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Arteries of the Gluteal Region in Macacus cyclopis

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This paper describes the state of origin, branches, course, distribution, etc., of the arteries of the gluteal region of Formosan monkey (Macacus cyclopis), using a relatively large sample of cases. Furthermore, the findings are considered from the statistical aspect for the determination of the standard types.

Although many reports have been made on the vascular system of the lower abdominal and pelvic regions of primates, most are concerned with the major stream or the state of bifurcation of the vessels and moreover involve the study of only a small sample. Likewise, little study has been done on the distribution and course of the peripheral arteries in the gluteal region. This department has been engaged in the statistical, anatomical investigation of as many cases of Macacus cyclopis as possible in order to determine the normal state, in other words the most common condition of the organ systems of this animal. As a part of this program, the author has studied the arteries of the gluteal region which so far have hardly been investigated at all. The results are presented in this report.

MATERIAL AND METHOD

The material consists of 25 bodies (15 male, 10 female) of Macacus cyclopis selected from among the specimen preserved in this department. These animals had been fixed immediately after strangulation by the injection of 10% formalin solution into the A. femoralis and some cases had been injected TEICHMANN's solution.

Both the right and left sides, a total of 50 sides, were studied and detailed gross anatomical inspection was done with the aid of magnifying lenses. The relation with the nerves were considered as well.

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FINDINGS

The gluteal region is primarily supplied by branches from the A. iliaca interna and one portion by branches from the A. iliaca externa (a. femoralis). These arteries may generally be classified into three groups according to their location.

Group 1 includes the A. glutea superior, the A. glutea inferior and the R. muscularis of the A. pudenda interna. These arteries, which are branches of the A. iliaca interna, emerge from the foramen ischiadicum majus and are distributed widely in the proper muscle of the gluteal region. This group provides the main arterial supply to this region. Furthermore, there is anastomosis between these arteries.

Group 2 is made up of the R. profundus of the A. circumflexa femoris medialis which appears in the gluteal region from the lateral side of the tuber ischiadicum and the R. perforans prima of the A. profunda femoris which emerges from the lower edge of the M. adductor magnus and supplies the insertion of the M. gluteus maximus.

Group 3 consists of the R. glutea and R. ascendens of the A. circumflexa femoris lateralis which emerge from the lateral edge of the M. gluteus minimus and supply the M. gluteus medius and M. gluteus minimus, and a branch of the A. profunda femoris which supplies the lateral edge of the insertion of the proper muscle of the gluteal region.

A. Group 1

I. A. glutea superior

In Prosimiae this artery is a branch of the A. caudalis or A. iliolumbalis (Hill), but it said that it ordinarily a ast of A. iliaca interna (Fransen). In Simiae it arises usually from the A. iliaca interna (Zuckerkandl, etc.) and it in Macacus cyclopsis is also a branch from the A. iliaca interna.

As in man, this artery in Macacus cyclopsis is the largest branch of the A. iliaca interna. It runs along the medial side of the N. gluteus superior and after penetrating the plexus lumbosacralis passes through the foramen suprapiriforme to outside of the pelvis. Then, it usually separates into three branches; the R. superior, R. inferior and R. caudalis superficialis.

With regard to the relation with other arteries, it very seldom arises independently. The origin is usually by a common trunk with the A. glutea interna (70%). Moreover, in the majority of these cases, the formation of the common trunk is within the pelvis. Formation of the common trunk outside of the pelvis is rare (10%).

Occasional anastomosis of this artery with the A. pudenda interna (4%) and with the A. glutea inferior (2%) is seen. Such anastomosis is on the lower surface of the M. gluteus maximus in each instance.
1. Branches of the A. glutea superior

(1) R. superior

This branch emerges from the upper lateral edge of the incisura ischiadica major and runs lateralward and upward. It accompanies the upper branch of the N. gluteus superior through the M. gluteus medius which it supplies and extends to the crista iliaca.

(2) R. inferior

This branch emerges from the lateral edge of the incisura ischiadica major and accompanies the lateral branch of the N. gluteus superior latero-downward through the M. gluteus medius and M. gluteus minimus which it supplies. Unlike the nerve, however, it never goes beyond the lateral edge of the upper gluteal muscles to the M. gluteus maximus or the pubic portion of the fascia lata.

