Journal of Vascular Medicine

Editorial

Cerebral Arterial System Anatomical Characteristics Associated with High-Altitude Adaptation in Yak and Tibetan Sheep

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Received Date : Aug 09, 2023

Accepted Date : Aug 12, 2023

Published Date : Sep 12, 2023

Yak and Tibetan sheep are the native domestic animals adapted to higher altitude plateau areas, and have showed excellent productivity in harshly cold, low-pressure and low-oxygen environments. The cerebral arterial system supplies nutrients and oxygen to the brain tissue. In order to study the morphological structures and anatomical characteristics of the constituent arteries of the cerebral arterial system in yak and Tibetan sheep, and explore mechanisms of environmental adaptation related to cerebral blood flow and its regulation, this work investigated morphological features, gross anatomic structures, arterial diameters and the superstructure of the cerebral arterioles in yak and Tibetan sheep, and compared differences with those of the low-altitude cattle and sheep vascular corrosion casts and the comparative anatomical methodology.

Results were as follows:

1. The native domestic animals adapted to higher altitude plateau regions are the yak and Tibetan sheep, which have demonstrated excellent productivity in harshly cold, low-pressure, and low-oxygen environments. The cerebral arterial system nourishes and oxygenates brain cells. To investigate the morphological structures and anatomical characteristics of the constituent arteries of the cerebral arterial system in yak and Tibetan sheep, as well as the mechanisms of environmental adaptation related to cerebral blood flow and its regulation, this study investigated the morphological features, gross anatomic structures, arterial diameters, and superstructure of the cerebral arterioles in yak and Tibetan sheep, and compared differences with those.

2. In this study, vascular corrosion casts of the cerebral arterial system from the plateau yak were acquired for the first time. The yak and bovine cerebral arterial systems were separated into three sections: intracranial cerebral arteries, epidural retia mirabile, and extracranial supply arteries. We discovered that the gross morphological characteristics, main arterial formation, and arterial diameters of the two species' cerebral arterial systems were comparable by comparing their basic structure, vessel formation, and arterial diameters. However, yak exhibited unique morphological structures in some anatomical characteristics.The anterior-posterior diameter of the cerebral arterial circle in the yak was shorter than that of cattle (21.44 mm vs. 30.33 mm), the left-right diameter of the posterior circle was wider (20.48 mm vs. 18.98 mm), the vessels of the circle were curvier than that of cattle, and the distance between the cerebral carotid arteries was less (9.32 mm vs. 12.07mm) than that of cattle. The internal diameters of the major cerebral arteries of yak were thinner than those of cattle, but the variations were not statistically significant ($P>0.05$). Yak middle cerebral artery and posterior communicating artery diameters were considerably smaller than those of cattle (P0.05).

3. The yak and cattle epidural retia mirabile was separated into four sections: anterior epidural retia mirabile, posterior epidural retia mirabile, basi-occipital arterial plexus, and anterior V-shaped extension. The morphological characteristics and structural development of the epidural retia mirabile of yak and cattle differed significantly, according to the analysis. To begin, the yak's anterior epidural retia mirabile was broader (33.98 mm vs. 30.23mm) and larger, with more developed posterior joint sections than cattle's. Second, the anterior epidural retia mirabile anastomotic branches in the yak were significantly more plentiful (6.73 vs. 5.22); third, the communicating rami of the posterior epidural retia mirabile were significantly more abundant (6.73 vs. 5.22). (5.43 vs. 3.21).The yak's epidural retia mirabile got blood primarily from five arteries: the maxillary, occipital, vertebral, external ophthalmic, and condylar arteries, which are comparable to cattle arterial sources.

4. The superstructure of the cerebral arterioles differed between yak and bovine. The vascular endothelium of cerebral arterioles in the yak was annular smooth muscle at arteriole diameters less than 100m, implying that the structure can increase blood flow resistance and may play a part in auto-regulating blood pressure. The smooth muscle fibres of the yak cerebral arterioles were more slender and the imprints of the endothelial cell nuclei were more conspicuous than those of cattle at diameters ranging from 100m to 300m.
5. We concluded that the cerebral arterial circle's unique anatomical structure slows blood flow velocity, supplying more nutrients and oxygen to the brain, and that relatively developed intracranial arterial vessels in yak were helpful in supplying more blood to the brain. Yak developed epidural retia mirabile appears to play an important role in buffering and regulating cerebral blood flow to meet the yak's brain's demand for nutrients and oxygen in high-altitude plateau regions. Furthermore, the superstructure of the cerebral arterioles in yak indicated that blood flow resistance was lower and velocity was higher, allowing more blood to reach the brain.

6. In contrast, we discovered only slight variations in the gross anatomical features of the cerebral arterial system between Tibetan and lowland sheep, such as individual cerebral arterial diameters, vessel spread, epidural retia mirabile size, and superstructure of the cerebral arterioles. The Tibetan sheep had a lengthier epidural retia mirabile than lowland sheep (22.99 mm vs. 20.96 mm, P0.05). The posterior communicating artery (1.36 mm) and maxillary artery (2.85 mm) widths were larger in highland sheep than in lowland sheep (1.10 mm vs. 2.18 mm, P0.05). Furthermore, compared to low-land sheep, Tibetan sheep had more developed cerebral arteria branches, greater arterial spread, and more numerous small branches.

7. Tibetan sheep had a slightly bigger cross section of main cerebral arteries per unit weight of brain tissue than low-land sheep (0.020 vs. 0.018), and the ratio of cross section of main cerebral arteries to average body weight was higher in Tibetan sheep than in low-land sheep (0.050 vs. 0.043). In general, we believed that the Tibetan sheep had more developed intracranial cerebral arteries, and it can be inferred that the blood volume serving the brain tissue was more abundant, which could explain the Tibetan sheep's better adaptation to high altitudes.

8. The superstructure of the cerebral arterioles in Tibetan sheep revealed prominent "oval" or "footprint" endothelial cell nuclei imprints with distinct edges at diameters ranging from 60 to 160m. The superstructure of cerebral arterioles in low-land sheep revealed primarily "spindle" endothelial cell nuclei imprints that were not distinct. The Tibetan sheep's cerebral arterioles had thicker smooth muscle fibre impressions and gap imprints at diameters ranging from 200 to 300 m than those of low-land sheep. Tibetan sheep had longer epidural retia mirabile, thicker cerebral arteries, and more developed intracranial cerebral arterial branches, suggesting that their cerebral arterial system was more evolved than that of low-land sheep. Furthermore, endothelial cell nuclei imprints were found in the cerebral arterioles and dense smooth muscle fibre of Tibetan sheep. We hypothesised that Tibetan sheep have greater vessel contraction than lowland sheep. As a result, these anatomical features in Tibetan sheep appear to enable for more efficient

blood supply to brain tissue via the cerebral arterial system and improved cerebral arterial pressure regulation. As a result, we hypothesised that these could be Tibetan sheep morphological mechanisms that enable adaptation to plateau environments.

