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THE HEAD AND NECK VASCULAR ANATOMICAL VARIABILITY IN THE LABORATORY RAT AND ITS SIGNIFICANCE TO MEDICAL SCIENCE

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ABSTRACT

Laboratory rats are often used in experimental research of concern to human and veterinary medicine. There are several advantages of using rats as a scientific medium. In this study rats will be used as the scientific model as, previously discussed, they have proven their effectiveness in cardiovascular studies. The aim is to give a description of the cranial region, the head and neck of the rat as well as imaging of the vasculature of these regions to support the planning of surgical therapeutic methods to be applied to human and veterinary medical research. The research of the blood vessels morphology in anatomical studies is key to the prevention of ischemia during organ surgery. In recent times the laboratory rat has become one of the most popular models for experiments in medical research. Corrosion casts were prepared on the cranial arteries of the body of 20 adult Wistar rats using Duracryl Dental® and PUR SP as the casting medium. We found the absence of the brachiocephalic trunk in some cases. Thyroid arteries originated independently or by the short common trunk from the right and left common carotid artery. The facial artery originated by the short trunk with the maxillary artery, or by the linguofacial trunk with the lingual artery from the common carotid artery. The results of this study revealed that, the functional anatomical relationship between the rat neck and head structures are important for the development of medical research of concern to human and veterinary experimental medicine.

Key words: arteries; blood supply; experimental medicine; laboratory animals

INTRODUCTION

Laboratory animals (nonhuman primates, dogs, pigs, cats, sheep and laboratory rodents) have proved to be a suitable model for numerous scientific experiments such as: tumour, and cancer investigation, immunological, and metabolic studies, anatomy, and physiology, biochemistry, and experimental transplantation for example.

Laboratory animals are often used in experimental research relative to human and veterinary medicine interests. Many structures or organs of the body of laboratory animals were studied by many authors, for instance on the: mouse [8, 9], hamster [7, 27], rabbit [1, 14], or rat [3, 13, 21]; but some details have not yet been examined. The knowledge of anatomical variations through experimental study can be applied to surgical practice [30]. The study of the morphology of blood vessels in anatomical studies is key to the prevention of ischemia during organ surgery. In recent times, the laboratory rat has become one of the most popular models for experiments in medical research.

The laboratory rat takes its origins from the wild brown rat and it was an albino mutant that was first used in science as an experimental model in 1828 in a fasting study. After these numerous experiments using rats were preformed, that led to the albino rat to become the first animal domesticated for purely scientific experimentation [17]. There are several advantages of using rats as a scientific medium. They have a short life span and a high reproductive rate with a large quantity of rats being able to be housed in a small area. In addition to this, they are easily handled and provide a low risk of injury if they attack. The rat has been chosen over the mouse as they more closely mimic human diseases, as well as, has having a better capacity for learning for use in behavioural studies. The rat has proved an excellent model for studies of the cardiovascular, reproductive, and nervous systems, as well as in studies for cancer and pharmaceuticals [12]. In this study, rats will be used as the scientific model as, previously discussed, they have proven their effectiveness in cardiovascular studies.

The aim of this paper is to give a description of the cranial region, the head and neck, of the rat as well as imaging of the vasculature of these regions to support the planning of surgical therapeutic methods to be applied to human and veterinary medical research interests [29, 30].

MATERIALS AND METHODS

The experiment was performed on 20 one-year old laboratory rats (*Rattus norvegicus f. domestica*). Both sexes (10 females, 10 males) of Wistar rats were used in this experiment with body weights ranging from 350—520 g. The animals were obtained from standard breeding conditions from the Laboratory of Research Biomodels, University of P. J. Safarik in Kosice which is an accredited facility.

Ethical statement

The experiment on rats was performed with approval of the Ethic Committee of the University of Veterinary Medicine and Pharmacy in Kosice and State Veterinary and Food Institute in Bratislava (No. SK P 12004) followed Slovakian protocols for ethical standards for the use of laboratory animals [15, 29, 30].