(i) The R. inferior gives off a descending branch which accompanies the lower branch of the N. gluteus superior downward along the medial edge of the M. gluteus minimus. This branch mainly supplies the M. gluteus minimus and one part supplies the M. gluteus medius and the M. piriformis. It ends at the lower edge of the M. gluteus minimus but occasionally it may go beyond the lower edge of the M. gluteus minimus to the Mm. gemelli (18%, figure 2 - A) or sometimes it may run lateralward along the lower edge of the M. gluteus minimus to the insertions of the M. gluteus minimus and the M. piriformis where it may anastomose with the A. circumflexa femoris medialis (40%) or with the both the A. pudenda interna and the A. circumflexa femoris medialis (4%).

(ii) Very often, this artery gives off a branch which accompanies the nerve into the ventral surface of the M. piriformis (56%). This branch sometimes is not from this artery but from the R. caudalis superficialis (10%), or directly from the A. glutea inferior (26%). It sometimes was absent (8%).

(iii) The N. ischiadicus receives nutrient vessels at different levels during its course from the foramen ischiadicum majus to the thigh. Frequently, the vessel to the upper part is from the descending branch of the A. glutea superior, that to the middle part from the A. glutea inferior while that to the lower portion is from the R. muscularis of the A. pudenda interna.

(3) R. caudalis superficialis

This artery, after emerging from the foramen suprapiriforme, runs backward from the upper lateral edge of the foramen ischiadecum majus and pierces the adhered portion of the origins of the M. gluteus medius and the M. piriformis. Frequently large branches are given off
to these two muscles (56%). Then, this artery proceeds from the medial edge to the dorsal surface of the M. piriformis where small branches are given off to the M. gluteus maximus, the M. gluteus medius and the M. piriformis. It then penetrates the region of transition of tendon to muscle of the M. gluteus maximus and appears beneath the skin where it becomes the A. caudalis superficialis (54%) (figure 2-A, D). There is considerable variation in the size of this artery. When poorly developed, it terminates on the dorsal surface of the piriformis after supplying the lower surface of the M. gluteus maximus and does not form the A. caudalis superficialis (2%, figure 2-E). In contrast, it may sometimes be well developed and widely distributed to the lower surface of the lower gluteal muscles (22%) or it may accompany the N. cutaneus femoris posterior and go beyond the lower edge of the M. gluteus maximus (22%).

2. Mutual relation between the branches of the A. glutea superior

Review of the mutual relation between the branches of the A. glutea superior, i.e., the R. superior, R. inferior and R. caudalis superficialis, shows that very frequently the R. superior and R. caudalis superficialis emerge from the pelvis by a common trunk (52%). In other cases, the R. superior and R. inferior form a common trunk (22%) or otherwise each branch arises independently (26%).

3. Relation with the plexus lumbosacralis

In Macacus cyclopsis, the plexus lumbalis and the plexus sacralis are combined to form the plexus lumbosacralis which is composed of the seven lumbar and two (S₁, S₂) sacral nerves.

There are Rr. communicans between L₁ and S₁ but the A. glutea superior prior to emerging from the pelvis penetrates the plexus lumbosacralis. The location of the A. glutea superior in relation to the nerve plexus is simple as compared with man and may be classified into five types.

Of these five types, the most common is that in which this artery passes through the triangle formed by L₁ and the Rr. communicans between L₁ and S₁ (49%). Next frequent is passage between L₁ and the R. communicans from S₁ to L₁ (38%).

It is said that in man, this artery usually passes between L₈ and S₁ (A.achi, Kono). The condition in man and Macacus cyclopsis is the same in the sense that this artery passes between the lowest lumbar nerve and the highest sacral nerve.

II. A. glutea inferior

The A. glutea inferior in lower monkey is either absent or very poorly developed and becomes better developed in anthropoid ape and higher animals (Popowsky, Zuckerkandle, etc.). The development of
this artery in *Macacus cyclopsis* likewise is very poor and may occasionally be absent with compensation by other arteries. In *Semnopithecus*, *Cynocephalus*, etc., it very rarely arises directly from the A. iliaca interna as in man. Very frequently it is a branch from the A. glutea superior as in *Macacus rhesus* (IMA).

