

A. femoralis and its Branches in *Macacus cyclopsis*

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In this investigation, gross anatomical inspection and statistical study were done on 100 limbs of 50 Formosan monkeys in order to ascertain the standard type of division and distribution of the A. femoralis. This arteria and its branches as well as their relations to the nerves were described in detail and a classification into the types of division were made. In addition the findings were compared with the findings in other primates.

In spite of the numerous anatomical studies on the arteries of the thigh in primates, very few have been concerns with the study of a large sample of one species. Inasmuch as most of the investigations that have been done involve a small number of cases, it is dangerous to ascertain and establish the characteristic type or ground type for the species because it would be impossible to avoid errors due to individual differences or variations in the study of a small number of cases.

Because of this belief, a statistical investigation is being done in this department, under the supervision of Prof. J. SATOH, on a large samle of *Macacus cyclopsis* in order to ascertain and establish the standard condition (type) of various characteristics of this animal.

This paper is concerns with one aspect of this study involving the investigation of the origin, branches, course and distribution of arteries of the thigh and their relations to the nerves. In addition, a comparison was made with the findings that have been reported for primates.

MATERIAL AND METHOD

The material consisted of both lower limbs of 50 *Macacus cyclopsis* (26 male, 24 female). All animals, after capture and strangulation, had been injected 10 % formalin into the femoral artery and preserved in 10 % formalin solution. Injections of dye had been given into the blood vessels of some of the animals. Gross anatomical inspection was done with a dissecting knife and tweezers. Binocular loupes were used when necessary. In cases in which dye had not been injected,

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repeated injections of dye was given into the local blood vessels at time of dissection to facilitate exploration of the smaller branches.

FINDINGS AND CONSIDERATION

The A. femoralis is the main artery which supply the lower extremity, and is the continuation of the A. iliaca externa and located medial to the M. iliopsoas.

It appears on the anterior surface of the thigh from beneath the Arcus cruralis. It descends in the Fossa iliopectinea and divides into its terminal branches, the A. saphena and A. poplitea, usually at the level of the lower third of the thigh immediately in front of the so-called Canalis adductorio-flexorius (BLUNTSCHLI). During its course superficial branches (subcutaneous arteries) to the lower inguinal region, lower abdomen, pudendum, and hip are given off in addition to the large muscular branches to the extensor, adductor and flexor muscles of the upper thigh. Further down, it divides into its terminal branches, the A. saphena and A. poplitea. In the vicinity of this bifurcation, small muscular branches as well as cutaneous branches and articular branches to the medial part of the knee are given off.

The branches given off prior to the division of the A. femoralis into the A. saphena and A. poplitea were called the proximal branches while those given off more distal were termed the distal branches by BLUNTSCHLI. I have also followed this classification.

1. ARTERIAL BRANCHES IN THE UPPER THIGH

The superficial subcutaneous arteries and the deeper A. profunda femoris and A. circumflexa femoris lateralis are given off in the upper half of the thigh, before the division of the A. femoralis into its two major terminal branches, the A. saphena and A. poplitea.

A. Superficial branches (subcutaneous arteries) (Fig. 1)

The A. femoralis, after emerging on the upper anterior surface of the thigh from beneath the Arcus cruralis, soon gives off superficial branches or subcutaneous arteries including the A. epigastrica superficialis, A. circumflexa ilium superficialis and A. pudenda externa superficialis (Table 1).

1) The *A. epigastrica superficialis*, which is the smallest of these arteries, passes over the Arcus cruralis, ascends in the Fascia abdominalis superficialis and supplies the anterior abdominal wall.

The *A. circumflexa ilium superficialis* which is the largest branch runs toward the upper lateral side of the thigh after giving off the Rami inguinales. One part runs toward the Spina iliaca anterior superior to supply the lateral side of the thigh and another part accompanies the

Fig. 1 Superficial branches of the A. femoralis
(Right, ventral view)



1. A. epigastrica superficialis
2. A. circumflexa ilium superficialis
3. A. pudenda externa superficialis superior
4. A. articularis genu suprema
5. A. musculocutaneous distalis (R. cut.)
6. A. pudenda externa superficialis inferior

N. cutaneous femoris lateralis and supplies the subcutaneous region of about the upper two thirds of the anterior surface of the thigh.

The *A. pudenda externa superficialis superior* most often forms a common trunk with the *A. epigastrica superficialis*. It runs medialward in front of the V. femoralis and supplies the upper medial side of the thigh, penis, labialis, and anterior surface of the scrotum.

2) These superficial branches usually arise from the A. femoralis by either a common trunk or independently. In some cases, the A.

Table 1.
The origin of the Rr. superficiales a. femoralis
(Cases exxermined : 50 cadavers, 100 fall)

situation of origin		single, independent									formation of common trunk								
arised from	rising artery	A. epig. superf.			A. circ. ili. superf.			A. pud. ext. superf. sup.			A. epig. superf. + A. circ. ili. superf.			A. epig. superf. + A. pud. ext. superf. sup.			A. epig. superf. + A. circ. ili. superf. + A. pud. ext. superf. sup.		
		r.	l.	to-tal	r.	l.	to-tal	r.	l.	to-tal	r.	l.	to-tal	r.	l.	to-tal	r.	l.	to-tal
		4	6	10	24	16	40	19	15	34	10	7	17	25	28	53	2	6	8
					10	8	18				1	0	1	1	0	1			
					2	11	13				1	2	3						
		3	0	3										3	1	4			

epigastrica superficialis and A. circumflexa ilium superficialis may arise from the A. profunda femoris and A. circumflexa femoris lateralis while in other cases the A. epigastrica superficialis may arise from the A. circumflexa femoris medialis.

3) Of these three superficial branches, the A. circumflexa ilium superficialis most frequently arises by an independent origin (71%), usually from the A. femoralis with some cases arising from the A. profunda femoris or A. circumflexa femoris lateralis. Independent origin of the A. pudenda externa superficialis also is frequent (34%) whereas independent origin of the A. epigastrica superficialis is the least common (13%).

Conversely, the formation of a common trunk is most frequent (58%) between the A. epigastrica superficialis and A. pudenda externa superficialis which form the Truncus pudendo-epigastricus. Next frequent is the formation of a common trunk by the A. epigastrica superficialis and A. circumflexa ilium superficialis (21 %).

The formation of a common trunk, the Truncus subcutaneous communis, by the union of all three branches is said to be the usual condition in lower monkey by such investigators as POPOWSKY, BLUNTSCHELI and MANNERS-SMITH but was found to be the least frequent in my cases of *Macacus cyclopsis* (8%). The Truncus pudendo-epigastricus usually arises from the A. femoralis (53 %), but there are some cases in which it arises from the A. profunda femoris (1%) or from the A. circumflexa femoris medialis, which originates from the A. iliaca interna (4%). In most cases in which the A. epigastrica superficialis and A.

circumflexa ilium superficialis form a common trunk, the origin was from the A. femoralis (17%). In other cases, it arose from the A. profunda femoris (1%) or the A. circumflexa femoris lateralis (3%). The Truncus subcutaneous communis was in all cases from the A. femoralis.

In man, these subcutaneous arteries arise mainly from the A. femoralis but occasionally they may arise from the main branch of the A. femoralis. In the majority of cases, the A. epigastrica superficialis and A. circumflexa ilium superficialis arise by a common trunk and the A. pudenda externa arises independently. Next frequent is the independent origin of each of the three branches. The formation of the Truncus pudendo-epigastricus or the Truncus subcutaneous communis is said to be rare (ADACHI, SHIMADA). Thus, the situation of the formation of a common trunk in man is considerably different from that in *Macacus cyclopsis*.

4) In addition to the above three superficial arteries, the A. epigastrica inferior and A. pudenda externa profunda also arise from the A. femoralis, immediately below the Arcus cruralis in some of the cases.

The A. epigastrica inferior and A. pudenda externa profunda are said to usually arise from the A. iliaca externa or A. circumflexa femoris medialis within the pelvis in almost all primates although they occasionally are seen arising from the A. femoralis in *Ateles*, *Cebus*, *Chimpanzee* and man (MANNERS-SMITH, SONNTAG, ADACHI).