Method of the preparing procedure of the corrosion casts specimens of the arterial system

The animals were euthanized by an intraperitoneal injection of sodium thiopental (50 mg.kg^{-1}, Thiopental Valent, Valeant Czech Pharma, Praha, Czech Republic). Under total anaesthesia the left ventricle of the heart was dissected. A cannula was then introduced into the aorta through the left ventricle which was secured by a ligature. The right auricular appendage was opened to allow good distribution of the perfusion medium. First the vessels where perfused with 0.9% isotonic saline solution at a flow rate of about 10 ml/min for 30 s through the left cardiac ventricle. Then 0.05% NaOH solution (Mikrochem, Michalovce, Slovakia) was added to the perfusion medium to aid removal of blood clots from the vessels. A perfusion pressure of approximately 200—250 mm Hg (2.6—3.25 mm H_2O) was maintained. The perfusion material used was injected in stoichiometric rates. The efficacy of the perfusion material was monitored by uniform colour fading of the tissues during the procedure. Corrosion casts were then prepared by using Duracryl Dental® resin (Spofa-Dental, Jičín, Czech Republic) and PUR SP resin (Institute of polymers, SAV, Bratislava, Slovakia). A suitable colour tone was achieved by the addition of 2—3 drops of red dye (oil-red paint 0). This was then applied after thorough mixing through the left ventricle of the heart. Once the resin formed a complete cast no manipulation of the casts or animals may be done for 30 minutes. After this time

the casts were submersed in 40—60 °C water for between 30 min and 24 hr to allow complete polymerization of the resin [18].

The soft tissue was then removed by chemical degradation in 2—4 % KOH solution (Mikrochem, Michalovce, Slovakia) at 60—70 °C. The degradation of the tissue took approximately 2—3 days. The corroded specimens were then submerged in water prior to being dried at room temperature.

Method of evaluation and interpretation of results

A stereo static Leica M 320 microscope (Leica Microsystems Schweiz AG, Heerbrugg, Switzerland) was used for the evaluation of the corrosion casts and anatomical dissection. Pictures were taken through a digital camera attached to the microscope. The results were then listed as percentages. The latest edition of the Veterinary Anatomic Nomenclature was consulted throughout this study [6].

RESULTS

The common carotid artery (*a. carotis communis*) is the main artery of the head and neck. The left common carotid artery (*a. carotis communis sinistra*) originates from the aortic arch (*arcus aortae*), and the right common carotid artery (*a. carotis communis dextra*) is a branch of the brachiocephalic trunk (*truncus brachiocephalicus*) but without the bicarotic trunk (*truncus bicaroticus*) as it is absent in rats (Fig. 1). We detected in 15 cases (75 %) that the aortic arch was divided into the brachiocephalic trunk, the left subclavian artery (*a. subclavia sinistra*) and the left common carotid artery. In only 5 cases (25 %) the brachiocephalic trunk was absent (Table 2) and so instead the left and right common carotid artery, and left and right subclavian artery (*a. subclavia sinistra* et *dextra*) originated from the aortic arch. The *a. carotis communis* first runs ventrally along the trachea and then later along the dorsomedial surface of the trachea. At this level *a. carotis communis* is covered by the ventral muscles of the neck. The branches of the common carotid artery were described as the cranial and caudal thyroid artery (*a. thyroidea cranialis* et *caudalis*) and inconstant muscular branches (*rr. musculares*) which supply the thyroid gland and surrounding structures (larynx, pharynx). The cranial thyroid artery (Fig. 4) divides into the laryngeal branch (*r. laryngeus*) specific to the larynx and the pharyngeal branch (*r. pharyngeus*) specific to the pharynx. Our results detected that *a. thyroidea cranialis* and *caudalis* arose separately from the *a. carotis communis dextra* et *sinistra* in 17 cases (85 %). In 3 cases (15 %) these two arteries originated from the right and left common carotid artery by the short common trunk (Table 2).

Along the neck on both sides, many inconstant branches for the ventral muscles were found. In the region of the thyroid gland (*glandula thyroidea*) the common carotid ar-

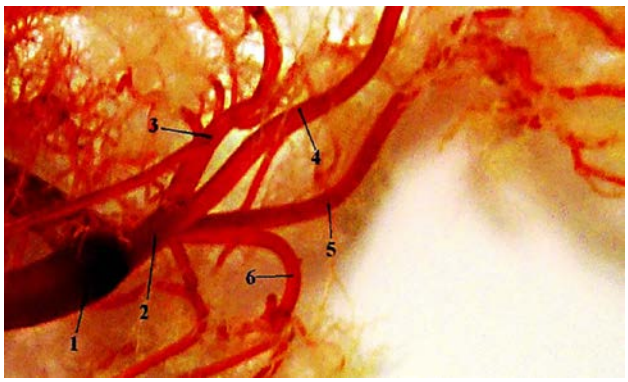


Fig. 1. The division of arcus aortae (PUR SP)
1 – *arcus aortae*; 2 – *truncus brachiocephalicus*; 3 – *a. axillaris dextra*; 4 – *a. carotis communis dextra*; 5 – *a. carotis communis sinistra*; 6 – *a. axillaris sinistra*

