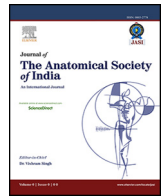




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Original article

# Comparative study of formation of circle of Willis in human and sheep brain

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### ABSTRACT

**Introduction:** Brain is one of the most metabolically active organs of the mammalian body receiving adequate blood supply, which is essential to maintain the glucose and oxygen levels. This demand is derived from circle of Willis (CoW) and its arterial anastomosis at the base of the brain.

To describe the arteries contributing to the formation of CW in sheep brain and to compare it with that of human. Sheep circle of Willis forms an animal model for undertaking further studies on blood supply of certain cranial nerves.

**Method:** In present study, 20 formalin fixed human brains from the Department of Anatomy, Mamata Medical College and 20 fresh sheep brains from local slaughterhouse were obtained. Sheep brain was removed as per the human brain removal procedure, and circle of Willis was studied by Radiological study.

**Results:** In sheep a well-developed four-sided arterial rete called 'Rete Mirabile cerebri' (RMC) was noted at the base of the brain in inter-peduncular fossa. Internal carotid arteries were either vestigial or absent in sheep. Two emergent arteries arising from steady pool of blood from RMC entered the inter-peduncular fossa. These arteries ascended on either side of infundibulum of pituitary gland and then diverged in cranial and caudal directions to form the Circle of Willis.

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## 1. Introduction

The circle of Willis, Willis' circle, loop of Willis, cerebral arterial circle, and Willis polygon is a circulatory anastomosis that supplies blood to the brain and surrounding structures. It is named after Thomas Willis (1621–1675), an English physician.<sup>1</sup>

The brain is particularly susceptible to increased temperature (hyperthermia). To protect the brain from any potential heat stress a number of species have developed protective mechanisms with the ability to selectively cool the brain. This protective system is often referred to as the Rete Mirabile<sup>2</sup> (in animals).

In humans blood supply to the brain is provided by four arteries, two vertebral, and two internal carotid arteries. The branches of these arteries anastomose at the base of the brain around the inter-

peduncular fossa forming a six-sided polygon of arteries called circulus arteriosus.<sup>3</sup> The main blood vessels of the brain and their principal branches lie in the subarachnoid space between the arachnoid and pia mater and smaller vessels ramify on the piamater before sinking in to the substance of the brain.<sup>4</sup>

In sheep common carotid artery usually divides in the retromandibular space at the cranial part of the neck, ventral to first cervical vertebra (Atlas). It divides either in to three branches, i.e. external carotid artery, internal carotid artery, and occipital artery (or) in to two branches with disappearance of internal carotid artery in ruminants.<sup>5</sup>

Internal carotid artery is not well developed in sheep brain. Internal maxillary artery, which is a branch of external carotid artery, contributes to the formation of circle of Willis via the anatomosing ramus. In this situation the basilar artery carries blood away from the circle of Willis (unlike in man). The carotid rete is an intracranial arterial plexus that consists of a large number of short, thin, and parallel arteries that merge into one vessel before leaving the cavernous sinus.<sup>6</sup>

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Emergent artery arises as a single trunk on either side of the carotid rete and divides into cranial and caudal primary branches. The cranial primary branch gives origin to middle cerebral and is continued as cranial cerebral artery. Caudal primary branch traverses backward to give rise to caudal cerebral artery and cranial cerebellar artery. Caudal primary branch continues inward at midline joining the corresponding branch of the opposite side to form basilar artery in the lower part of the midbrain. The union of cranial primary branches and caudal primary branches of opposite side formed a complete circle termed as circle of Willis.<sup>7</sup>

The arrangement of the arteries forming the circle of Willis creates redundancies or collaterals in the cerebral circulation. If one branch of the circle becomes blocked (or) stenosed blood flow from the other blood vessels can often preserve the cerebral perfusion well enough to avoid the symptoms of ischemia.<sup>8</sup>

## 2. Aim and objectives

- 1) To describe arteries contributing for the formation of the circle of Willis in sheep brain.
- 2) To compare the formation of circle of Willis between human and sheep brain.
- 3) To find out the effectiveness of Sheep brain model for human brain experiments.

## 3. Material and methods

### 3.1. Material

20 formalin fixed human brains from the department of anatomy Mamata Medical College, Khammam, 20 fresh sheep brains from local slaughterhouse.

### 3.2. Method

- 1) Dissection method
- 2) Injecting contrast material
- 3) Radiological Method

### 3.3. Procedure

Sheep heads were washed under the running tap water to remove the debris. 10% formalin were injected into right and left common carotid arteries after flushing with normal saline.