In *Macacus cyclopsis*, the A. epigastrica inferior arises from the A. iliaca externa by a common trunk with the A. pudenda externa profunda in the majority of cases (63%). Next frequent is the origin from the A. circumflexa femoris medialis (17%) with some cases arising from the A. femoralis (13%). There are cases in which the A. epigastrica inferior and A. pudenda externa profunda arise independently from the A. femoralis or A. circumflexa femoris medialis but such instances are very rare.

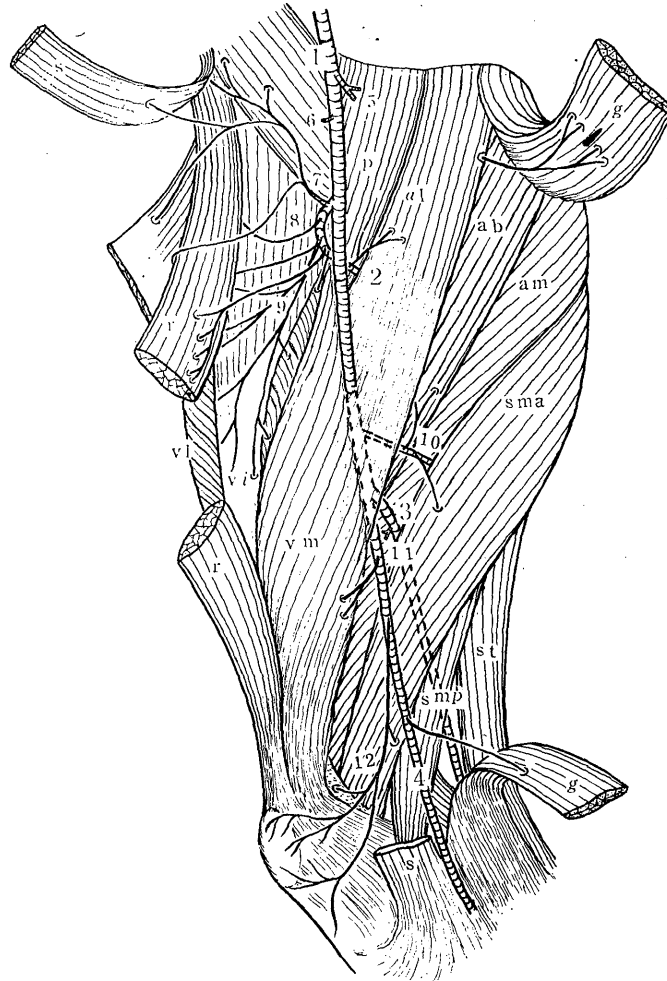
B. Deep branches

The deep branches in *Macacus cyclopsis* include the A. profunda femoris and the A. circumflexa femoris lateralis which arise in most cases from the A. femoralis in close relation to each other.

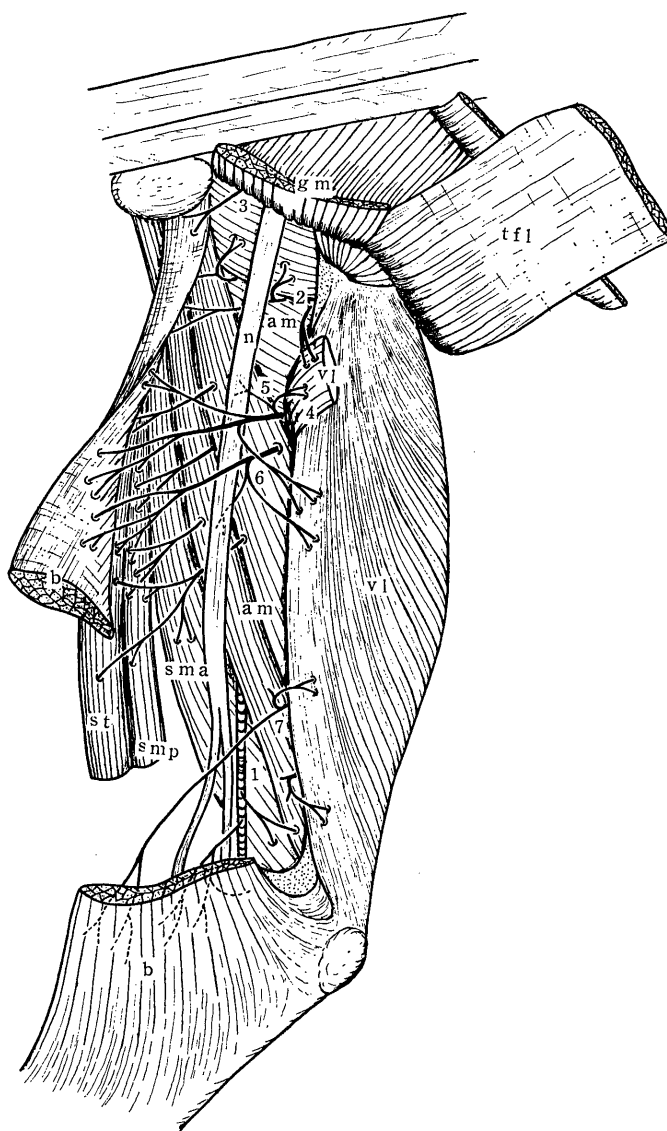
1) A. profunda femoris

This artery, the largest of the major branches of the A. femoralis, arises chiefly from the lateral or posterior surface of the A. femoralis (82%) and descends in a medialward direction in the Fossa ilipectinea. Slightly below the middle of the upper edge of the M. adductor longus, it enters between the M. pectineus and the M. adductor longus. Occasionally, during its course, small branches are given off to the

Fig. 2 A. femoralis and its branches (Right thigh, ventro-medial view)



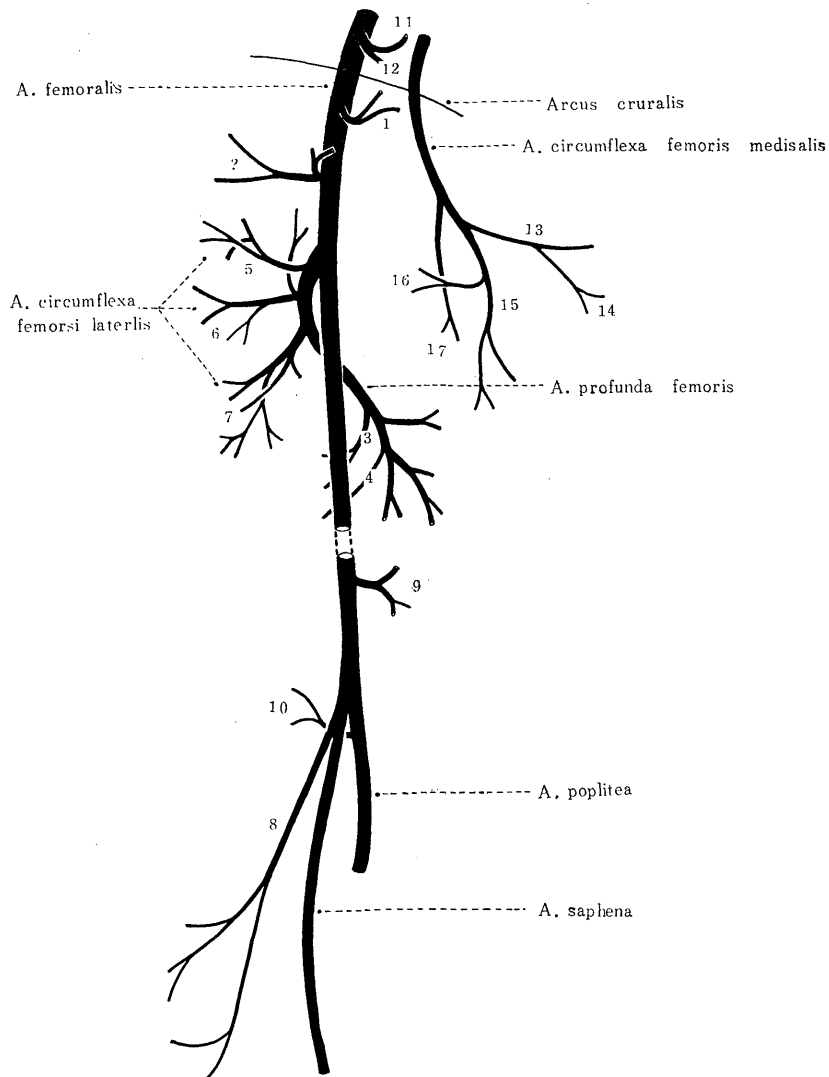
- | | |
|---|------------------------------------|
| 1. A. femoralis | 11. A. perforans distalis |
| 2. A. profunda femoris | 12. A. articulatio-genu suprema |
| 3. A. poplitea | ab. M. adductor brevis |
| 4. A. saphena | al. M. add. longus |
| 5. Truncus pudendo-epigastricus | am. M. add. magnus |
| 6. A. circumflexa ilium superficialis | g. M. gracilis |
| 7. R. glutealis (A. circumflexa femoris lateralis) | p. M. pectineus |
| 8. R. ascendens (A. circumflexa femoris lateralis) | r. M. rectus femoris |
| 9. R. descendens (A. circumflexa femoris lateralis) | s. M. sartorius |
| 10. A. musculo-cutaneous distalis | sma. M. semimembranosus accesorius |
| | smp. M. semimembranosus proprius |
| | st. M. semitendinosus |