This artery in *Macacus cyclopsis* frequently arises from the A. iliaca interna by a common trunk with the A. glutea superior within the pelvis (68%) but there are instances in which it arises outside of the pelvis (2%). In addition, there are cases where it may arise independently directly from the A. iliaca interna (9%).

This condition of origin in *Macacus cyclopsis* differs from the condition in man in that independent direct origin from the A. iliaca interna is more frequent (47%) than origin by a common trunk with the A. glutea superior (16.6%) (KONO).

This artery passes along the medial side of the plexus lumbosacralis to the foramen infrapiriforme where it gives off small branches to the M. ischiococcygeus and the M. piriformis and very frequently gives rise to the A. comitans n. ischiadici (54%) after which it separates into the R. interna and R. externa.

The R. externa runs latero-downward and is widely distributed in the lower surface of the M. gluteus maximus. It then extends beyond the lower edge of the M. gluteus maximus to beneath the skin where it may accompany the radix medialis and radix lateralis of the N. cutaneus femoris posterior (32%, figure 2 – D) or give off a branch which goes around the lateral side of the tuber ischiadicum (4%).

The R. interna primarily supplies the Mm. pubofemoralis brevis from both the dorsal and ventral surfaces and may run laterward beneath the N. ischiadicus to the medial edge of the insertions of the M. piriformis and the M. gluteus medius.

Because the A. glutea inferior is poorly developed, it is infrequent that both the R. interna and R. externa are found (22%). Either only the R. interna (18%) or the R. externa (16%) is found and often one may be compensated by another artery. In addition to cases in which it is very small (28%) there may be extreme instances in which the A. glutea inferior may be absent (16%) (figure 2 – A).

1. Compensation by other arteries depending upon the size of A. glutea inferior

As previously mentioned, the A. glutea inferior is smaller than the A. glutea superior. Its size may vary and is often compensated by other arteries.

When the A. glutea inferior is entirely absent, it primarily is compensated by the A. pudenda interna (50%). In other cases it is compensated by the R. caudalis superficialis of the A. glutea superior (25%), or by both the A. pudenda interna and the R. caudalis superficialis (25%) (figure 2 – A).
Even when it is not absent but very small, it may be compensated or supplemented primarily by a branch from the A. pudenda interna (28%). When the R. externa is absent, compensation may be by the R. caudalis superficialis (18%) and the absence of the R. interna may be compensated by the A. pudenda interna (16%).

2. Anastomosis with other arteries

The branch which runs lateralward beneath the N. ischiadicus to the medial edge of the insertions of the M. gluteus medius and the M. piriformis (22%) joins with either the R. profundus (14%) or the posterior branch (4%) of the A. circumflexa femoris medialis while the branch to the Mm. pubofemoralis brevis anastomoses with the R. profundus (14%), or the posterior branch (4%) or both the R. profundus of the A. circumflexa femoris medialis and the A. pudenda interna (12%) or with the A. pudenda interna (6%) on the dorsal surface and occasionally the ventral surface of these muscles. In one case there was additional anastomosis with the R. caudalis superficialis on the lower surface of the M. gluteus maximus.

III. A. pudenda interna

The A. pudenda interna is the principal artery supplying the pudendal region. Among Prosimiae, the A. pudenda interna is absent and compensated by the A. urethrogenitalis in Lemur and Chiromys. Only in primates such as Platyrrhinae and those better developed is the A. pudenda interna present (ZUCKERKANDLE, etc.).

The A. pudenda interna gives off the R. muscularis which supplies the gluteal muscles. The general condition of this artery is as follows. After arising from the A. iliaca interna within the pelvis it descends along the medioventral side of the N. ischiadicus to the foramen infrapiriforme where it emerges out of the pelvis. Occasionally small branches are given off to the medial edge of the lower gluteal muscles and the M. ischiococcygeus and sometimes may give off the A. comitans n. ischiadic, but in most cases such small branches are not given off. At about the middle of its course the large R. muscularis is given off. This artery after giving rise to the R. muscularis leaves the medial edge of the N. ischiadicus and runs mediodownward on the ventral side of the N. ischiadicus and on the medial side of the radix medialis of the puboischiofemoralis to its termination in the fossa ischiorectalis.