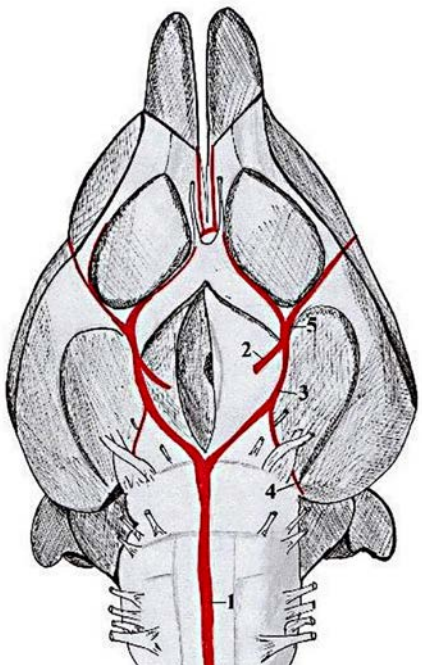


Fig. 2. The arteries of the brain
1 – *a. basilaris*; 2 – *a. carotis interna*; 3 – *a. communicans caudalis*; 4 – *a. cerebri caudalis*; 5 – *a. cerebri media*

Tab. 1. Blood supplying the area of the cerebral arteries

Cerebral artery	Part of the brain
cerebri rostralis	cerebral cortex
cerebri caudalis	dorsal surface of the mesencephalon
communicans caudalis	dorsal surface of the mesencephalon
cerebri media	lateral and dorsal surface of the hemispheres
choroidea	cerebral peducles, hippocampus, lateral geniculate body, lateral ventricule of the brain
basilaris	caudal part of the brain

Tab. 2. The biggest variations are in the origin of these arteries

Vessel	Percentages
The absence of the brachiocephalic trunk	In 25 %
The short common origin of the both thyroid arteries from the left common carotid artery	In 15 %
The origin of the occipital artery from the common carotid artery	In 10 %
The short common trunk for the origin of the facial and maxillary artery from the common carotid artery	In 10 %
The presence of the linguofacial trunk	In 50 %

tery is divided into the internal and external carotid artery (*a. carotis interna* et *externa*).

The internal carotid artery is the main artery of the brain. It branches from the common carotid artery at the level of the thyroid gland. It proceeds directly to the base of the skull through the jugular foramen (*foramen jugulare*), to the tympanic bulla (*bulla tympanica*) by the name, of the stapedian artery (*a. stapedia*). The stapedian artery continues through three openings: the petrotympanic fissure (*fissura petrotympanica*), the caudal alar foramen (*foramen alare caudale*) and the rostral alar foramen (*foramen alare rostrale*) into the orbita. Here the stapedian artery divided into two branches: the supraorbital artery (*a. supraorbitalis*) and the infraorbital artery (*a. infraorbitalis*). This branching was found to occur on the right and left side in all cases. The supraorbital artery runs along the caudal border of the orbita. Its branch is the lateral superior palpebral artery (*a. palpebralis superior lateralis*) which supplies the lateral margin of the upper eyelid. This artery was also found to be on the right side and on the left side in all cases. The infraorbital artery is the second branch of the stapedian artery, which runs along the ventral margin of the eyelid, where it then runs through the infraorbital foramen (*foramen infraorbitale*). The pterygopalatine artery (*a. pterygopalatina*) originates from the internal carotid artery before the entrance to the cranial cavity. The *arteria pterygopalatina* then continues through the jugular foramen (*foramen jugulare*) into the skull as, the palatine artery (*a. palatina*). The palatine artery runs along the dorsal surface of the temporal bone through the petrotympanic fissure to the ventral surface of the skull, along the wing of the basisphenoidale bone and then into the hard palate (*palatum durum*). The major palatine artery (*a. palatina major*) continues along the hard palate where it is gives off the dental branches (*rr. dentales*) for molars. The palatine artery was found to be on the right side in 18 cases (90 %) in 16 (80 %) on the left side. The second branch of the pterygopalatine artery is the pharyngeal artery (*a. pharyngea*), which arises at the point of origin of the palatine artery. This artery was described in 18 cases (90 %) on the right side and in 16 cases (80 %) on the left side. A. pharyngea continues through the petrotympanic fissure (*fissura petrotympanica*) to the region of the pharynx. *A. pterygopalatina* was seen in all cases, on both sides.