Brain removal was done by sawing the calvaria manually 1 cm above the supraorbital margin anteriorly and basilar part of occipital bone posteriorly. In neck region after removing the muscle mass, lamina was chiseled up to 4th cervical vertebra.

Brain was removed along with dura mater (meningeal layer and endosteal layer) to prevent the injury to the arteries. 2% eosin 1 ml and 9 ml of distilled water was injected into basilar artery to observe the fine capillaries after cutting endosteal layer of duramater of sheep brain.

Formation of circle of Willis was observed in both human and sheep brains. Photographs were taken by digital camera (Figs. 1–5).

5 ml of Iopomidal and 5 ml of distilled water were injected into basilar artery after cutting the endosteal layer in both human and sheep brains for radiological study.

## 4. Discussion

Sulman Rahmat, reported modifications in carotid and vertebral artery sources. These modifications include reduction or elimination of either the internal carotid or vertebral arteries, along with a

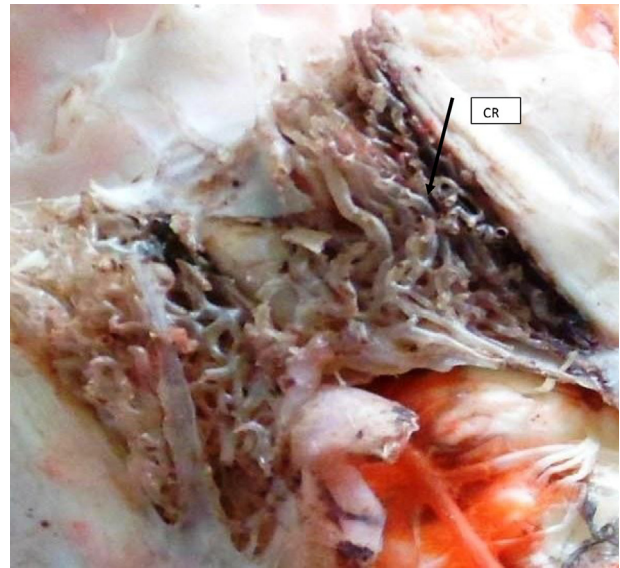


Fig. 1. Rete Mirabile Cerebri in sheep lies on either side of pituitary gland, CR, carotid rete.

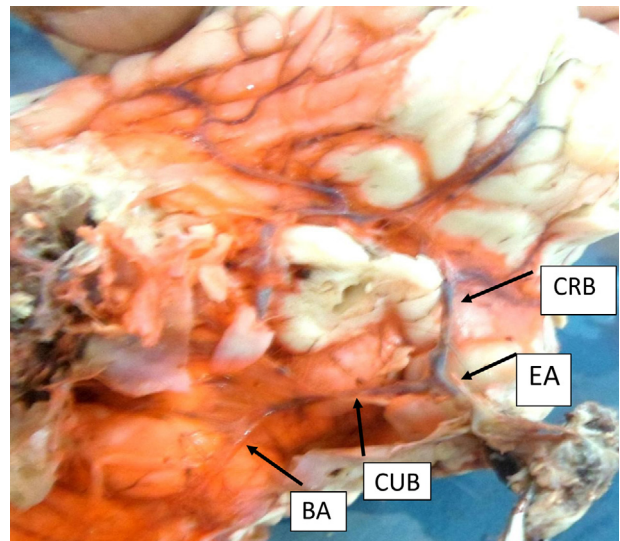


Fig. 2. After cutting the carotid rete identify the emergent artery divides into cranial and caudal branches. EA, emergent artery; CRB, cranial branch; CUB, caudal branch; BA, basilar artery.

variety of anastomotic connections between branches of internal carotid branches and those of the external carotid, stapodial, and their cranial arteries.<sup>9</sup>

Parmeggiani noted that in species like sheep, cat, goat the carotid blood supply to brain is thermally conditioned prior to formation of circle of Willis by countercurrent heat exchange between carotid rete and venous sinuses.<sup>10</sup>

Baldwin described the basilar artery in both sheep and ox having tenuous connections with the vertebral. In both species, the basilar artery tapers caudally and is continued as the ventral spinal artery. Hence basilar artery was regarded as a caudally directed branch of the circle of Willis in both these animals. A well-developed occipito-vertebral anastomosis was reported as marked feature of the cephalic circulation in both sheep and ox.<sup>11</sup>

According to Ashwini<sup>12,13</sup> circle of Willis in sheep was complete due to anastomosis between the two cerebral arteries. This compensation may provided by nature prevents the discrepancy of

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