The area supplied by the R. muscularis depends upon the degree of development of the A. glutea inferior and the R. caudalis superficialis. When these arteries are very poorly developed or absent, this branch is large and compensates their absence. In all cases, this branch supplies the dorsal and ventral surfaces of the Mm. gemelli. When well developed, it accompanies the N. gluteus inferior and is widely distributed in the lower surface of the M. gluteus maximus as well as
in the M. puboischiofemoralis brevis. Sometimes it may run lateralward beneath the N. ischiadicus to the medial edge of the insertions of the M. gluteus medius and the M. piriformis. Thus, there are cases in which it supplies the medial edge of the insertion of the M. gluteus medius, the Mm. gemelli and the M. gluteus maximus (20%); others in which it is distributed to the medial edge of the insertion of the M. gluteus medius and the Mm. gemelli (16%); some in which it supplies the Mm. gemelli and the M. gluteus maximus (12%) while in others it supplies only the Mm. gemelli (14%).

B. Group 2

IV. A. circumflexa femoris medialis

In primates the level of origin of the A. circumflexa femoris medialis differs depending upon the genus or species. It may be from the A. femoralis, the A. iliacus externa or from the A. iliacus interna. In Macacus cyclops, it most frequently is from the A. iliacus interna (79%) followed in frequency by that from the A. iliacus externa (15%) with rare cases from the A. glutea superior or the A. pudenda interna. In no case did it arise directly from the A. femoralis.

Most often, this artery arises from the A. iliacus interna by a common trunk with the A. obturatoria. After emerging from the lacuna vasorum it divides into the R. superficialis and the R. profundus at the upper edge of the M. obturatorius externus. The R. superficialis further separates into anterior and posterior branches.

The arteries supplying the gluteal muscles are the posterior branch of the R. superficialis and the R. profundus.

1. R. profundus

The R. profundus after it separates from the R. superficialis runs backward on the lower surface of the ramus inferior ossis ischii between the Mm. gemelli and the M. obturatorius externus to the M. quadratus femoris. During its course, a branch (lateral branch) which runs toward the fossa trochanterica and a branch (medial branch) that runs toward the lateral side of the tuber ischiadicum and emerges between the Mm. gemelli and the M. quadratus femoris are given off.

(i) Lateral branch

This branch supplies the Mm. gemelli and the M. obturatorius externus as it passes between these two muscles to the fossa trochanterica where it quite frequently anastomoses with the posterior branch (46%). Very frequently, however, it ascends further along the medial edge of the trochanter major to the medial edge of the insertion of the M. gluteus medius where it anastomoses with other arteries (86%). In such cases, anastomoses with the A. glutea inferior is the most common
(46%) with some cases of union with the A. pudenda interna (26%) or the A. glutea superior (14%). There were some instances in which this branch contributed to the formation of the r. trochanterica (20%) while in some cases this branch was absent (4%).

(ii) Medial branch

This branch runs medio-dorsalward between the Mm. gemelli and the M. quadratus femoris. It supplies these muscles and the M. obturatorius externus as well. Near the lateral edge of the tuber ischiadicum it emerges in the skin and anastomoses with other arteries which descend along the Mm. gemelli and the M. obturatorius medius. In other words, there was in addition to anastomosis with the A. pudenda interna (20%), union with the R. caudalis superficialis of the A. glutea superior (2%) and with the A. glutea inferior (18%).

Furthermore, on the lateral side of the tuber ischiadicum this artery frequently gives rise to a branch which passes around the lateral side of the tuber ischiadicum (58%) and occasionally the A. comitans n. ischiadici is given off (16%). When this artery is large, it compensates the supply by the A. pudenda interna and the A. glutea inferior and may accompany the N. gluteus inferior to be widely distributed in the lower surface of the M. gluteus maximus (10%) or may accompany the N. cutaneus femoris posterior to the subcutaneous region of the dorsal side of the thigh (38%).

