,8
Aplasia of the posterior communicating artery	16	15,1	9	8,5	18	17,0
Tortuosity of the vessels of the craniovertebral region	9	8,5	13	12,3	18	17,0
Trifurcation of the cerebral arteries	-	-	2	1,9	4	3,8



**Fig. 1. MR angiography. Native image. A) Patient N., 41 years old. Closed circle of Willis. B) Patient T., 19 years old. Incomplete circle of Willis: absence of posterior communicating artery on both sides (indicated by arrows).**



**Fig. 2. Patient G., 24 years old. MR angiography. Tortuosity of the AV on both sides: A) native image (front view); B) 3D reconstruction (back view).**



**Fig. 3. Patient B., 37 years old. MR angiography. Tortuosity of the internal carotid artery and VA on both sides: A) native image (front view); B) 3D reconstruction (back view).**

Magnetic resonance angiography (MRA) revealed various types of incomplete cerebral arterial circles in patients with Kimmerle’s anomaly (Fig. 1). A common finding was discontinuity in the posterior segment of the cerebral arterial circle, often due to aplasia of the posterior communicating artery. This anomaly was observed in 43 patients (40.6%): in 18 cases (17%), it was absent bilaterally; in 9 cases (8.5%), it was missing on the left; and in 16 cases (15.1%), it was absent on the right.

No occlusive or stenotic lesions in the carotid arteries were detected in patients with spondylogenic VBI during MRA. However, tortuosity of the craniovertebral vessels—a characteristic feature of the arterial architecture in patients with Kimmerle’s anomaly—was noted in 40 cases (37.7%) at the V3 and V4 segments of the vertebral artery (VA). Some studies suggest that alterations in the VA pathway may occur in up to 65.6% of cases. Most patients exhibited a combination of different tortuosity patterns (Fig. 2, Fig. 3), with C-shaped tortuosity of the vertebral artery identified in 29 patients (27.4%)., S-shaped - in 11 (10.4%).

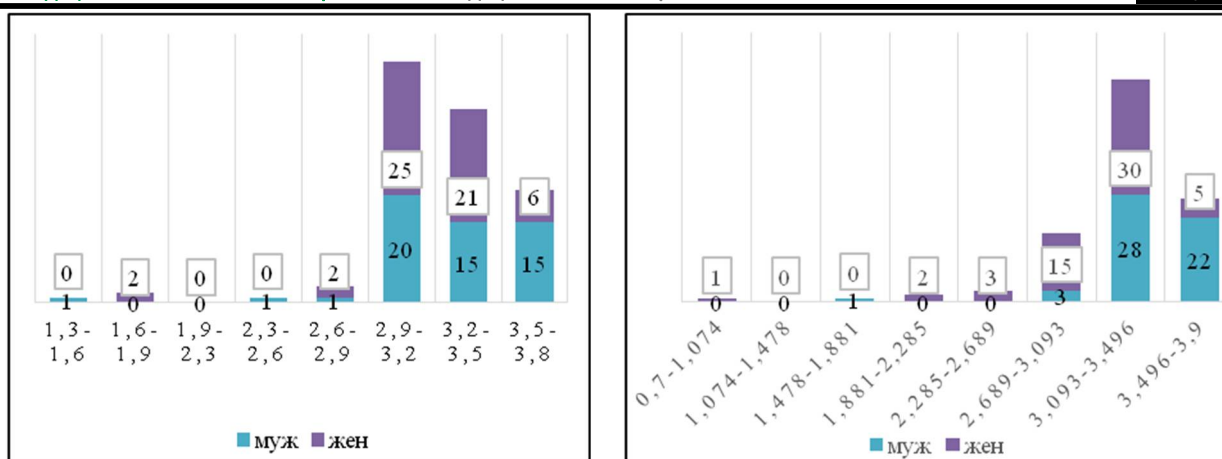
Table 4

**Morphometric data of the AV diameter from the total sample of patients with KA in MRI**

AV (diameter)	min	max	M	m	p
right	1,32	3,82	3,18	0,03	0,01
left	0,67	3,90	3,21	0,04	0,01

When measuring the diameter of the vertebral artery (VA) using MR angiography at the V3-V4 segment level, the average transverse size on both sides was  $3.2 \pm 0.04$  mm ( $3.21 \pm 0.04$  mm on the left and  $3.18 \pm 0.03$  mm on the right). Descriptive statistics for the VA diameter from the total sample of patients examined by MRA are presented in Table 4.

Figure 4 shows the histograms of the distribution of the parameters under study for the total population of patients. These histograms show that the parameters determined from the MRA data correspond to a normal distribution.

