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Study of the arterial vascularisation of the medial tibial condyle in the fetus

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Summary. Varus deformity of the knee is common in young children who have suffered from fulminating purpura. This study was directed at the anatomic features of the vascularisation of the upper end of the tibia that might account for such deformation. It was based on the dissection of 28 anatomic specimens prepared by injection of Indian ink into the vascular trunk. 16 specimens were diaphanised for better analysis of the intracartilaginous distribution of the vessels. The study showed that the vascularisation of the medial condyle of the tibia is poor and of terminal nature, which may explain the occurrence of ischemic growth disorders following fulminating purpura.

Key words : Superior tibial epiphysis — Articulation of the knee — Vascularisation — Fulminating purpura — Blount's disease

Etude de la vascularisation artérielle du condyle médial du tibia chez le foetus

Les déformations en varus du genou chez les jeunes enfants ayant présenté un purpura fulminans sont fréquentes. Ce travail a pour objet de rechercher les caractéristiques anatomiques de la vascularisation de l'extrémité supérieure du tibia qui peuvent expliquer ces déformations. L'étude porte sur la dissection de 28 pièces anatomiques préparées par injection de l'axe vasculaire à l'encre de Chine. Pour mieux analyser la répartition intra-cartilagineuse des vaisseaux, 16 pièces ont été diaphanisées. Cette étude montre que la vascularisation du condyle médial du tibia est pauvre, de type terminal, ce qui peut expliquer la survenue de troubles de croissance ischémiques dans les suites d'un purpura fulminans.

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The frequency of occurrence of growth disturbance of the upper part of the tibia following fulminating purpura in young children less than a year old led us to investigate the vascularisation of the medial condylar portion of the tibial epiphysis. These varus deformities, associated with major morphologic modifications of the upper end of the tibia, are either of infective origin due to destructive changes, or of vascular origin due to ischemic necrosis. The absence of major deformities of the other epiphyses suggests that the upper tibial epiphysis is poorly vascularised in its medial part. To confirm this hypothesis we engaged in a study of the distribution of the arterial vascular supply of the superior tibial epiphysis.

Material and method

Twenty-eight knees of 17 fresh cadavers of fetuses aged from 8 to 9 months were studied. Because of imperfections of preparation of the anatomic specimens, mainly due to inadequate injection of the vascular bed, only 11 subjects were studied for comparative purposes.

Method

The femoral vascular axis and its branches were colored blue with Indian ink. Manual filling under pressure with 5 ml of india ink was made from the common iliac a. or the external iliac a. The introduction of 5 ml of gelatin allowed fixing of the ink and prevented its extravasation during dissection of the specimens. In some specimens, addition of a radio-opaque medium to the ink allowed supplementary radiographic study. The knee, removed throughout the popliteal region, was stripped of its superficial and muscular coverings. The arterial axis was carefully exposed, preserving all the divisional branches destined for the articulation and the capsulo-ligamentous structures. The course of the vessels was noted on a diagram. Sixteen specimens were diaphanised by the method of Spalteholz [2], allowing a more precise study of the intracartilaginous course of the vessels (Fig. 1). Eight specimens were studied by performing transverse sections of the whole of the upper tibial osteocar-

tilaginous epiphysis, at right angles to the long axis of the shaft. 4 specimens were used for simple macroscopic study.

Results

The classical pattern of the arterial network of the knee was found in all our specimens (Fig. 2). The variations noted related to the origin of the different branches, their number and their distribution.

* The femoral a. gives off the descending genicular a., whose articular and deep oblique branches pass to the medial condyle.

* The five branches arising from the popliteal a. were constantly found, but their mode of division varied (Fig. 3) :

- the proximo-lateral and proximo-medial aa. travel to the femoral condyles, the disto-lateral and disto-medial aa. to the tibial condyles,
- the middle genicular a. passes toward the intercondylar notch. It gives off several collateral branches to the ligamentous apparatus and the central part of the femoral and tibial epiphyses.

* The anterior and posterior recurrent tibial aa. and the recurrent fibular aa. share in the vascularisation of the lateral tibial condyle.

The origin of the proximal and middle aa. was variable (Fig. 4) :

- in 6 cases the three branches arose separately from the popliteal a.,
- in 13 cases there were two trunks of origin, the proximo-lateral and proximo-medial aa. arising separately at the posterior aspect of the popliteal a. The middle genicular a. arose from the lateral branch in 9 cases and from the medial branch in 3. In one case a common branch was noted for the proximal arteries, whose origin was separate from that of the middle genicular a.
- in 9 cases we noted a common trunk, which terminated by division into three branches in 7 cases and by bifurcation into a proximo-medial and proximo-lateral branch in 2 cases, the medial genicular a. arising from the lateral branch in one case and from the medial branch in one case.

