

Vascularisation of the head of the radius in the adult

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Summary. Although rare, ischemic necrosis of the head of the radius after fracture is a theoretic possibility. The epiphyseal vascularisation of the proximal end of the radius was studied by dissection and diaphanisation techniques. The main extra-osseous supply is derived from epiphyseo-metaphyseal arteries given off by the recurrent radial a. and the first collateral of the ulnar a. These, to the number of three or four, anastomose together in a peri-cervical arterial circle continuous with the periosteal vessels of the shaft. From the proximal part of this network there arise three main intra-epiphyseal branches, which traverse the head, but nearly the entire periphery of the osteochondral junction is the site of small periosteal branches penetrating the head, though to no great depth. When the head of the radius is fractured, the commonest displacement is posterolateral, and the main vessel-bearing periosteal layer probably remains intact.

Contribution à l'étude de la vascularisation de la tête du radius de l'adulte

Résumé. Bien qu'exceptionnelle, la nécrose ischémique post-fracturaire de la tête radiale reste théoriquement possible. La vascularisation épiphysaire de la partie proximale du radius a été étudiée par des techniques de dissection et

de diaphanisation. L'apport extra-osseux principal provient d'artères épiphyso-métaphysaires issues de l'a. récurrente radiale et de la première a. collatérale de l'a. ulnaire. Celles-ci, au nombre de trois ou quatre, s'anastomosent en un cercle artériel péricervical en continuité avec la vascularisation périostée diaphysaire. De la partie postéro-latérale de ce réseau naissent trois branches intra-épiphysaires principales, traversant la tête, mais presque toute la périphérie de la jonction ostéochondrale est le siège de petites branches périostées pénétrant la tête sur une faible profondeur. Lors d'une fracture de la tête radiale, le déplacement postéro-latéral le plus fréquent, respecte probablement la lame périostée porte-vaisseaux principale.

Key words: Arteries — Radius

The intra-articular position of the head of the radius, covered with cartilage, rather like the femoral head, theoretically exposes it to necrosis in cases of fracture of the neck of the radius. While relatively common in children [1], such necrosis remains rare in adults [2, 3], but when it does occur it suggests by analogy an ischemic origin involving the vessels supplying the epiphysis. This vascularisation seems to have been little studied until now, and few details are given in the classical texts.

Material and method

The study was made on 24 fresh subjects aged from 62 to 81 years, and three techniques were employed:

- injection of latex colored red into the brachial a., then dissection to the finest branches reaching the epiphysis: 8 cases,

- injection of red lead diluted with oil of turpentine into the brachial a., followed by removal of the radial head and radiography on sensitive film, in some cases after section in the frontal or sagittal plane: 5 cases,