In this study it was observed that at the base of the brain were the following branches of the internal carotid artery: the caudal cerebral artery (*a. cerebri caudalis*), the caudal communicating artery (*a. communicans caudalis*), the middle cerebral artery (*a. cerebri media*), the rostral cerebral artery (*a. cerebri rostralis*) and the choroidal artery (*a. choroidea*) (Table 1).

The caudal communicating artery is very small and together with the caudal cerebral artery supplies the dorsal surface of the midbrain (*mesencephalon*) (Fig. 2). The middle cerebral artery is the strongest branch of the internal carotid artery and it reaches lateral and dorsal surfaces of the hemispheres (Fig. 2). The rostral cerebral arteries from both sides are fused and form the rostral cerebral trunk (*truncus cerebri rostralis*), which then supplies the cerebral cortex (*cortex cerebri*). The choroidal artery reaches the cerebral peduncle (*pedunculus cerebri*), the hippocampus, the lateral geniculate body (*corpus geniculatum laterale*) and the lateral ventricle (*ventriculus lateralis*). The caudal part of the rat brain is supplied by the

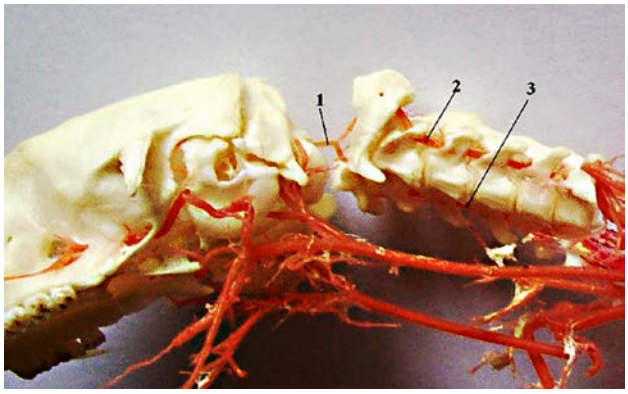


Fig. 3. The presence of vertebral arteries and their fusion into *a. basilaris*
1—*a. basilaris*; 2—*a. vertebralis sinistra*; 3—*a. vertebralis dextra*; Duracryl Dental®

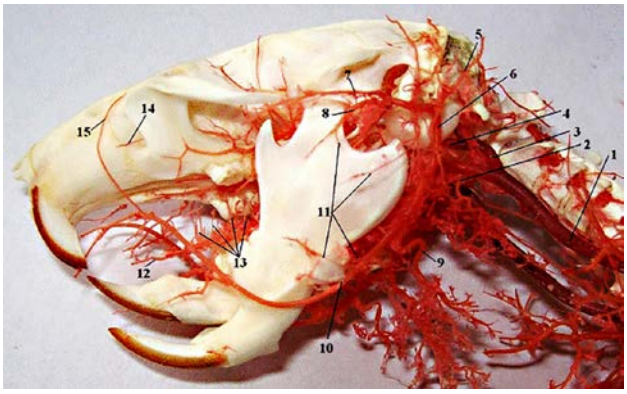


Fig. 4. The division of the *a. carotis communis sinistra*
1—*a. carotis communis sinistra*; 2—*a. thyroidea cranialis*; 3—*a. carotis interna*; 4—*a. pterygopalatine*; 5—*a. auricularis caudalis*; 6—*a. maxillaris*; 7—*a. temporalis profunda*; 8—*a. transversa faciei*; 9—*r. glandularis a. facialis*; 10—*a. facialis*; 11—*rr. masseterici*; 12—*a. profunda linguae*; 13—*rr. dorsales linguae*; 14—*a. infraorbitalis*; 15—*a. frontalis*; Duracryl Dental®