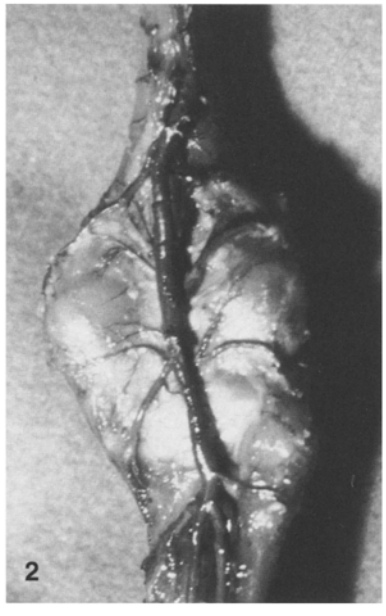
The proximal medial a. was single in 26 cases, and double in two. The proximo-lateral a. was single in 25 cases and double in three.

The disto-medial a. arises opposite the joint-space, at the medial edge of the popliteus m. It passes downward and inward, applied to the periosteum of the medial condyle, following the upper border of the popliteus m. It skirts the medial border of the tibia, passes inder the medial collateral ligament, and reaches the medial border of the anterior tibial tuberosity (Fig. 5). It gives off superior branches which supply the postero-medial aspect of the tibia. The terminal branches are distributed between the anterior tibial tuberosity and the infrapatellar fat-pad. A capsular branch reaches the medial joint-line and supplies the capsule and the peripheral margin of the medial meniscus. This branch arose directly from the popliteal a. in 11 cases, from the disto-medial a. in 10 cases, and from a common trunk with the proximo-medial a. in 8 cases (Fig. 6).

The disto-lateral a. arises opposite the the joint-line at the lateral border of the popliteus m. (Fig. 7). It has an almost horizontal course just below the joint-line. It passes laterally under the popli-

Fig. 1
Postero-medial view after diaphanisation : the vascularisation of the articular capsule and the peripheral part of the menisci is well shown

Vue postéro-médiale après diaphanisation: la vascularisation de la capsule articulaire et de la partie périphérique des ménisques est bien visualisée



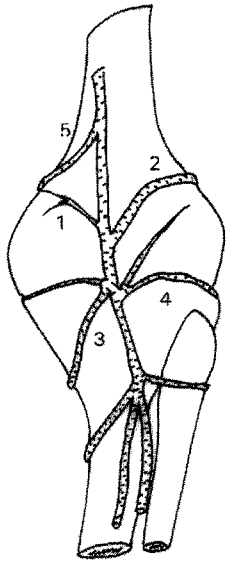
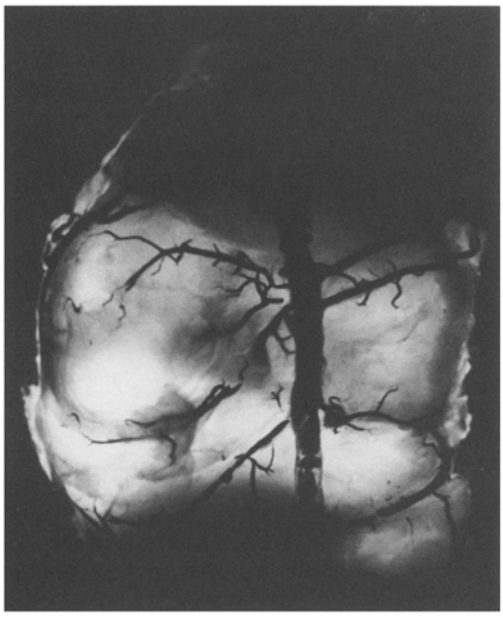


Fig. 2
Posterior view after dissection of the popliteal region to show the articular branches : *1* proximo-medial a., *2* proximo-lateral aa., *3* disto-medial aa., *4* disto-lateral aa., *5* descending genicular a.