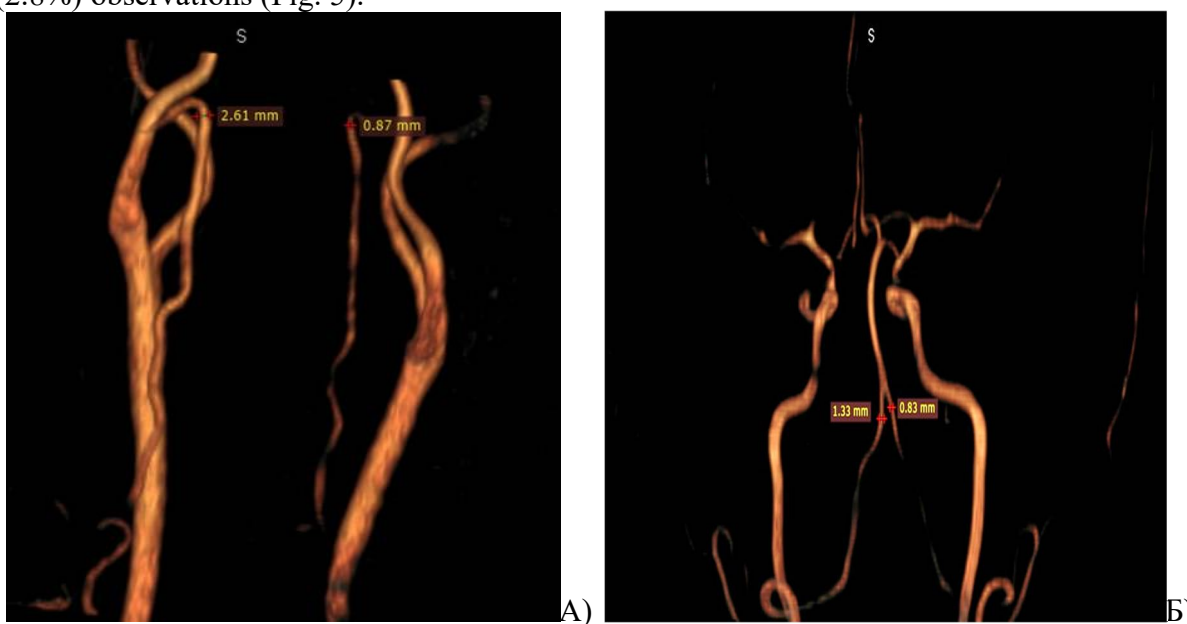


Diameter of the right vertebral artery

Diameter of the left vertebral artery

**Fig. 4. Diameter of vertebral arteries in patients with KA using MRI.**

A reduction in artery diameter to less than 3.0 mm is considered a diagnostic criterion for vertebral artery hypoplasia. According to the literature, parameters indicative of VA hypoplasia are observed in 32.9% of cases. However, in our study, unilateral VA hypoplasia was identified in 16 patients (15.1%): on the right - 7 (6.6%), on the left - 9 (8.5%), and bilateral - was detected only in 3 (2.8%) observations (Fig. 5).



**Fig. 5. MR angiography. 3D reconstruction. A) cervical spine; hypoplasia predominantly of the right AV (posterior view). B) brain region involving the craniovertebral region; hypoplasia of the AV on both sides (posterior view).**

Hypoplasia of the AV may be a background condition, in combination with structural pathology of the cerebral vessels, including the vertebral arteries, as well as a variant of normal architectonics of the vertebral arteries in patients with VBI in KA. It should be noted that when detecting reduced physiological capabilities of the reactivity of the vessels of the VBI, as well as in the absence of hemodynamically expressed stenosis of the extracranial arteries, those examined with hypoplasia of the AV constitute a risk group for hypovolemic stroke.

According to the MRA study, asymmetry in the caliber of the intracranial portion of the vertebral artery (AV) was more frequently observed in patients with signs of VBI, occurring in 53.8% of cases, while in those without pronounced symptoms, it was noted in only 17.0%. Evaluation of vertebral artery blood flow using the MRA method revealed a predominant trend of flow slowing,

observed in 65.5% of cases in the right VA and even more frequently in the left VA (87.3%) (Table 5).

Table 5

**Alterations in vertebral artery blood flow velocity in patients with Kimmerle's anomaly on MRA**

	Not changed		Accelerated		Slowed down	
	Abs.	%	Abs.	%	Abs.	%
Right AV	34	30,9	-	-	72	65,5
Left AV	10	9,1	-	-	96	87,3

Summarizing the results of the evaluation of MRA data in patients with KA, the presence of variants in the architecture of the cerebral vessels was clarified, which reflects changes in the formation and development of the main arteries of the head.