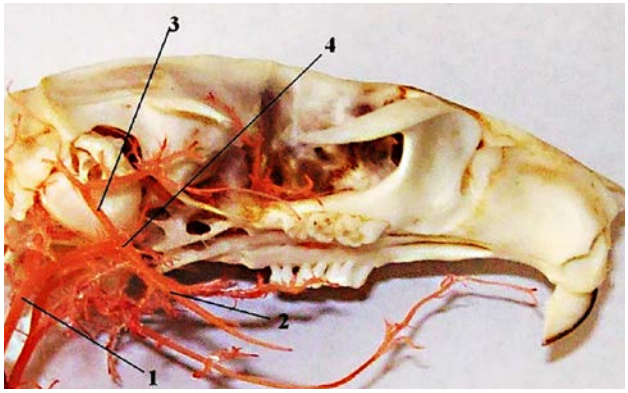


Fig. 5. The common trunk of *a. maxillaris* and *a. facialis*
1 – *a. carotis communis dextra*; 2 – *a. facialis*; 3 – *a. maxillaris*; 4 – The common trunk of *a. maxillaris* and *a. facialis*; Duracryl Dental®

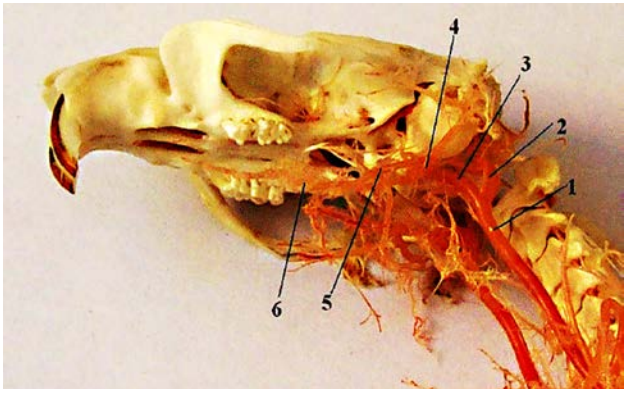


Fig. 6. Truncus linguofacialis
1 – *a. carotis communis sinistra*; 2 – *a. carotis interna*; 3 – *a. carotis externa*; 4 – *truncus linguofacialis*; 5 – *a. facialis*; 6 – *a. lingualis*; Duracryl Dental®

basilary artery (*a. basilaris*), which is a fusion of the right and left vertebral artery (*a. vertebralis dextra* et *sinistra*), (Fig. 3).

The external carotid artery forms the main continuation of the common carotid artery. It runs between the digastric muscle (*m. digastricus*) and the stylohyoid bone (*os stylohyoideum*). The external carotid artery has six branches, namely the occipital artery (*a. occipitalis*), the caudal auricular artery *(a. auricularis caudalis*), the superficial temporal artery (*a. temporalis superficialis*), the facial artery (*a. facialis*), the lingual artery (*a. lingualis*) and the maxillary artery (*a. maxillaris*). The occipital artery is the first branch that arises from *arteria carotis externa* immediately after the division of the common carotid artery. It runs along the jugular process (*processus jugularis*), where at this level, it then divides into a muscular branch (*r. muscularis*) for the surrounding muscles and an auricular branch (*r. auricularis*) for the ear. Its main continuation is the condylar artery (*a. condylaris*). In 18 cases (90%) the occipital artery was found to be a branch of the external carotid artery and in the other 2 cases (10%) this artery was a branch of common carotid artery on both sides of the head (Table 2). The caudal auricular artery supplies the auricle by its branches. On the caudal margin of the auricle, the caudal auricular artery continues as the intermediate auricular artery (*a. auricularis intermedia*). The rostral part of the auricle is supplied by the rostral auricular artery (*a. auricularis rostralis*). In this investigation all cases proved that the caudal auricular artery was a branch of the external carotid artery. The intermediate auricular artery was stronger and longer than the rostral auricular artery. The caudal auricular artery was observed to divide into

two branches in 14 cases (70%) and in just 6 cases (30%) the rostral auricular artery was a branch of the intermediate auricular artery (Fig. 4). The superficial temporal artery is another branch of external carotid artery and it reaches the temporal region. This branch was found in all 20 rats. The strongest branch of the *a. carotis externa* is the facial artery. This artery runs along the medial pterygoid muscle (*m. pterygoideus medialis*) then ventrally through the notch for the facial vessels (*incisura vasorum facialium*) and along the lateral surface of the face, where it supplies muscles of the face. In this study variations in the origin of this artery were noted. In 10 cases (50%) facial artery had common origin with the maxillary artery on the right side and in 6 cases (30%) on the left side (Table 2; Fig. 5). Similarly, the linguofacial trunk (*truncus linguofacialis*) was observed to be on the right side in 10 cases (50%) and in 14 cases (70%) to be on the left side (Table 2; Fig. 6).