Vue postérieure après dissection de la région poplitée visualisant les branches articulaires: *1* a. articulaire proximo-médiale, *2* a. proximo-latérale, *3* a. disto-médiale, *4* a. disto-latérale, *5* a. descendante du genou



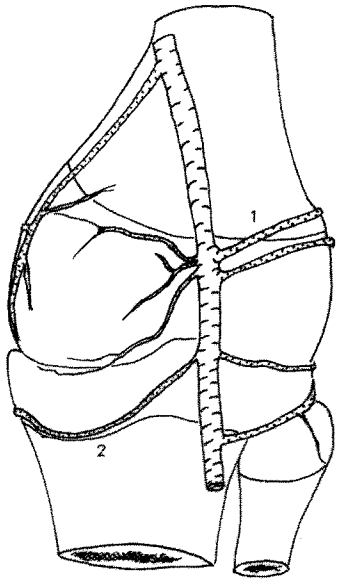


Fig. 3
Posterior view of diaphanised specimen : the proximo-lateral articular a. (*1*) is duplicated. The disto-medial branch (*2*) passes at the upper border of the popliteus m.

Vue postérieure d'une pièce diaphanisée: l'a. articulaire proximo-latérale (*1*) est dédoublée. L'a. disto-médiale (*2*) passe au bord supérieur du m. poplité

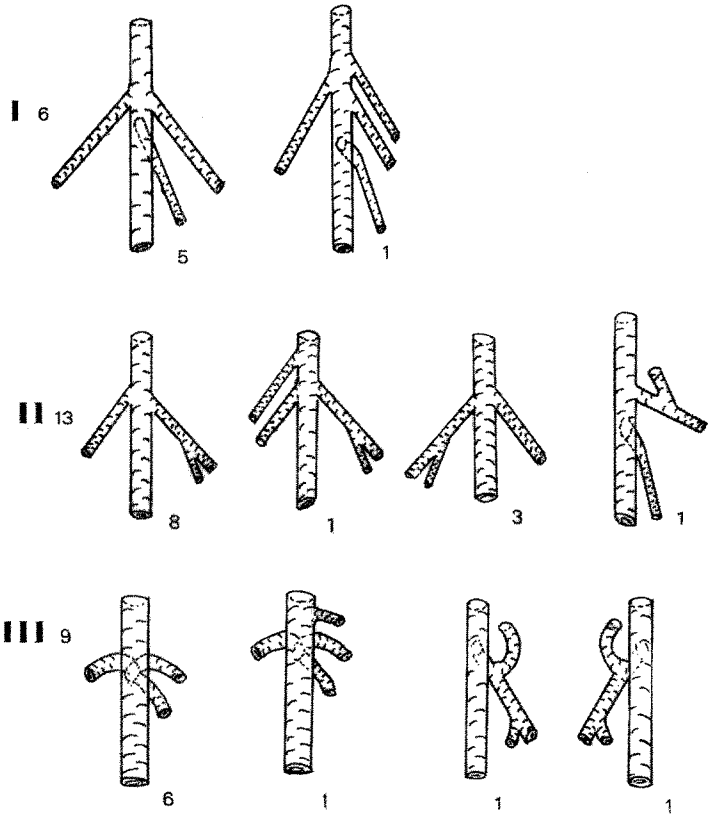


Fig. 4
Variations of origin of the superior articular aa.

Variations de naissance des aa. articulaires proximales

teus m., applied to the periosteum. It then travels above the head of the fibula, enters the lateral aspect of the tibia medially and the biceps tendon and then the fibular collateral ligament laterally. It skirts round the lateral condyle to reach the tibial tuberosity and ends in a fine plexus for the infrapatellar fat-pad and the patella. It gives an ascending branch toward the lateral border of the patella.

- In 20 cases this main artery was solitary, giving off superior vertical branches to the capsule and lateral meniscus
- In 8 cases a branch was noted that arose either directly from the popliteal a., or more often from a common trunk with the disto-lateral a. This artery was distributed to the lateral capsulo-meniscal structures.

Laterally, the anterior tibial a. completes the vascularisation of the tibial epiphysis, via the anterior and posterior recurrent tibial aa. These supply the antero-lateral aspect of the tibia, lateral to the tibial tuberosity.

In front, the patellar branches form a rich vascular network with numerous anastomoses joining the proximal to the distal branches and the lateral to the medial branches.

A terminal anastomosis between the disto-lateral and disto-medial aa. was noted behind the infra- patellar fat pad in 18 cases. In the absence of true anastomoses, there was a major capillary plexus whose functional role was identical.