2. Posterior branch

This artery primarily supplies the M. quadratus femoris and the flexor muscles of the thigh, and does not contribute much to the supply of the gluteal region. In other words, this artery runs backward between the M. quadratus femoris and the M. obturatorius externus and then enters the M. quadratus femoris. However, a branch is given off which enters the fossa trochanterica and ascends along the medial side of the femur. It may anastomose with the R. profundus (48%) and ascend further to the medial edge of the insertion of the M. gluteus medius.

In other cases there may be anastomosis with the A. glutea superior (8%), the A. glutea inferior (4%) or the A. pudenda interna (6%).

Frequently, a twig contributes to the formation of the rete trochanterica (26%) and in very rare cases there is the A. comitans n. ischiadici (2%).

V. A. perforans prima of the A. profunda femoris

This artery is a branch of the A. profunda femoris. At the level of the lower edge of the insertion of the gluteal muscles into the femur, it runs backward between the partes cranialis and intermedius of the M. adductor magnus to the flexor muscles of the thigh. A branch is given
off which ascends to the medial edge of the insertion of the M. gluteus maximus into the femur.

There may be cases in which this branch may ascend farther to the dorsal surface of the M. quadratus femoris (14%), or it may contribute to the formation of the rete trochanterica (26%) or send off the A. comitans n. ischiadici (2%).

C. Group 3

VI. A. circumflexa femoris lateralis

This artery very rarely is a single vessel such as in man but more often arises as several arteries (71%). In man this artery is a single vessel and arises from the A. profunda femoris. In Macacus cyclopsis when it is a single vessel it arises directly from the A. femoralsis or the A. profunda femoris at about equal frequency. When it is several branches it most often is from the A. profunda femoris in contrast to the condition in man. Thus, it may be said that in Macacus cyclopsis this artery arises from the A. profunda femoris as several branches.

Furthermore, there is much variation in the course as well as the state of origin of this artery. In most cases, however, it ascends along the lateral edge of the M. iliacus between the M. rectus femoris and the M. tensor fasciae latae. During its course small branches are given off to the M. sartorius, M. tensor fasciae latae and M. rectus femoris.

A small branch which emerges onto the M. gluteus minimus and M. tensor fasciae latae from the lateral edge of the M. rectus femoris at the level of the apex of the trochanter major accompanies the terminal part of the lateral branch of the N. gluteus cranialis to the lower surface of the M. gluteus maximus, the M. gluteus medius, the lateral edge of the M. gluteus minimus and the M. tensor fasciae latae. After it gives off a twig which ascends along the dorsal surface of the origin of the M. tensor fasciae latae, the main branch supplies the M. gluteus medius and terminates in the lower surface of the M. gluteus minimus.

VII. A. profunda femoris

This artery is the largest of the Rr. muscularis of the A. femoralsis and arises from the lateral or dorsal surface of the A. femoralsis (82%). It primarily is distributed in the adductor and flexor muscles of the thigh but a branch is sent off which supplies the gluteal muscle.

In other words, this artery emerges between the M. adductor magnus and the M. adductor brevis, and after giving off the Aa. perforantes, supplies the M. adductor magnus. Then, after penetrating this muscle, it further supplies the flexor muscles of the dorsal surface of the thigh and a branch is given off which emerges at the lateral edge of the M. gluteus minimus from the space formed by the M. gluteus minimus, the lateral femoral muscle and the M. rectus femoris.
This branch supplies the M. tensor fasciae latae and the M. gluteus minimus, the M. gluteus medius and the insertion of the M. gluteus maximus. It further extends beyond the lateral edge of the insertion of the M. gluteus medius to the anterior and posterior sides of the trochanter major and contributes to the formation of the rete troCHANT-ERICA.

SUMMARY

The arteries of the gluteal region in *Macacus cyclops* may be classified into three groups according to their distribution. When viewed in relation to the state of origin, the main supply is provided by branches of the A. iliaca interna with one portion supplied by branches from the A. iliaca externa (A. femoralis).