The facial artery has many branches. One such being the glandular branch (*r. glandularis*) which supplies the sublingual gland (*glandula sublingualis*). It is a very strong and marked branch and was found on both side of the face in all cases (Fig. 4). The other branch of the facial artery is the masseteric branch (*r. massetericus*) which supplies the masseter muscle (*m. masseter*). Masseteric branch arose from the right facial artery in 12 cases (60%) and from the left facial artery in 10 cases (50%). The inferior labial artery (*a. labialis inferior*) is the branch for the lower lip. In this experiment this branch was observed in 15 cases (75%) on the right side and in 2 cases (10%) on the left side. The mental branches (*rr. mentales*) are the branches for the chin and were observed in all cases on both sides. The three cases (15%) of the corrosion casts revealed the oral angular artery (*a. angularis oris*) which is the branch for the area of the angle of the mouth, to be on the right side, and then in 2 cases (10%) this artery was revealed to originate on the left side. In the region of the nose and orbita the other branch, the nasal lateral artery (*a. lateralis nasi*) was found in 5 cases (25%) to be on the right. Also, in the region of the frontal bone (*os frontale*), the frontal artery (*a. frontalis*) was found in 4 cases (20%) on the left side. The lingual artery, which enters the tongue near to the stylohyoid bone, is taken to arise from the *arteria carotis externa* close to the origin of the *arteria facialis*. However, the lingual artery did not originate from the external carotid artery in 10 cases (50%) where it was on the right side and 6 cases (30%) on the left side. Interestingly, in some cases the short common trunk was found to be the origin of the lingual and facial arteries (Fig. 6). The deep lingual artery (*a. lingualis profunda*) arises from the lingual artery close to the root of the tongue. The dorsal lingual branches (*rr. dorsales linguae*) which originate from the deep lingual artery, go into the muscles of the tongue. The deep lingual artery and dorsal lingual branches were observed in all cases.

The maxillary artery runs along the medial surface of the mandible. The area which the maxillary artery supplies in other animals is supplied by the internal carotid artery in laboratory rats. The main continuation of the maxillary artery is the inferior alveolar artery which enters into the mandibular foramen (*foramen mandibulae*) through the mandibular canal (*canalis mandibulae*) and mental foramen (*foramen mentale*) and the mental artery (*a. mentalis*). It was observed that the buccal artery (*a. buccalis*), a branch of the maxillary artery in the rostral part of head, was on the right side in 5 cases (25%) and in 4 cases (20%) on the left side. Continuing dorsally from the maxillary artery to the temporal muscle (*m. temporalis*) is the deep temporal artery (*a. temporalis profunda*). The deep temporal artery was evident in all cases. Originating from the deep temporal artery is the transverse facial artery which is very important for blood supply to the face. The transverse facial artery (*a. transversa faciei*) runs in the rostral direction on the lateral surface of the zygomatic arch (*arcus zygomaticus*) into the facial region. The transverse facial artery was detected in 17 cases (85%) on the right side and in 15 cases (75%) on the left side. Many masseteric branches (*rr. masseterici*) were found supplying the masseter muscle, as were branches of transverse facial area.

DISCCUSSION

An exact description of the vasculature in the cranial parts of the rat body is fundamental for experimental surgical research in this model of laboratory animals. The knowledge of the anatomical variability of the vasculature of the head and neck would help to avoid critical complications when they perform different experimental surgery on these parts of the rat body. Many authors, previous publications and descriptions mentioned only partial results of rat morphology [18]. We have submitted well-knit knowledge about arterial vasculature of the cranial parts of the