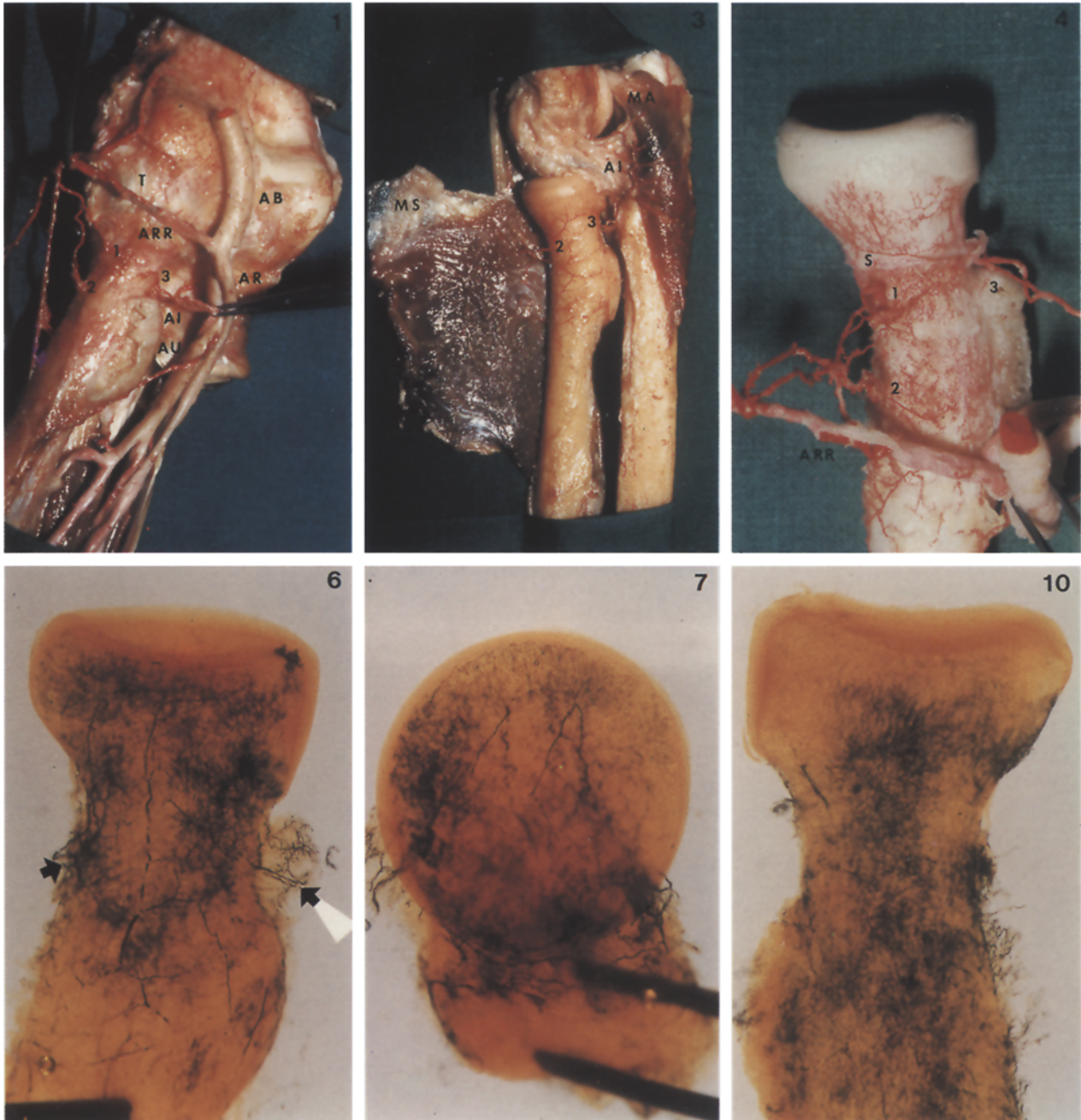
- injection of gelatin mixed with indian ink into the brachial a., followed by removal of the heads and preparation of these by the method of Spalteholz: 11 cases.

Results

The extra-osseous circulation was first studied in the dissections, and then the intra-epiphyseal vessels were studied in the specimens prepared with red lead and especially by the method of Spalteholz.

Extra-osseous vascularisation

The vascular supply to the head of the radius consists partly of the epiphyseo-metaphyseal arteries divided into two groups, one derived from the recurrent radial a., the other from the first collateral of the ulnar a. (or superior interosseous a.), and partly from the periosteal network



Figs. 1, 3, 4, 6, 7, 10

1 Right proximal radial epiphysis, injection with red latex, ventral view. The muscles and the ulna have been excised. *AB* brachial a. ; *AI* superior interosseous a. ; *AR* radial a. ; *ARR* recurrent radial a. ; *AU* ulnar a. ; *T* radial head (intra-articular) ; *1*, *2* pedicles given off by radial recurrent a. ; *3* pedicle given off by superior interosseous a. **3** Left elbow, dorsal view, latex injection. *AI* superior interosseous a. ; *MA* reflected anconeus m. ; *MS* reflected supinator m. ; *2* pedicle from recurrent radial a. traversing supinator m. ; *3* pedicle from superior interosseous a. **4** Right radial head, ventral view, latex injection. *ARR* recurrent radial a. s. synovium ; *1* first pedicle ; *2* second pedicle ; *3* third pedicle (cf Fig. 1).