Fig. 3 A. femoralis and its branches (Right thigh, dorso-lateral view)

1. A. poplitea
2. R. posterior (A. circumflexa femoris medialis)
3. R. profundus (A. circumflexa femoris medialis)
4. A. perforans prima (A. profunda femoris)
5. A. commitans n. ischiadici (A. profunda femoris)
6. A. perforans secunda (A. profunda

- femoris)
7. A. perforans distalis
- am. M. adductor magnus
- b. M. biceps femoris
- gm. M. gluteus maximus
- sma. M. semimembranosus accessorius
- smp. M. semimembranosus proprius
- st. M. semitendinosus
- tfl. M. tensor fascia lata
- vl. M. vastus lateralis

Fig. 4 Arteries of the thigh (Right, ventral view)



- | | |
|--|--|
| 1. Truncus pudendo-epigastricus | 9. A. musculocutaneus distalis |
| 2. A. circumflexa ilium superficialis | 10. A. perforans distalis |
| 3. A. perforans prima (A. profunda femoris) | 11. A. epigastrica inferior |
| 4. A. perforans secunda (A. prof. f.) | 12. A. pudendalis externa profundus |
| 5. R. glutealis (A. circumflexa femoris lateralis) | 13. R. superficialis (A. circumflexa femoris medialis) |
| 6. R. ascendens (A. circumf. f. 1.) | 14. R. ventralis (A. circumf. f. m.) |
| 7. R. descendens (A. circumf. f. 1.) | 15. R. dorsalis (A. circumf. f. m.) |
| 8. A. articularis genu suprema. | 16. Rr. acetabuli (A. circumf. f. m.) |
| | 17. R. profundus (A. circumf. f. m.) |

muscles on each side. After entering the space between these two muscles, the A. profunda femoris gives off a small ascending branch which supplies the posterior surface of the M. pectineus and the pars superior of the M. adductor brevis. The continuation of the A. profunda femoris (A. profunda propria) proceeds in the space formed by the M. adductor magnus and the pars inferior of the M. adductor brevis. After giving off the Aa. perforantes prima and secunda, it is widely distributed to the M. adductor magnus. One portion penetrates the M. adductor magnus and ends in the flexor muscles of the posterior surface of the thigh and the gluteal region.

The *A. perforantes prima* is regarded as the continuation of the A. profunda. It gives off the A. nutricia femoris and periosteal artery on the posterior surface of the femur and appears on the latero-dorsal side of the thigh from between the insertion of the pars superior (M. adductor minimus) and pars inferior of the M. adductor magnus. The main branch supplies the M. biceps femoris (caput longum) while small branches are sent to the origin of other flexor muscles and the insertions of the M. quadratus femoris, M. vastus lateralis and M. gluteus maximus into the femur.

The *A. perforantes secunda* most frequently arises as the lateral branch of the A. perforantes prima, but occasionally it may arise more distally, from the A. profunda propria. It penetrates the pars inferior of the M. adductor magnus in a downward and lateralward direction to supply the flexor muscles. This artery is slightly smaller than the A. perforantes prima.

Extremely fine *A. comitans nervi ischiadici* are seen extending from both.

Although it is not infrequent for such branches to be given off from the A. profunda femoris as it runs through the fossa iliopectinea, the lateral branches all follow the same course as the main branch of the M. profunda femoris in the space between the muscles. Unlike in man, the main branch in most cases winds through the space between the muscles to the flexor muscles and only the peripheral branches penetrate the adductor muscles.

The above course and distribution of the A. profunda femoris in *Macacus cyclopsis* is similar to that reported for other catarrhine.

Just as there are racial differences in the level of origin of the A. profunda femoris in man, there are differences in primates by Genus and the height of origin is said to be farther down in lower monkeys. After the method of BLUNTSCHLI, the A. femoralis, from the Arcus cruralis to the division of the A. saphena and the A. poplitea, was separated into 20 segments. The height (region) of origin of the A. profunda femoris in *Macacus cyclopsis* was studied in relation to these segments. In most instances, the origin was between the third to sixth

segments but there were rare occasions in which comparatively high origin at the level of the second segment or low origin at the eighth segment occurred. However, origin from as high as the A. iliaca externa, said to be noted in man, was found in no case.

The average level of origin in *Macacus cyclopsis* was the fifth segment. This is slightly higher than that reported by BLUNTSCHLI for macaques and generally the same as in *Cercopithecus*, but slightly lower than in *Semnopithecus* (table 2).

Table 2.
Region of the origin of A. profunda femoris
(A. femoralis separated into 20 segments)

material \ height of origin	2 seg.	3 seg.	4 seg.	5 seg.	6 seg.	7 seg.	8 seg.	average	examined cases
<i>Macacus cyclopsis</i> (Tu)	1	16	27	28	13	9	6	5 (seg.)	100
Lemur (Bluntschli)		2	1	3	1			4	7
<i>Papio</i> and <i>Cynopithecus</i> (Bluntschli)		2	1	2	7	3		6	15
<i>Macacus</i> (Bluntschli)		3	1	3	5	4	2	6	18
<i>Cercocebus</i> (Bluntschli)				1	1			5 or 6	2
<i>Cercopithecus</i> (Bluntschli)	1	4	3	7	4	2	1	5	22
<i>Semnopithecus</i> (Bluntschli)	5	9	2	1				3	17

Table 3.
Origin of A. profunda femoris
(relations of A. prof. f. with other arteries)

material \ situation of origin \ region of origin	independent, without relation to A. circumfl. f. lat.		independent, close proximity to A. cir. f. lat.		A. prof. f. gives off A. circumfl. f. lat. on its main branches		total cases examined
	2-5 seg.	6-8 seg.	2-5 seg.	6-8 seg.	2-5 seg.	6-8 seg.	
<i>Macacus cyclopsis</i> (Tu)	7	10	3	4	62	14	100
Lemur (Bluntschli)	6	1					7
<i>Papio</i> (Bluntschli)	1	9	2		2		14
<i>Cynopithecus</i> (Bluntschli)		1					1
<i>Macacus</i> (Bluntschli)	1	4	2	4	4	3	18
<i>Cercocebus</i> (Bluntschli)	1	1					2
<i>Cercopithecus</i> (Bluntschli)	2	5	4	1	9	1	22
<i>Semnopithecus</i> (Bluntschli)			12		5		17

When the average height of origin is observed by sex, it is the fifth segment in males and the fourth segment in females indicating that it is higher in females. This is the same as the relation in man but a difference by side such as demonstrated in man was not noted.