rat body, which is more important for performing experiments in this model of laboratory animals, because venous drainage and alternative veins pathways of the rat brain were described by some authors [11, 15]. The morphological relationship between the head and neck of human and rat is still sufficiently undefined. The circulatory system of this part of the body in the rat is considered similar to human therefore the rat is the most often using laboratory animals [26, 32]. The origin, division and course of the cranial arteries of the aortic arch (Fig.1) and its branches are similar to human, but the area of supplying of single arteries is different. The experiment of the blood supply to the head and neck in rats showed the same scheme of the aortic arch division with some authors [11, 22, 24, 25]. Through this study it was found, in some cases, that the brachiocephalic trunk was absent whereas, in research carried out by [20] he found that the brachiocephalic trunk was absent in all of the rat fetuses he examined. In the cases in which the brachiocephalic trunk was absent from both the left and right common carotid and the left and right subclavian arteries it had originated directly from the aortic arch. The different anatomical nomenclature of the brachiocephalic trunk in rats is used by many authors [11, 22]. They named the brachiocephalic trunk in their study results as *arteria anonyma*. In this study, it was found that the cranial and caudal thyroid artery arose from the left and right common carotid artery (*a. carotis communis sinstra* et *dextra*) or, in some cases, it arose from the short common trunk. The cranial thyroid artery is divided into two branches, laryngeal and pharyngeal. The same division was described by N e j e d l ý [22] and P o p e s k o et al. [24]. The cranial thyroid artery *(a. thyroidea cranialis*), as named by P o p e s k o et al. [24], arises from the external carotid artery (*a. carotis externa*). In the study of Y a m a s a k i [31], the cranial thyroid artery formed a common trunk with the pharyngeal artery [15]. According to H e b e l and S t r o m b e r g [11] the caudal thyroid artery is a branch of the deep cervical artery (*a. cervicalis profunda*). Other authors describe the origin of the caudal thyroid artery as coming from the pericardiacophrenic artery (*a. pericardiacophrenica*) [31]. The internal carotid artery (*a. carotis interna*) is the main artery supplying the brain. It arises from the common carotid artery (*a. carotis communis*) at the thyroid gland. According to some authors the common carotid artery is at the level of the larynx [11, 22, 24], observed the division of this artery in the caudal margin of the thyroid gland. As described by A l b i o n [2], the internal carotid artery then passes into the skull where it changes its name to the stapedain artery (*a. stapedia*). The stapedia artery has two branches: the supraorbital artery (*a. supraorbitalis*) and the infraorbital artery (*a. infraorbitalis*). In this study it was found that, in all cases, both of these arteries branched on both the left and right side. L e V e r e [19] drew attention to the supraorbital artery off which is a branch called the lateral superior palpebral artery (*a. palpebralis superior lateralis*). In our study it was found on both the left and right sides. The pterygopalatine artery (*a. pterygopalatina*), as described by H e b e l and S t r o m b e r g [11] branches from the internal carotid artery just before the skull cavity entrance. After it enters through the jugular foramen (*foramen jugulare*), as described by both C o x [5], H e b e l and S t r o m b e r g [11] the pterygopalatine artery (*a. pterygopalatina*) is the first branch of the internal carotid artery and passes through the tympanic bulla (*bulla tympanica*). The results of this study are concurrent with this. We found in all cases this branching on both sides. H e b e l and S t r o m b e r g [11] describes three branches of the internal carotid artery that supply the brain: the rostral cerebral artery (*a. cerebri rostralis*), the choroidal artery (*a. chorioidea*) and the caudal cerebral artery (*a. cerebri caudalis*). All three of these arteries were present in this study. Also found was the caudal communicating artery (*a. communicans caudalis*), and the middle cerebral artery (*a. cerebri media*). In agreement with H e b e l and S t r o m b e r g [11] we found the middle cerebral artery running dorsally to the cerebral hemisphere and ramifying both laterally and dorsally. The choroidal artery, in both our study and according to H e b e l and S t r o m b e r g [11] and H e et al. [10] runs to the cerebral peduncle (*pedunculus cerebri*), the lateral ventricle (*ventriculus lateralis*), the lateral geniculate body (*corpus geniculatum laterale*), and the hippocampus. According to T h o m a s [28] the brain is supplied by the common carotid artery and verterbral artery. O g a t a [23] on researching the ischemia of the rat brain, found that the main arteries for the brain are the common carotid artery, the vertebral artery and the basilar artery. Among these arteries are anastomoses. The external carotid artery (*a. carotis externa*), as described by H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24] is the largest continuation of the common carotid artery. The occipital artery (*a. occipitalis*) is the first branch that arises