**Discussion**

Thus, the Kimmerle anomaly, i.e. the C1 bony bridge, is combined with various variants of angiodysplasia of the cerebral arterial circle, revealed by MRA. Clinically manifested KA are often (58.5%) combined with dysangiogenesis, especially frequent reflections of which in this category of patients are hypoplasia of the vertebral arteries (17.9%), vessel tortuosity in the vertebrobasilar region (37.7%) and discontinuity of the posterior segment of the cerebral arterial circle (40.6%), as well as trifurcation of the internal carotid artery (5.7%).

The MRA findings highlight the hemodynamic significance of vascular anomalies and confirm the potential risk of cerebrovascular disorders of arterial origin in patients with Kimmerle's anomaly. The influence of structural changes in the atlas on the duration of clinical symptoms, depending on the changed arteries, was also emphasized. However, the degree of expression of degenerative-dystrophic changes in the cervical vertebrae did not aggravate the trajectory of the AV. The combination with the foramen arch of the atlas aggravates the effect on blood flow, which is revealed by MRA, including damage to the vertebral artery.

The question of possible asymmetry of blood flow in the hemispheres of the brain is controversial and can be substantiated from both functional and anatomical points of view. According to experts, symmetry is a feature that ensures the preservation of the organism's evolution, as a sign of stability and sustainability. The manifestation of vascular asymmetry creates conditions for maintaining an unstable state, equilibrium, which guarantees the process of developmental variability.

As we can see, the change in the atlas architecture does not seem to be a normal variant and with it, over time, there is a depletion of compensatory mechanisms. We believe that this change is more related to a developmental anomaly.

The cervical spine acquires pathological significance against the background of degenerative changes and all kinds of neck injuries [11], which is relevant and explains the conduct of targeted studies. In cases of vertebral motor segment instability and mechanical irritation of the arterial wall by pathologically altered structures, primarily osteophytes, irritation of the sympathetic plexus of the vertebral artery (VA) of vertebrogenic origin occurs. This mechanism is likely the basis of vertebral artery syndrome in the patients with cervical spine disorders examined in our study. It is well known that for the syndrome to develop, the presence of static or dynamic loads on a dystrophically or degeneratively altered cervical spine is necessary, as these conditions contribute to the activation of irritating factors.

A significant proportion of patients (52.7%) reported shooting or burning pain in the cervico-occipital region, which was poorly localized, diffuse, and radiated to the frontal-orbital area. This pain was most likely a manifestation of sympathetic plexus irritation, particularly involving the VA and the Frank nerve.

Irritation of sympathetic structures at specific segments, including the cerebral artery's sympathetic plexus, induces a pronounced vasoconstrictor effect. In the vertebrobasilar system, symptoms of circulatory disturbances associated with vertebral artery syndrome may result from a

vasospastic reaction that extends from the proximal segment of the cerebral artery to the branches of the posterior cerebral arteries.

In the pathogenesis of headache, the significance of vascular changes is confirmed by a review of literary sources and our study, which predetermines prevention and treatment tactics.

Due to the lack of a clear understanding of the complex mechanisms underlying vertebrobasilar insufficiency, treatment is often unjustified. A comprehensive approach to evaluating blood flow alterations in the atlanto-occipital region is both pathogenetically justified and clinically significant. Unambiguously, further assessment of the interdependence of pathologies of the neck and its vessels can lead to insufficient blood flow in the VBS in the examined patients with Kimmerle anomaly.

Unfortunately, many doctors today are either unaware of this pathology or do not consider it in their diagnostic approach. As a result, patients often undergo symptomatic treatment for months or even years without identifying the underlying cause, despite the fact that routine diagnostic methods can confirm or rule out Kimmerle's anomaly. The continuous advancement of radiological imaging techniques, which allow for detailed anatomical assessment of the spine and craniovertebral region, presents a valuable opportunity to refocus attention on this complex area of the skeletal system.

### Conclusions

As a result of the study, it was established that the Kimmerle anomaly is detected as an incidental finding on lateral radiographs of the cervical spine in approximately 17.1% of cases. A large proportion of patients with spondylogenic circulatory disorders in the vertebrobasilar basin are young people - from 18 to 44 years old (53.6%).

Kimmerle's anomaly is associated with variations of angiodyplasia in the cerebral arterial circle, primarily affecting the vertebrobasilar basin vessels, as detected by MRA. Clinically significant cases of Kimmerle's anomaly are frequently (58.5%) accompanied by dysangiogenesis, which in this patient group is manifested by vertebral artery hypoplasia (17.9%) and discontinuity of the posterior segment of the cerebral arterial circle (40.6%), tortuosity of the vertebrobasilar basin vessels (37.7%) and trifurcation of the internal carotid artery (5.7%). Asymmetry of the vertebral artery (VA) diameters in the intracranial segment was more frequently observed in patients with spondylogenic vertebrobasilar insufficiency (53.8%), whereas in those without signs of VBI, asymmetry of the V4 segment diameters was detected in only 17.0% of cases..

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