Review of the relations of this artery with other arteries shows that it is most closely related to the A. circumflexa femoris lateralis, which usually arises entirely or partially from this artery (76 %). The relation between these two arteries is closer in cases in which the A. profunda femoris arises from the upper part of the A. femoralis than when it arises from the lower part (table 3).

The origin is extremely high in *Macacus cyclopsis* although the above relation is similar to that noted by BLUNTSCHLI in catarrhine, excluding *Semnopithecus*. This artery is said to be closely related to the A. circumflexa femoris medialis in man, *Anthropoides*, *Semnopithecus*, etc. However, hardly any relation was noted between the two in *Macacus cyclopsis*. Only an anastomosing branch between the two was seen.

2) *A. circumflexa femoris lateralis*

This artery usually arises from the A. profunda femoris by several stems in the majority of cases or frequently as a single branch. In some cases it arises from the A. femoralis and in some other cases the origin is from both the A. femoralis and A. profunda femoris. This artery divides into the R. glutealis, R. ascendens (R. trochantericus, BLUNTSCHLI) and the R. descendens. The state of origin of these branches and the relations to the nerves is highly variable.

(1) The origin and course of the R. glutealis is much more variable than in the other two branches and frequently gives rise to the A. circumflexa ilium superficialis (13 %). This arterial branch, immediately after it arises, passes over the origin of the M. rectus femoris and proceeds in a lateralward and upward direction between the M. sartorius and M. rectus femoris, to which small branches are given off. It then supplies the M. tensor fasciae latae, M. iliopsoas and the gluteal muscles.

(2) The R. ascendens (R. trochantericus) most frequently is the lateral branch of the R. descendens (65%). It passes beneath the origin of the M. rectus femoris, runs slightly lateralward and upward, and after giving rise to small branches to the origin of the M. vastus medialis and lateralis and to the insertion of the M. iliopsoas as well as sending off the R. articularis to the hip joint, it ends in the gluteal muscles and M. tensor fasciae latae.

(3) The R. descendens is the largest of the three branches. Like the R. trochantericus, it passes beneath the M. rectus femoris and runs downward and lateralward between the M. rectus femoris and the M.

Table 4.
Situation of the origin of A. circumfl. fem. lat.

material	situation of origin total cases	a single A. circumfl. fem. lat.	2 or more A. circumfl. fem. lat.	as a simple A. circumfl. f. lat. arises from				as several Aa. circumfl. f. lat. arises		
				Truncus profundo- circumfl. perfect.	A. prof. f.	A. femoralis, close to A. prof.	A. femoralis, without relation to A. prof.	all from A. prof. f.	all from A. femoralis	partly from A. prof. and partly from A. femoralis
Macacus cyclopsis (Tu)	100	29(29%)	71(71%)		12(41%)	1(3.4%)	16(55.6%)	43(61%)	7(10%)	21(29%)
Lemur (Bluntschli)	7	7(100%)					7(100%)			
Papio (Bluntschli)	14	8(57%)	6(43%)			2(25%)	6(75%)	2(33%)	4(64%)	
Macacus (Bluntschli)	18	8(44%)	10(56%)		1(12.5%)	3(37.5%)	4(50%)	4(40%)	4(40%)	2(20%)
Cercopithecus (Bluntschli)	22	16(73%)	6(27%)		5(31%)	3(19%)	8(50%)	2(33%)	1(17%)	3(59%)
Semnopithecus (Bluntschli)	17	4(23.5%)	13(76.5%)	2(50%)	1(25%)	1(25%)			4(30%)	9(70%)
Homo (Bluntschli)	100	72(72%)	28(28%)	58(80%)		7(9.7%)	7(9.7%)	8 (29%)	7(25%)	13(46%)

vastus medialis. It ends in the central part of the medial side (femoral surface) of the M. vastus intermedius and M. vastus lateralis, but a small branch penetrates these muscles and descends to the knee. This arterial branch gives rise to muscular branches to the M. rectus femoris and M. vastus medialis as well as cutaneous branches to the lower anterior surface of the thigh. In rare cases, however, these branches may arise independently from the A. femoralis or the A. profunda femoris.

(4) From whichever artery it may arise, the origin of this artery is either as a single A. circumflexa femoris lateralis (29 %) or as a number of Aa. circumflexa femoris lateralis (71%). Instances of single origin is less frequent. Single origin as used here means that the origin of the three branches, R. glutealis, R. ascendens and R. descendens, is by a single trunk from the A. profunda femoris or the A. femoralis. According to the report of BLUNTSCHLI, this single origin is the common type in Lemur, Cercopithecus and man while in macaques single origin and other types are seen in about an equal number of cases. However, the frequency of single origin in my cases of Macacus cyclopsis was very similar to that in Semnopithecus (Table 4).

i) This single origin, as in other lower macaques, occurred most frequently from the A. femoralis unrelated with the A. profunda femoris (55.6 %). Next frequent was the origin from the A. profunda femoris (41 %). However, the type in which the A. profunda femoris, A. circumflexa femoris lateralis and medialis from a common trunk, in other words the type in which the A. circumflexa femoris lateralis arises from the Truncus profundocircumflexus perfectus, which is the most common type in man and most frequently seen in Semnopithecus, was seen in no case.

Origin from the A. femoralis adjacent to the A. profunda femoris was found in only one case in Macacus cyclopsis (3.4%). In contrast to this, the fact that such an origin was seen at a considerable frequency among macaques by BLUNTSCHLI (37.5%) while origin from the A. profunda femoris was comparatively few (12.5 %) is noteworthy, but this difference perhaps is due to the size of the study sample. In no case was the origin from the A. femoralis more distal than the site of separation of the A. profunda femoris.

The level of the single origin of the A. circumflexa femoris lateralis from the A. femoralis was between the second and eighth segments, but most frequently between the third to fifth segments. This is similar to the report of BLUNTSCHLI for Cercopithecus and is slightly higher than in macaques. In Macacus cyclopsis, the origin occurred adjacent to the A. profunda femoris at the level of the fifth segment in only one case. In contrast to this, in cases of single origin

from the A. profunda femoris, the highest (medial) origin was at the second segment which is similar to the results of BLUNTSCHLI for *Cercopithecus* and lower than that in *Semnopithecus* but higher than in macaques (Tables 4, 5, 6).

ii) Origin as several so-called Aa. circumflexae femoris laterales is very frequent in *Macacus cyclopsis* (71 %) and the ratio to single origin is completely opposite to that in man. According to the investigation by BLUNTSCHLI, among catarrhine, the frequency of both instances is about equal in *Papio* and macaques, and single origin which is the human type is more frequent in *Cercopithecus* while in *Semnopithecus* single origin is infrequent as in my study of *Macacus cyclopsis*. In cases that show this type of division, all branches most frequently were from the A. profunda femoris (61 %). Next frequent was cases in which one part separated from the A. profunda and one part was from the A. femoralis (29 %). Cases in which all branches arose from the A. femoralis were very rare (10 %). Such a relationship in frequency cannot be seen in any other catarrhine (Table 4).

(5) The relations of the Aa. circumflexae femoris laterales to nerves and level of origin are as follows.

i) The course of the A. femoralis in the thigh accompanies the N. saphenus. The A. circumflexa femoris lateralis which is a branch of the A. femoralis is particularly closely related to the N. saphenus and N. m. vasti medialis. As previously described by other investigators, there is some difference in the condition between man and lower macaques.

In my study of *Macacus cyclopsis*, it was found that the N. saphenus and Nn. cutanei femoris anteriores form a group which accompany the A. femoralis, whereas the N. m. vasti medialis accompanies the other fasciculi to the M. quadriceps as is the condition in other lower macaque. Thus, the N. saphenus does not necessarily accompany the N. m. vasti medialis in *Macacus cyclopsis* and the relation of these two to the A. circumflexa femoris lateralis also is not necessarily the same. In other words, the N. saphenus may be located either ventral or dorsal to the R. ascendens and R. descendens of this artery whereas with regard to the N. m. vasti medialis, besides cases in which both of these branches are located either ventral or dorsal to this nerve there are instances in which one branch is ventral and the other branch is located dorsal. Therefore, the relation between the location of both nerves and both arterial branches may assume a variety of combinations.