6 Left radial head, dorsal view, diaphanisation. *Left arrow*: periosteal vascularisation beneath supinator m. *Right arrow*: branch of superior interosseous a. **7** Same specimen as **5**, axial view. Diametric course of branches within the head. **10** Left radial head, diaphanisation. Vascularisation of intramedullary origin

1 Epiphyse radiale proximale droite. Injection au latex coloré en rouge. Vue ventrale. Les muscles et l'ulna ont été excisés. *AB* a. brachiale ; *AI* a. interosseuse supérieure ; *AR* a. radiale ; *ARR* a. récurrente radiale ; *AU* a. ulnaire ; *T* tête du radius (intra-articulaire) ; *1*, *2* pédicules issu de l'a. récurrente radiale ; *3* pédicule issue de l'a. interosseuse

supérieure. **3** Coude gauche. Vue dorsale. Latex. *AI* a. interosseuse supérieure ; *MA* m. anconé relevé ; *MS* m. supinateur relevé ; *2* pédicule issu de l'a. récurrente radiale et traversant le m. supinateur ; *3* pédicule issue de l'a. interosseuse supérieure. **4** tête du radius droite. Vue ventrale. Latex. *ARR* a. récurrente radiale ; *S* synoviale ; *1* premier pédicule ; *2* deuxième pédicule ; *3* troisième pédicule (cf fig. 1). **6** tête du radius gauche. Vue dorsale. Diaphanisation. *Flèche de gauche* : vascularisation périostée sous le m. supinateur. *Flèche de droite* : branche de l'a. interosseuse supérieure. **7** Même pièce que **5**. Vue axiale. Trajet des branches intracéphaliques selon le diamètre de la tête. **10** Tête du radius gauche. Diaphanisation. Vascularisation d'origine intramédullaire

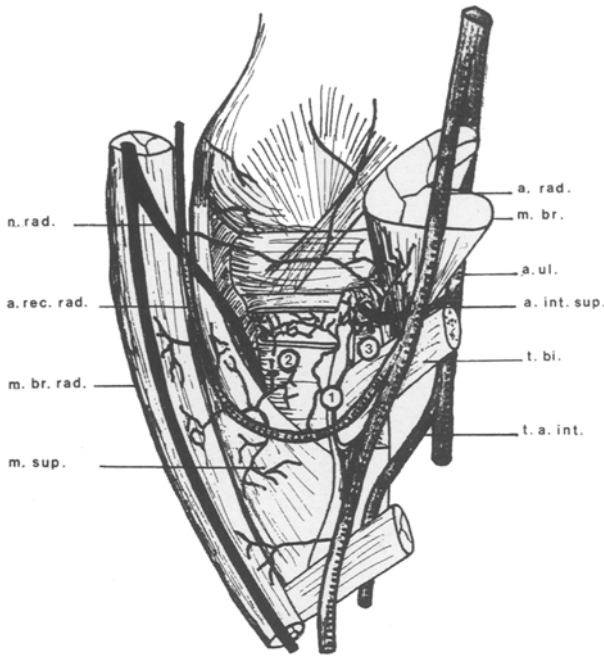


Fig. 2
Ventral view of elbow. 1 first pedicle from recurrent radial a.; 2 second pedicle, traversing supinator m.; 3 pedicle from superior interosseous a.; a. int sup.: superior interosseous a.; a. rad.: radial a.; rec. rad.: recurrent radial a.; a. ul.: ulnar a.; m. br.: brachialis m.; m. br. rad.: brachioradialis m.; m. sup.: deep fascia of supinator m.; m. rad.: posterior branch of radial n.; t. a. int.: trunk of interosseous aa.; t. bi.: biceps tendon

a. int. sup. : a. interosseuse supérieure ; *a. rad.* : a. radiale ; *a. rec. rad.* : a. récurrente radiale ; *a. ul.* : a. ulnaire ; *m. br.* : m. brachial ; *m. br. rad.* : m. brachioradial ; *m. sup.* : faisceau profond du m. supinateur ; *m. rad.* : branche postérieure du nerf radial ; *t. a. int.* : tronc des aa. interosseuses ; *t. bi.* : tendon du m. biceps brachial

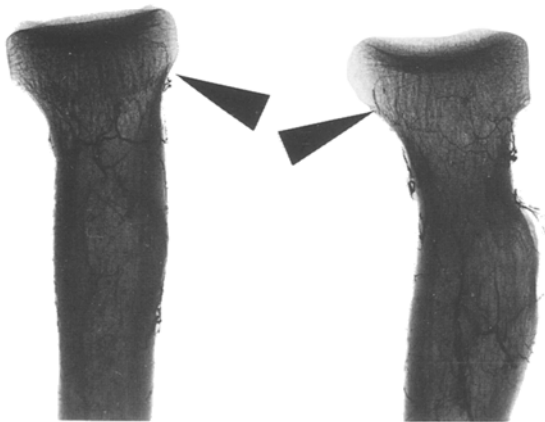


Fig. 5
Frontal and lateral radiographs of right radial head injected with red lead; the vessels within the head are indicated with an arrow

Radiographie de face et de profil, d'une tête du radius droite injectée au minium de plomb. Les vaisseaux intracéphaliques sont repérés par une flèche

around the diaphysis. These two sources anastomose together in a peri-cervical plexus.