The sections made in 8 cases allowed study of the intracartilaginous distribution of the vascular branches. Their entry into the cartilaginous bloc followed a perpendicular path at the circumference of the epiphysis. No intracartilaginous anastomosis was demonstrable. Their course was short. A central zone could be identified, supplied by the terminal branches of the middle genicular a.

Altogether, the vascular network was quite dense at the level of the bony and capsulo-ligamentous structures of the knee. The infero-medial portion, opposite the medial condyle of the tibia, appeared less well supplied.

Discussion

Studies of the vascularisation of the epiphyses are numerous [4, 5, 9, 13].

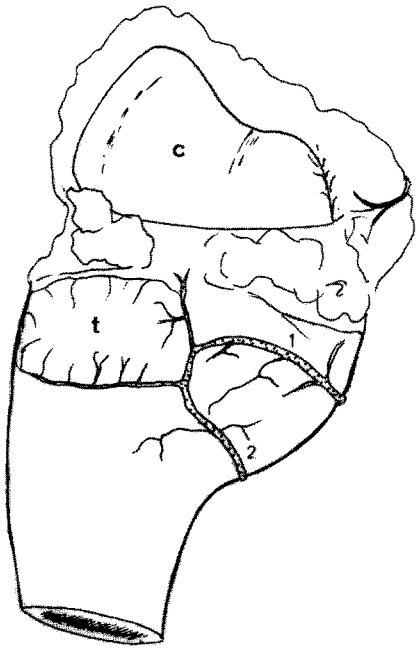


Fig. 5
Antero-medial view with the joint opened to show the terminal anastomoses of the capsular branches (*1*) and the disto-medial branches (*2*). *c* femoral condyle, *t* anterior tibial tuberosity

Vue antéro-médiale, articulation ouverte, montrant les anastomoses terminales des branches capsulaire (*1*) et disto-médiale (*2*). *c* Condyle fémoral, *t* tubérosité tibiale

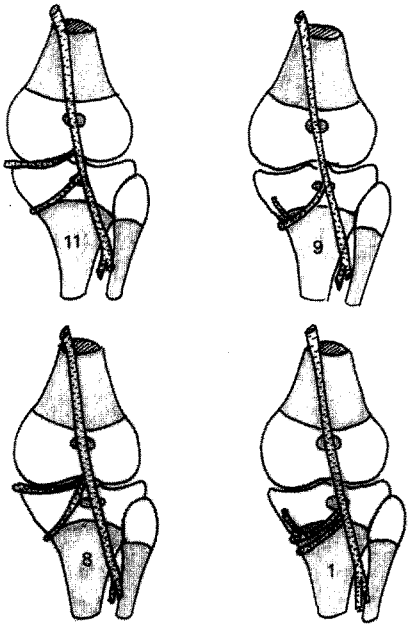


Fig. 6
Anatomic types of origin of disto-medial articular a.

Formes anatomiques de l'origine de l'a. articulaire disto-médiale

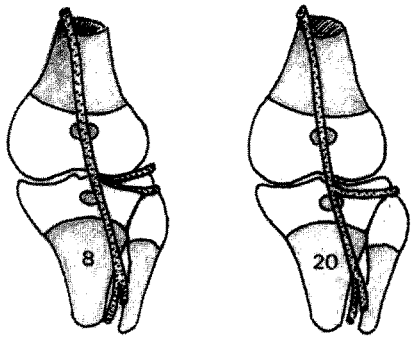


Fig. 7
Variant origins of disto-lateral articular a.

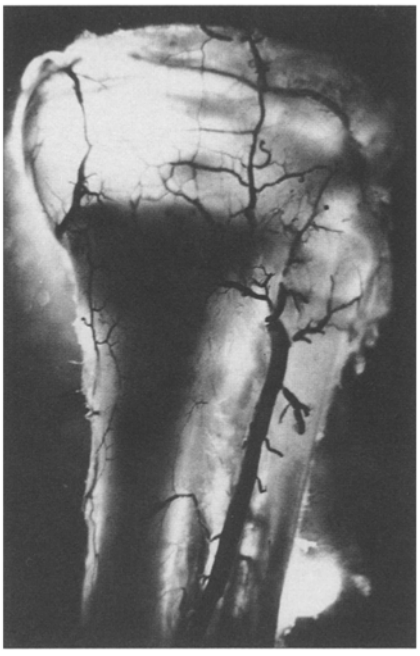
Variations d'origine de l'a. articulaire disto-latérale

Among these must be cited that of Langer, who was the first to describe the cartilage canals. Wislam and Van Sickle [14, 15] showed that there was a continuity between the canals and the perichondral vessels. Scapinelli [11] gave a very detailed and magnificently illustrated account of the vascularisation of the knee at all ages. Lastly, Skawina [12] showed that the cartilage canals are present from the 21st day and that there are no anastomoses between them.