RUGE has discussed the relation between this artery and the N. saphenus and N. m. vasti medialis separately for those cases in which this artery is located ventral and cases located dorsal. However, it is difficult to apply this method directly to our cases. Therefore, in order

to discuss the relations of this artery to nerves, only the N. saphenus has been taken into consideration and cases in which the R. descendens and R. ascendens (R. trochantericus) run lateralward in front of this nerve were regarded as a ventral A. circumflexa femoris lateralis while cases in which they run lateralward behind the nerve were regarded as a dorsal A. circumflexa femoris lateralis. Thus, my ventral or dorsal type is not exactly the same as in the case of man.

ii) The location in relation to the N. saphenus in almost all cases of *Macacus cyclopsis* was the dorsal type with only one case of the ventral type in which the artery arose from the A. femoralis. The site of origin of this artery in relation to the A. femoralis was between the second and the seventh or eighth segments regardless of whether the origin is directly from the A. femoralis or from the A. profunda. In the majority of cases the origin was between the third to fifth segments.

When the findings in *Macacus cyclopsis* are compared with that in macaque obtained by BLUNTSCHLI, the origin in cases arising from the A. femoralis is more frequently higher (proximal) while on the contrary in cases arising from the A. profunda the origin is lower (distal). Among catarrhine, these findings are the closest to *Cercopithecus* and least similar to that for *Semnopithecus*.

RUGE in his investigation of man classified the level of origin into three types; proximal, intermediate and distal A. circumflexa femoris lateralis which correspond respectively to the second to third segment, the fourth segment, and the fifth to sixth segments.

In man the distal A. circumflexa femoris lateralis of RUGE, the origin at the level of the fifth to sixth segments of the A. femoralis, is comparatively infrequent. In such cases origin is from the A. femoralis or the A. profunda with all cases being of the dorsal type. This is the most common condition in *Papio* and is considerable frequent in macaques and *Cercopithecus* with all cases being the dorsal type. The findings in *Macacus cyclopsis* are almost entirely the same. The only exception was one case of the ventral type in which it arose from the A. femoralis. In contrast to this, such a low origin is said to be very infrequent in *Semnopithecus*.

The intermediate A. circumflexa femoris lateralis with origin from near the level of the fourth segment, which corresponds to the middle portion, is the most common condition in man and may be from either the A. femoralis or the A. profunda with the majority of cases being the dorsal type. Similar findings have been noted in *Semnopithecus*. In contrast to the comparatively small number of this type in macaques and *Cercopithecus*, the majority are of this group in *Macacus cyclopsis* (40 %).

The proximal A. circumflexa femoris lateralis which arises at the

Table 5.

Level of origin of A. circumf. f. lat. and its relation
to N. saphenus (A. circumf. f. lat. arise from A. femoralis)

material	region of origin relation to nerve		2 seg.		3 seg.		4 seg.		5 seg.		6 seg.		7 } 8 seg.		total
			v	d	v	d	v	d	v	d	v	d	v	d	
Macacus cyclopsis (Tu)				4		12		18		11	1	3		3	52
Lemur (Bluntschli)			7 (all dorsal)												7
Papio (Bluntschli)							2	3		7		2			14
Macacus (Bluntschli)						3		3				2		2	15
Cercopithecus (Bluntschli)				4		8		3						1	21
Semnopithecus (Bluntschli)			3			6	2	3	7			2			23

v ventral, d dorsal

Table 6.

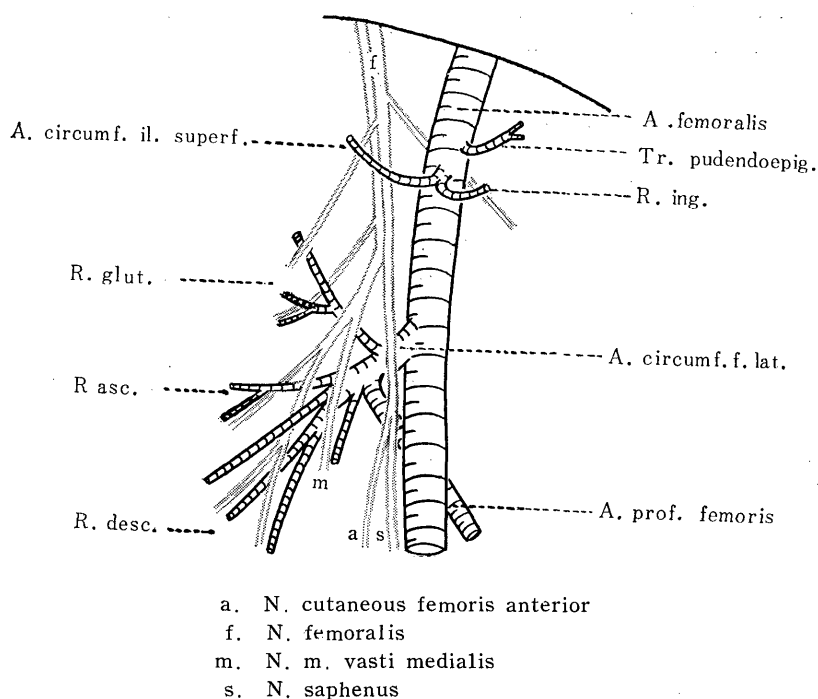
Level of origin of A. circumf. f. lat. and its relation
to N. saphenus (A. circumf. f. lat. arise from A. prof. f.)

material	region of origin relation to nerve		2 seg.	3 seg.	4 seg.	5 seg.	6 seg.	7 } 8 seg.	total
			d	d	d	d	d	d	
Macacus cyclopsis (Tu)			1	15	22	23	7	7	75
Papio (Bluntschli)				2					2
Macacus (Bluntschli)				3	1	1		2	7
Cercopithecus (Bluntschli)			1	3	1	4			9
Semnopithecus (Bluntschli)			4	8					12

level of the second to third segments is comparatively frequent in man and the origin is usually by a common trunk with either the A. profunda or the A. circumflexa femoris medialis, or with both. Independent origin is infrequent with the dorsal type being predominant. This type is seen in all catarrhine but is particularly frequent in Semnopithecus with a considerable number of the ventral type. In Macacus cyclopsis this type is considerably frequent but none were of the ventral type.

As an exception, the A. profunda along with the Aa. circumflexae femoris laterales was located anterior to the N. saphenus in one case. (Table 5, 6, Fig. 5).

Fig. 5 Relation of arteries to nerves (right, ventral view)



iii) According to BLUNTSCHLI, N. m. vastus medialis and the fasciculi running toward the M. quadriceps femoris are consolidated into a single group with regard to their course and position in relation to the R. ascendens (R. trochantericus) and R. descendens of the A. circumflexa femoris lateralis.

In *Macacus cyclopsis*, however, of the nerve groups which run together with the N. m. vastus medialis, the N. m. vastus lateralis separates into several branches which supply the origin and midportion of the M. vastus lateralis while the N. m. recti femoralis separates from the N. femoralis high up. Therefore, it is very rare for the course of these nerves to form a single bundle with the N. m. vastus medialis and intermedialis or to take the same position in relation to these branches. The condition is highly variable.

It is of little significance to discuss the relation of only the N. m. vastus medialis and the arteries. However, for reference the result of such a review is as follows.

The R. ascendens (R. trochantericus) is, as in other lower monkey, located dorsal to this nerve as well as the N. saphenus. In rare cases, this branch separates from the distal portion of the main trunk of the A. circumflexa femoris lateralis and together with the R. descendens is located ventral to this nerve (4%).

The R. glutealis also is usually located dorsal to this nerve as well as

the N. saphenus but cases in which it is located ventrally are not infrequent. In a small number of cases it was located ventral to both the N. saphenus and this nerve (6 %).

The R. descendens is located dorsally in most cases but in addition to cases in which it was ventral to both the N. saphenus and this nerve, there were a considerable number of cases in which it was ventral to only this nerve (36 %).