I. A. glutea superior

This is the largest branch of the A. iliaca interna and usually appears from the foramen ischiadicum majus by a common trunk with the A. glutea inferior. It separates into the R. superior which supplies the M. gluteus medius, and the R. inferior which supplies the M. gluteus medius, the M. gluteus minimus and one part of the M. piriformis, as well as the R. caudalis superficialis which supplies the M. gluteus maximus, the M. gluteus medius and the M. piriformis. The distribution and course of the R. caudalis superficialis is determined by the size of the A. glutea inferior.

Before this artery emerges from the foramen ischiadicum majus, it penetrates the Tr. lumbosacralis. Most often this penetration is through the triangle formed by the Tr. lumbosacralis and the Rr. communicans between the truncus and the N. sacralis.

II. A. glutea inferior

This artery separates into the R. interna and the R. externa which are widely distributed in the M. ischiococcygeus and the M. piriformis. Such typical cases, however, are few and frequently it is compensated by the R. musclraris of the A. pudenda interna and the R. caudalis superficialis of A. glutea superior. There often is anastomosis with the A. circumflexa femoris medialis and the A. pudenda interna.

III. A. pudenda interna

This is a branch of the A. iliaca interna which supplies the M. gluteus minimus and the M. ischiococcygeus. Frequently, a large muscular branch is sent off, but this branch may compensate the A. glutea inferior by extending to the medial edge of the insertion of the M. gluteus medius, or accompany the N. cutaneus femoris posterior to
the subcutaneous region on the dorsal side of the thigh, or accompany the N. gluteus inferior to the lower surface of the M. gluteus maximus, or give off the A. comitans n. ischidici.

IV. A. circumflexa femoris medialis

This artery is a branch of the A. iliaca interna and frequently arises by a common trunk with the A. obturatoria. It separates into the R. profundus and the R. superficialis. The gluteal region is supplied by the R. profundus and the posterior branch of the R. superficialis.

The R. profundus supplies the M. quadratus femoris after giving off a branch which runs lateralward between the Mm. gemelli and the M. obturatorius externus, and a branch which runs medialward between the Mm. gemelli and the M. quadratus femoris. The branch which runs lateralward anastomoses with the posterior branch at the fossa trochanterica or it may anastomose with the A. pudenda interna at the medial edge of the insertion of the M. gluteus medius. The branch which runs medialward may compensate the A. glutea inferior or the A. pudenda interna and comparatively frequently extends to the lower surface of the M. gluteus maximus or to the subcutaneous region of the posterior side of the thigh.

The posterior branch primarily supplies the M. quadratus femoris but frequently gives off a branch which contributes to the formation of the rete trochanterica.

V. A. perforans prima of the A. profunda femoris

The main branch supplies the flexor muscles of the thigh but small twigs are given off which supply the insertion of the M. gluteus maximus.

VI. A. circumflexa femoris lateralis

This artery frequently arises from the A. profunda femoris as several branches. It supplies the tensor fasciae latae as well as the upper lateral edge of the M. gluteus maximus, the M. gluteus medius and the M. gluteus minimus. There is much variation in its origin and course.

VII. A. profunda femoris

This is the largest branch of the A. femoralis and mainly supplies the adductor and flexor muscles of the thigh. Branches are sent off to the lower lateral edge of the M. gluteus maximus, the M. gluteus medius and the M. gluteus minimus after which it contributes to the formation of the rete trochanterica.
REFERENCES

Fig. 1 Blood vessels of the gluteal region
Fig. 2  The compensative interrelation among the R. descendens (A. glutea superior), R. caudalis superficialis, A. glutea inferior, A. pudenda interna, A. circumflexa femoris medialis (R. profundus and R. posterior) and the A. perforans prima (A. profunda femoris).

(A) Absence of the A. glutea inferior.  (B) Absence of the R. muscularis in the A. pudenda interna.  (C) Absence of the R. muscularis in the A. pudenda interna, and the A. perforans prima is large.  (D) Absence of the R. muscularis in the A. pudenda interna.  (E) The R. caudalis superficialis is small, and the R. profundus is large.