from *a. carotis externa* immediately after the division of the common carotid artery. It runs along the jugular process (*processus jugularis*), where at this level it then divides into a muscular branch (*r. muscularis*) for the surrounding muscles and an auricular branch (*r. auricularis*) for the ear. Its main continuation is the condylar artery (*a. condylaris*). As described by H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24] the occipital artery runs dorsally along the jugular process and supplies the digastric muscle (*m. digastricus*) and the muscles of the neck. In line with H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24] this study found that, in many cases, the occipital artery branched from the external carotid artery, and in others, the occipital artery branched from the common carotid artery instead. The next branch of the external carotid artery is the caudal auricular artery (*a. auricularis caudalis*) which supplies the ear. The caudal auricular artery branches into the intermediate auricular artery (*a. auricularis intermedia*) and, as described by P o p e s k o et al. [24] the rostral auricular artery (*a. auricularis rostralis*). It was found in all of the cases in this research that the caudal auricular artery branched directly from the external carotid artery. In many cases the caudal auricular artery was found to divide into two branches and, in the remaining cases, the rostral auricular artery divided from the intermediate auricular artery. The results of this study agree with research by H e b e l and S t r o m b e r g [11]. N e j e d l ý [22] determined just one auricular branch from the external carotid artery and named it the *arteria auricularis magna*. Reaching the temporal region is another branch of the external carotid artery, the superficial temporal artery (*a. temporalis superficialis*). This branch was present in all cases of this study which agrees with research by N e j e d l ý [22] and H e b e l and S t r o m b e r g [11]. According to H e b e l and S t r o m b e r g [11] the superficial temporal artery gives off four branches: the *r. temporalis* and, *r. massetericus*, the transverse facial artery (*a. transversae faciei*), and the lateral palpebral artery (*a. palpebralis lateralis*). In this study in all the corrosion casts revealed that the superficial temporal artery was present. The facial artery (*a. facialis*) forms the largest branch of the external carotid artery. According to H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24] the facial artery branches from the external carotid artery running along the ventral margin of the mandible between the masseter and the digastric muscles. N e j e d l ý [22] found the origin of this artery to be from the maxillary artery. Within this study it was found that the facial artery originated from the maxillary artery but in some cases the origin of the facial artery was from the short common trunk, the linguofacial trunk (*truncus linguofacialis*) with lingual artery. The linguofacial trunk (*truncus linguofacialis*) was observed by P o p e s k o et al. [24]. The glandular branch (*r. glandularis*) is the first branch of the facial artery according to H e b e l and S t r o m b e r g [11] and in this study this branch was present on both sides in all cases. Another branch of the facial artery is the inferior labial artery (*a. labials inferior*) which supplies the lower lip in concurrence with H e b e l and S t r o m b e r g [11]. The commissure of the mouth is supplied by the angular oris artery (*a. angularis oris*), a further branch of the facial artery according to H e b e l and S t r o m b e r g [11]. However, in research done by Nejedlý [22] the angular oris artery is a branch of the inferior labial artery (*a. labialis inferior*). The lateral nasal artery (*a. lateralis nasi*) is the final branch of the facial artery. As described by H e b e l and S t r o m b e r g [11] and C h a g a s [4], the lateral nasal artery originates at the level of the lateral part of the nose before it branches to the nostril and upper lip where they anastomose with the lateral nasal artery coming from the other side of the nose. Returning to the external carotid artery, another branch of it is the lingual artery (*a. lingualis*) which according to P o p e s k o et al. [24] originates from the external carotid artery at the same level as the facial artery. These two arteries form the linguofacial trunk (*tr. linguofacialis*). N e j e d l ý [22] described the origin of the lingual artery as being from the maxillary artery but, according to H e- b e l and S t r o m b e r g [11] the lingual artery originates from the external carotid artery. Within this study it was found that in some cases the origin was from the linguofacial trunk. The lingual artery continues to the root of the tongue where it then becomes the deep lingual artery (*a. profunda linguae*) and this branch was found in all cases which concurs with research conducted by both H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24]. Also, in this research, the dorsal lingual branches (*rr. dorsales linguae*) were found in all cases which again agrees with research by H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24]. The maxillary artery (*a. maxillaris*), as described by H e b e l and S t r o m b e r g [11] and C h a g a s [4] branches from the external carotid artery behind the mandibular joint before continuing along

the mandible and branching to form the alveolar mandibular artery (*a. alveolaris mandibularis*) and pterygoid artery (*a. pterygoidea*). H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24] described that maxillary artery as the main continuation of the external carotid artery. N e j e d l ý [22] observed that the maxillary artery originates from external carotid artery and then it divides into two branches – the external and the internal maxillary arteries. From the maxillary artery originates the transverse facial artery, the buccal artery and the deep temporal artery. Other authors such as H e b e l and S t r o m b e r g [11] and P o p e s k o et al. [24] described the same pattern.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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