II. ARTERIAL BRANCHES IN THE LOWER THIGH

The A. femoralis in *Macacus cyclopsis* divides into its terminal branches, the A. saphena and the A. poplitea, in the lower thigh. In the neighbor of this division, the branch to the knee (the A. articularis genu suprema), the muscular branch to the lower medial thigh (A. musculo-cutanea distalis) and the branch which penetrates to the posterior side of the thigh (the A. perforans distalis) are given off.

These various branches will be discussed below. With regard to the A. saphena and A. poplitea, the report of MIZUTANI of this department is available (MIZUTANI, 1960) and therefore will not be included here except to mention that there was some disagreement concerning the size of these two arteries. That is, MIZUTANI reported that the A. saphena is well developed in *Macacus cyclopsis* and larger than the A. poplitea. In my study, however, comparison of the size immediately below the division showed the A. poplitea to be more frequently larger than the A. saphena (61 %) followed by cases in which both were of equal size (36 %) while instances in which the A. saphena was larger than the A. poplitea were very rare (3 %).

The A. saphena is better developed and larger in lower monkeys. Even in catarrhine there are cases in which it is difficult to determine which is larger (BLUNTSCHLI, etc.), but in general it seems that the A. saphena does not exceed the A. poplitea in size. It is felt that the difference between the results of MIZUTANI and myself is possibly due to the difference in the site of comparison.

1) A. articularis genu suprema

This branch arises in most cases from the A. saphena and in rare cases from the lower end of the A. femoralis. Together with a small branch from the N. saphenus, it passes beneath the M. sartorius through the groove between the M. vastus medialis and the M. semimembranosus accessorius to the medial side of the knee where it divides into two groups.

One group supplies the region of insertion of the M. vastus medialis and M. semimembranosus accessorius after which the terminal branches contribute to the formation of the Rete articulare genu.

The other group passes around the epicondylus medialis and supplies the subcutaneous region of the lower medial patellar region after which

one part enters the popliteal joint space beneath the Lig. patellae.

There was one exceptional case in which this artery arose as two independent branches from the A. saphena. The proximal branch (upper branch) which was accompanied by a small branch from the N. saphenus corresponds to the first group described above while the distal branch (lower branch) corresponds to the second group.

In the majority of the cases this artery arose by an independent origin from the A. saphena (88 %) with only rare instances of independent origin from the A. femoralis (3 %). In the other cases, the origin was by a truncus with the A. perforantes distalis either from the A. femoralis (5 %) or the A. saphena (3 %).

According to BLUNTSCHLI, among catarrhine, origin from the A. femoralis is slightly more frequent than the origin from the A. saphena in macaque, both are of about equal frequency in Cynopithecus, Cercopithecus and Semnopithecus, while the origin from the A. saphena is more frequent in Papio and Cercopithecus. Thus, my findings for Macacus cyclopsis are opposite to the findings obtained by him and are more similar to the condition in Papio or Cercopithecus. The origin from the A. poplitea is said to be seen very occasionally in Cercopithecus and Semnopithecus but was seen in no case of Macacus cyclopsis.

2) *A. musculo-cutanea distalis.*

This artery arises in all cases from the medial wall of the A. femoralis within or immediately below the Canalis adductorio-flexorius. It passes anterior to the V. femoralis and may be classified grossly into Rami cutanei and Rami musculares.

The *Rami cutanei* is accompanied by small branches from the Nn. cutanei femoris anteriores and supplies the fascia and subcutaneous region of the postero-medial portion of the lower thigh. One part sometimes may extend as far as the pudendum. In many cases, a small branch which passes over the M. sartorius toward the knee is given off.

Some of the *Rami musculares* enter the M. adductor longus, M. adductor magnus and the M. gracilis while the others penetrate the M. semimembranosus accessorius to the M. semimembranosus proprius.

The origin of this artery is considerably proximal in Lemur and Semnopithecus but is closer to the terminal bifurcation of the A. femoralis in Cercopithecus.

3) *A. perforans distalis*

This branch, immediately after its origin, runs in a backward and lateralward direction. After sending a branch to the insertion of the M. semimembranosus accessorius or the Fossa poplitea, it penetrates the M. adductor magnus near the femur (most frequently between the

longus and intermedius) to the flexor side of the thigh where the main branch runs to the M. biceps femoris (Caput longum) and small branches are given off to the M. vastus lateralis and intermedius. One part passes between the M. vastus lateralis and the M. biceps femoris, or penetrates the M. biceps femoris to supply the Fascia lata.

The site of origin of this branch is variable but most commonly arises from the proximal end of the A. poplitea (50 %). Next frequent is origin from the lower end of the A. femoralis (25 %) while other cases arise from the proximal end of the A. saphena (14 %) or by a common trunk with the A. articularis genu suprema as mentioned previously (8 %).

There were exceptional cases in which this artery consisted of two branches. In two cases they arose from the A. femoralis and A. poplitea respectively and in one case they arose from the A. femoralis and A. saphena respectively.

According to BLUNTSCHLI, this artery most frequently arises from the proximal end of the A. poplitea in Papio and Cercopithecus and from the lower end of the A. femoralis in Semnopithecus. In contrast to my findings, this artery in macaque usually arises by a common trunk with the A. articularis genu suprema.