The distribution of the arteries arising from the disto-medial and disto-lateral branches was well shown in the diaphanised specimens. These branches give off rami which are at right angles to them and which penetrate the epiphyseal model at the level of the cartilage canals. These two vessels inter-anastomose in front in the region of the fat-pad.

In addition to these two vessels, there are in front and laterally the recurrent branches of the anterior tibial a., which share in the supply of the anterior portion of the tibial tuberosity.

As with some other epiphyses, there is a secondary vascular source, in this case by way of the middle genicular a. This vessel arrives in the knee region at the level of the intercondylar notch, gives off branches to the posterior capsulo-synovial structures, and two branches to the femoral and tibial epiphyses (Figs. 1 and 2). The tibial branch, or so-called central a., penetrates the cartilaginous nucleus of the tibia at the level of the intercondylar tubercles and supplies the central portion of the epiphysis. The same pattern is found at the upper end of the femur with the artery of the ligament of the head of the femur, but the penetration and extent of the ter-



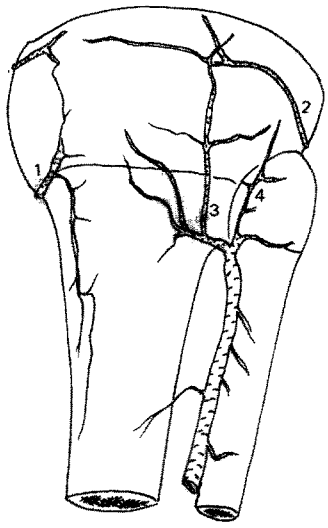


Fig. 8
Anterior view showing termination of disto-medial (*1*) and disto-lateral (*2*) articular aa. and of recurrent tibial (*3*) and fibular (*4*) aa.

Vue antérieure montrant la terminaison des aa. articulaires disto-médiale (*1*) et disto-latérale (*2*) et des aa. récurrentes tibiale (*3*) et fibulaire (*4*)

ritory supplied at the knee appears greater.

The center of ossification of the upper tibial epiphysis, or point of Tood, appears after birth. We were unable to specify the role of this artery in ossification of the secondary nucleus.

The medial tibial condyle is supplied solely by the the single disto-medial a. The lateral condyle is supplied by the disto-lateral a. and the the recurrent tibial aa., the anterior in front and the posterior behind (Fig. 8). Despite the anastomoses, particularly those behind the patella between the lateral and medial vascular systems, the medial tibial condyle is more vulnerable than its lateral counterpart.

Experiments have been conducted to assess the effect of vascular disorders on growth. Nussbaum [10] noted arrest of growth after ligature of the epiphyseal vessels, but Mc Kibbin and Holdsworth [6, 7] showed that such ischemia produces only a temporary arrest of growth if the lesions are not irreversible, ie if they have not given rise to a bridge of epiphyseodesis. Current studies seem to conclude that there is a threshold of epiphyseal ischemia which must not be exceeded if definitive sequelae are to be prevented.

Conclusions

It may be conceded that the medial tibial condyle is more vulnerable and adapts less well to a decrease in blood perfusion. During the course of a fulminating purpura, the lesion is revealed by fragmentary necrosis of the cartilaginous epiphyseal bloc, leading to varus deviation and sometimes to joint instability. The lesion may also involve the growth-plate and lead to a progressive deformity, temporary or permanent, depending on whether or not epiphyseodesis has taken place.

The tibial lesions of Blount's disease may be of ischemic origin. Martinez et al have recently published a case report [8] in which the deformity of tibia vara occurred after a vascular lesion of the popliteal a. above the emergence of the distal aa. The radiologic appearance of the tibia some years after this injury was that of true Blount's disease. The authors' arteriogram shows interruption of the popliteal a. just above the emergence of the distal arteries.

To sum up, the disto-medial a., sometimes double, is a branch of the popliteal a. and supplies the medial portion of the tibial epiphysis. This supply is of terminal type; it penetrates the cartilaginous epiphyseal model and reaches the vascular canals. Intracartilaginous anastomoses do not exist, while at the periphery of the epiphysis there are no other arterial sources as is the case for the lateral portion. These features may account for the growth disorders most frequently met with at the medial aspect of the condyle.

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