III. TYPES OF DIVISION OF A. FEMORALIS

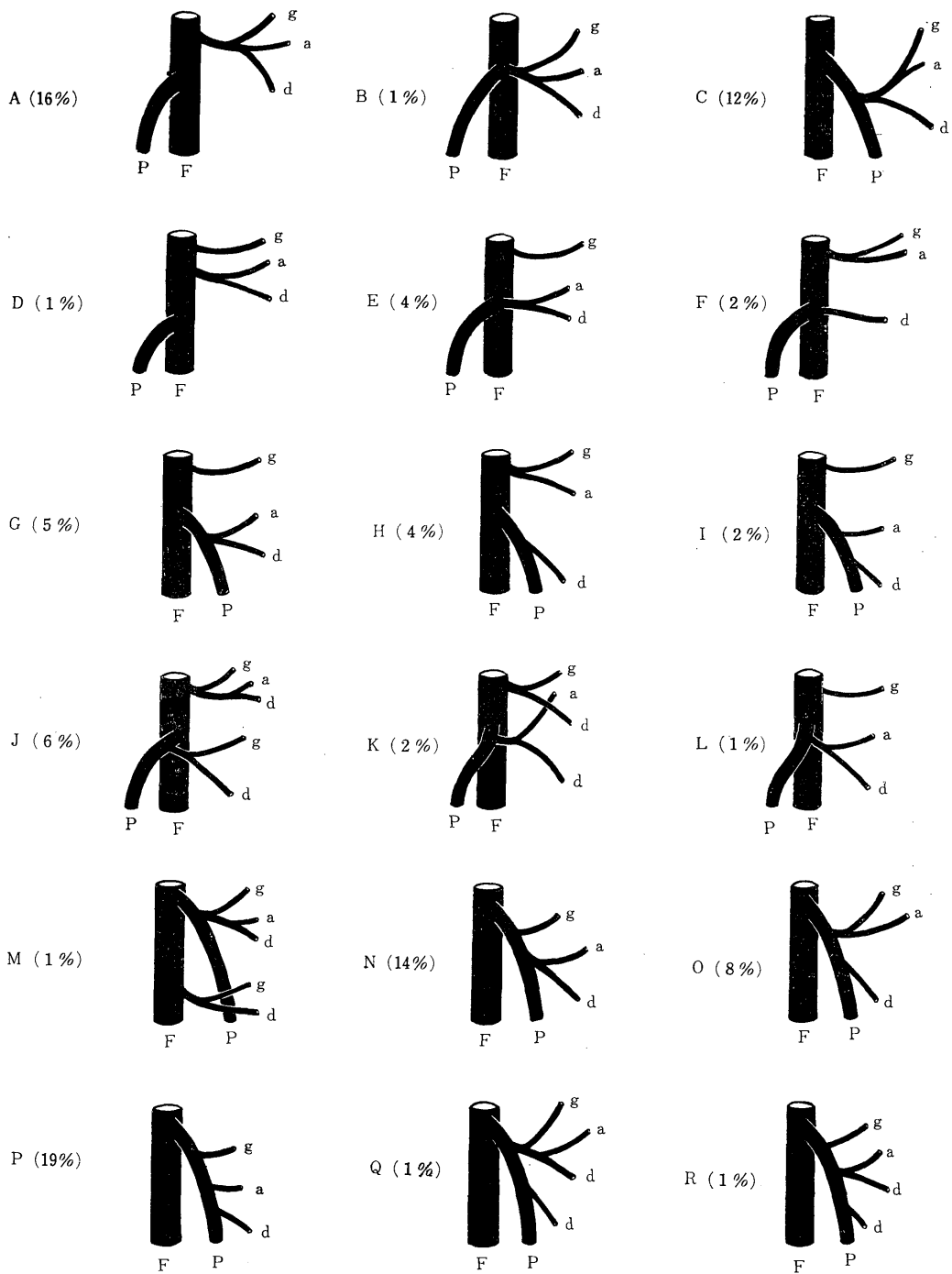
1) *Arterial types in the upper thigh*

The reports on the relation between A. femoralis and its branches mainly with respect to their site of origin have been made for man by RUGE (1895), AUBURTIN (1905), ADACHI (1928), etc. and for primates by THEILE (1852), POPOWSKY (1893), BLUNTSCHLI (1906), ZUCKERKANDL (1908), MANNERS-SMITH (1912), etc.

For man, ADACHI made a classification into eight arterial types (of division) according to the combination of the main branches. This included the Truncus profundo-circumflexus perfectus (formation of a common trunk by the three branches), Truncus profundo-circumflexus lateralis (independent origin of only the A. circumflexa femoris medialis) and the Truncus profundo-circumflexus medialis (independent origin of only the A. circumflexa femoris lateralis) as well as the variation of the A. circumflexa femoris lateralis. With regard to the A. circumflexa femoris lateralis, emphasis was placed upon only the R. ascendens and R. descendens. Of the ascending branches and descending branches, the largest one of each was selected as the R. ascendens and R. descendens and the other smaller branches were excluded.

However, in *Macacus cyclopsis*, as previously mentioned, the R. glutealis is always present as a branch of the A. circumflexa femoris lateralis. Therefore, it is improper to exclude this branch only.

Fig. 6 Branch types of A.femoralis in upper thigh



More important is the fact the *A. circumflexa femoris medialis*, as a rule, arises within the pelvis from the *A. iliaca interna* which is different from the condition in man. Even though there are a small number of cases in which it arises from the *A. iliaca externa*, origin from the *A. femoralis* was not seen at all and therefore the classification for man cannot directly applied.

Consequently, the *A. circumflexa femoris medialis* was disregarded and the three branches of the *A. circumflexa femoris lateralis* including the *R. glutealis* were considered equally in an attempt to establish a classification for the origin and divisions of the *A. circumflexa femoris lateralis* and *A. profunda* in relation to the *A. femoralis*.

First, a classification was made by whether the *A. profunda femoris* and *A. circumflexa femoris lateralis* arise by a common trunk (type I) or whether they arise independently (type II). Cases in which the origin was independent but very close to each other (type III) were also distinguished.

In making this classification, when the condition of one of the three branches of *A. circumflexa lateralis* was different from the other two, only the two branches of the same condition were considered. In other words, if two out of the three branches separated from the *A. profunda femoris*, the *A. circumflexa femoris lateralis* and *A. profunda femoris* were considered to arise from the *A. femoralis* by a common trunk.

It was found that type I, that is the type in which both arteries arise from the *A. femoralis* by a common trunk was the most frequent (60 %) while cases in which both arose independently were few (29 %). Cases in which the origin was independent but situated close together were very infrequent (5 %).

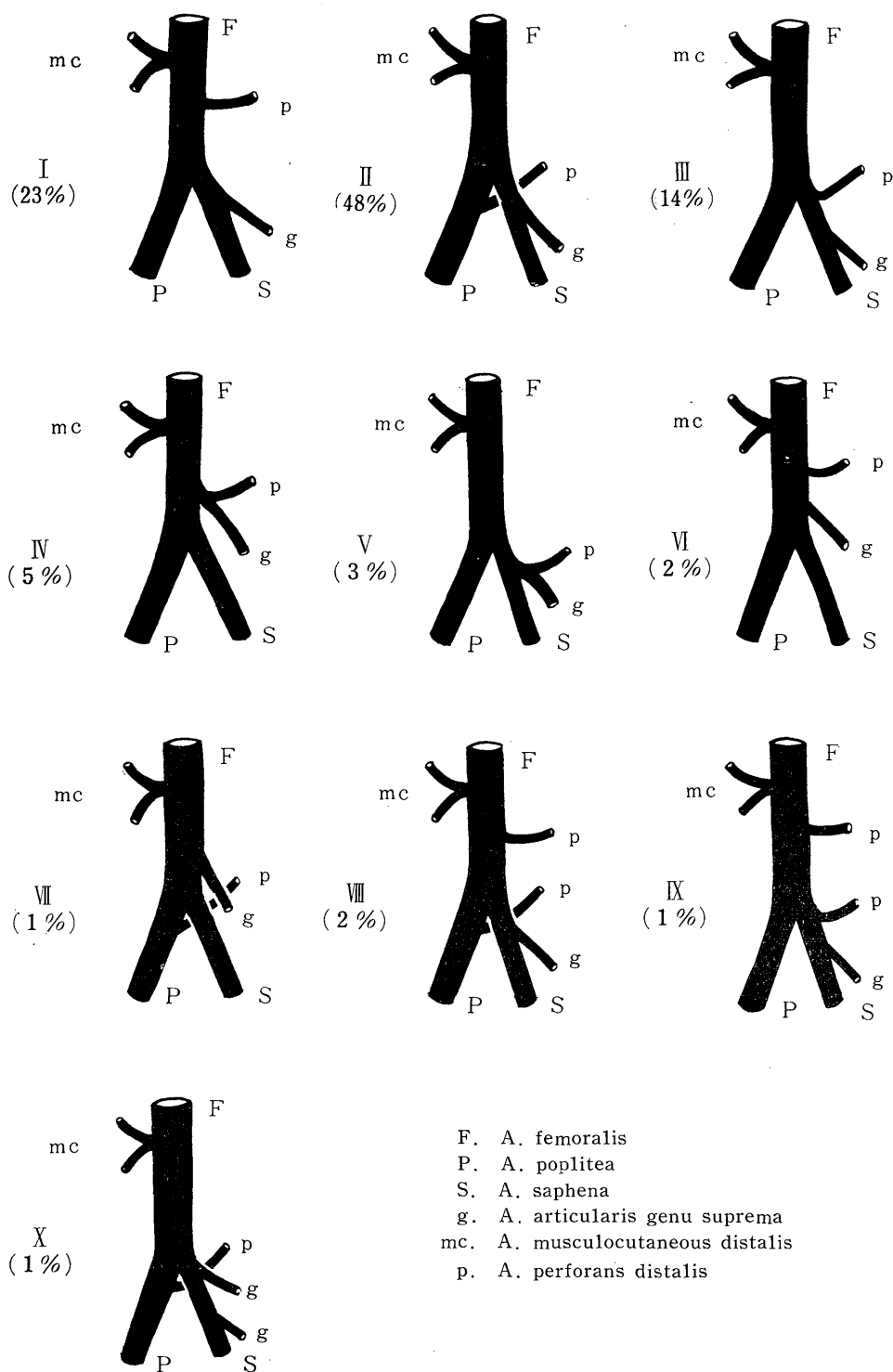
when the origin of the three branches of the *A. circumflexa femoris lateralis* are considered in relation to the *A. femoralis* or the *A. profunda femoris*, a classification into 18 types can be made which is considerably complicated. Among these types, four types had a frequency over 10% : P (19%), A (16 %), N (14 %) and C (12 %) (Fig. 6).

When past reports are reviewed regarding the state of branches in primates, the *A. profunda femoris* and *A. circumflexa femoris lateralis* are largely independent branches in *Prosimiae*; *Cebidae* except *Cercothrix*; *Cynocephalus*, *Cynopithecus* and *Cercocebus* among *Cercopithecidae*; and in *Gorilla* among *Simidae*. Both arteries usually arise from the *A. femoralis* by a common trunk, the *Truncus profundo-circumflexa lateralis*, in *Hapale*; *Chrysotrix*; *Macacus*; *Cercopithecus*; and in *Simidae* except *Gorilla*.

The condition in *Macacus cyclopsis* belongs to this latter category. This type is frequently seen in man and is said to be more frequent among Europeans than in Japanese.

Among catarrhine, the situation is unique in *Semnopithecus* in

Fig. 7 Branch types of A. femoralis in lower thigh



which the A. profunda femoris and A. circumflexa femoris medialis form a common trunk, the so-called Truncus profundo-circumflexa medialis. This type is considerably frequent in man but was not found in *Macacus cyclopsis*.

In man, the most common type is the Truncus profundo-circumflexus perfectus in which a common trunk is formed by all three arteries; the A. profunda femoris, A. circumflexa femoris lateralis and medialis. Differences by race are said to be present and this type is more frequent in Japanese than in Europeans. This type is reported to be seen in rare cases in *Simia innus*, *Semnopithecus*, Chimpanzee, etc., but no case was found in *Macacus cyclopsis*.

2) *Arterial types in the lower thigh* (Fig. 7)

In the lower thigh where the A. femoralis divides into the A. poplitea and A. saphena, the A. articularis genu suprema, A. musculo-cutanea distalis and A. perforans distalis are given off. Consequently, classification into various types of division may be made according to the site and state of origin of these arteries.

Among these arteries, the A. musculo-cutanea distalis always separates from the A. femoralis, and therefore the type of division is determined by the other two arteries.

In my *Macacus cyclopsis*, a classification into ten types (I-X) was made. The most common type in *Macacus cyclopsis* was type II in which the A. articularis genu suprema arises from the A. saphena and the A. perforans distalis separates from the A. poplitea (48%). Next frequent is type I in which the A. articularis genu suprema is from the A. Saphena and the A. perforans distalis is, like the A. musculo-cutanea distalis, from the A. femoralis (23%) followed by type III in which both the A. articularis genu suprema and A. perforans distalis are from the A. saphena (14%). Other type are very few.

SUMMARY

The A. femoralis, which is the continuation of the A. iliaca externa, appears on the anterior surface of the thigh from beneath the Arcus cruralis and, at about the lower third of the thigh, divides into its two terminal branches, the A. saphena and A. poplitea. During its course the following superficial branches, deep branches, etc. are sent off.

I. BRANCHES IN THE UPPER THIGH

The A. femoralis gives rise to cutaneous arteries, which are superficial branches, in the upper half of the thigh. In addition, two arteries, which are deep branches, are given off.

A. Superficial branches (subcutaneous arteries)

The A. femoralis, immediately after it appears on the anterior

surface of thigh from beneath the Arcus cruralis, gives rise to three subcutaneous arteries, the A. epigastrica superficialis, A. circumflexa ilium superficialis and A. pudenda externa superficialis, which supply the lower abdomen, inguinal region, hip, etc.. These arteries arise either independently or by a common trunk, but in both instances the origin is usually from the A. femoralis. The common trunk most frequently seen is the Truncus pudendo-epigastricus. The formation of the Truncus subcutaneus communis which is the common type in primates was very infrequent. Independent origin was most frequent for the A. circumflexa ilium superficialis as in other lower monkeys while it was most infrequent for the A. epigastrica superficialis.

B. Deep branches

The deep branches arising from the A. femoralis are the A. profunda femoris and A. circumflexa femoris lateralis.

1. *A. profunda femoris*

This artery, which is the largest of the main branches of the A. femoralis, enters between the M. pectineus and A. adductor longus. After giving off the Aa. perforantes, it supplies the adductor and flexor muscles. Although there are considerable individual variations in the level of origin of this artery, it is generally slightly higher than midway along the A. femoralis. The average height of origin was found to be a little higher than reported heretofore and the origin is slightly higher in females than in males, but there is no difference by side. Most closely related to this artery is the A. circumflexa femoris lateralis. The relationship is greater in cases in which the height of origin is high. In contrast to this, there is little relation with the A. circumflexa femoris medialis.

2. *A. circumflexa femoris lateralis*

i) This artery is the main branch supplying the extensor muscles and usually arises from the A. profunda femoris by several stems. The state of origin, height of origin and relations to the nerves are variable. This artery divides into three branches, the R. glutealis, R. ascendens (R. trochantericus) and R. descendens. The R. ascendens often is a lateral branch of the R. descendens, both of which are well developed arterial branches which run lateralward along the lower surface of the M. rectus femoris. The R. glutealis crosses over the origin of the M. rectus femoris and its state of origin is comparatively varied.

ii) Cases in which the three branches arise by a single trunk are comparatively infrequent, but in such instances the origin is usually from the A. femoralis and slightly higher than reported heretofore. In contrast to this, cases in which they arise as several branches to form the so-called Aa. circumflexae femoris laterales are very numerous.

In such cases the origin is usually from the A. profunda femoris and the height of origin is low.

iii) This artery is closely related to the N. saphenus and N. m. vasti medialis, but the relation of these two nerves to this artery is not necessarily the same in all cases. The so-called dorsal type in which the R. ascendens and R. descendens of this artery passes behind the N. saphenus is the most frequent. However, the relation between the N. m. vasti medialis and the branches of this artery is complicated and varied, and therefore it is difficult to make a generalization on its types. Cases in which the R. ascendens is located dorsal to this nerve and the R. descendens is ventral are not infrequent, but cases in which the R. glutealis is located dorsally and ventrally are noted at equal frequency.

II. BRANCHES IN THE LOWER THIGH

In the lower thigh where the A. femoralis divides into its two branches, the A. saphena and A. poplitea, the following branches are given off.

1. *A. articularis genu suprema*

This artery which usually arises by an independent origin from the A. saphena consists of the R. articularis which runs toward the knee and the R. muscularis which runs toward the insertions of the M. vastus medialis and the M. semimembranosus accessorius.

2. *A. musculo-cutanea distalis*

This branch arises in all cases from the A. femoralis either within or immediately below the Canalis adductor femoris. It consists of the Rr. cutanei which runs toward the lower medial side of the thigh and the Rr. musculares which supplies the adductor muscles and a part of the flexor muscles. A branch from the former supplies the pudendum.

3. *A. perforans distalis*

This branch, after penetrating the M. adductor magnus, gives off the main branch to the M. biceps femoris. It also supplies the M. vastus lateralis and intermedius or the area beneath skin on the flexor side. It most frequently arises from the proximal end of the A. poplitea.

III. TYPES OF DIVISION OF A. FEMORALIS

1. *Arterial types in the upper thigh*

The main arteries supplying the upper thigh are the A. femoralis and its branches, the A. profunda femoris and A. circumflexa femoris lateralis, and the A. circumflexa femoris medialis. Of these arteries, the A. circumflexa femoris medialis as a rule arises from the A. iliaca

interna within the pelvis. Therefore, this artery was disregarded and the types of division were classified mainly by the state of origin of the A. profunda femoris and the Aa. circumflexae femoris laterales.

The most common arterial type in *Macacus cyclopsis* was the so-called Truncus profundo-circumflexus lateralis in which the A. profunda femoris and the A. circumflexa femoris lateralis arise from the A. femoralis by a common trunk. The formation of the Truncus Profundo-circumflexus medialis, which is characteristic of *Semnopithecus*, and the Truncus profundo-circumflexa perfectus, which is the usual type in man, were seen in no case.

2. Arterial types in the lower thigh

The A. femoralis, near the division of its two major terminal branches, the A. saphena and A. poplitea, gives off distal branches including the A. articularis genu suprema, A. musculo-cutanea distalis and A. perforans distalis. Since the A. musculo-cutanea distalis always arises from the A. femoralis by an independent origin, the arterial type is determined by the combination with the other two arterial branches. The most usual type is that in which the A. articularis genu suprema arises from the A. saphena and the A. perforans distalis originates from the A. poplitea.

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