1) Epiphyseo-metaphyseal arteries (Fig. 1)

a) Pedicles of the recurrent radial a. The recurrent radial a., a branch of the radial a., soon after its separation from the ulnar a., forms a loop with a superior concavity which passes in front of the neck of the radius and ascends towards the lateral epicondyle of the

humerus. During this course it gives off several pedicles for the regional muscles -brachioradialis, radial wrist extensors and supinator-, the articular capsule and the proximal radial epiphysis (Fig. 2). Two of these reach the neck of the radius. The first skirts the medial border of the supinator m. to reach the ventral aspect of the neck, where it gives rise to a subperiosteal plexus. The second passes between the two heads of the supinator m., which it vascularises in passage, traverses the deep head and reaches the ventrolateral

aspect of the neck where it also breaks up in the periosteum.

Sometimes three pedicles were noted instead of two, for while the first has a quite constant course the second may be double and has variable relations with the deep branch of the radial n., crossing it either medially or laterally. All these pedicles are longer than their direct course requires, forming flexures ensuring a reserve of length adequate to allow movements of pronation and supination without excessive traction.

b) Pedicles of the first collateral of the ulnar a. (or superior interosseous a.). Soon after the division of the brachial a., a small branch arises at the dorsal aspect of the ulnar a. This is its first collateral and we term it the superior interosseous a. It then plunges into the interosseous space in contact with the proximal radio-ulnar articulation and supplies in this course the terminal tendon of the brachialis m., the ventral aspect of the articular capsule of the elbow, the upper pole of the radial tuberosity, and in particular it gives off one or two branches to the medial aspect of the neck of the radius (Fig. 2). The superior interosseous a. then continues its course posteriorly, curves upward in contact with the olecranon under the anconeus m., which it supplies, and terminates in the lateral peri-epicondylar plexus. It is sometimes joined by the recurrent interosseous a.

c) Posterior aspect (Fig. 3). We were unable in our dissections to demonstrate any pedicles directly accessing the dorsal aspect of the neck, which received merely the terminations of the ventral branches.

In summary, the neck of the radius is therefore accessed by epiphyseo-metaphyseal branches on its medial, lateral and ventral aspects. These are given off by the recurrent radial a., lateral to the superior interosseous a. medially.

2) Subcapital peri-cervical anastomotic circle

These three or four branches (Fig. 4) access the extra-articular part of the

radial neck distal to the synovial attachment and anastomose in a rich peri-cervical plexus, which can be traced beneath the synovium to where it reaches the articular cartilage. This anastomotic circle is also continuous with the periosteal vascularisation of the diaphysis.

3) Periosteal network

Without there being any sharp demarcation (Fig. 4), the peri-cervical anastomotic circle extends to the level of the diaphyseal periosteum. This periosteal plexus is particularly dense under the attachment of the supinator m. and at the radial tuberosity. It is fed laterally by the muscular arterioles of the supinator m., as well as by some larger branches given off by the recurrent radial a. that traverse the muscle before reaching the periosteum. Medially, it receives branches from the superior interosseous a. and is continuous with the network vascularising the radial tuberosity, which is itself given off from branches of the ulnar a. Two zones are more sparsely supplied: in front, under the passage of the tendon of the biceps m., and behind, at the junction of the branches given off by the radial and ulnar aa.

4) The problem of the capsular branches

A certain number of branches reach the joint capsule and share in the vascularisation of the synovium. However, no communication was noted between the vascularisation of the peri-cervical synovium, arising from the epiphyseo-metaphyseal branches of the radial neck, and the rest of the synovium. These capsular branches therefore do not participate in the supply of the head.

Intra-osseous vascularisation

After the arterial injection of red lead and radiography, it was possible in one specimen to demonstrate intra-epiphyseal arterioles emerging from the periosteal circulation and penetrating the head in its posterolateral portion

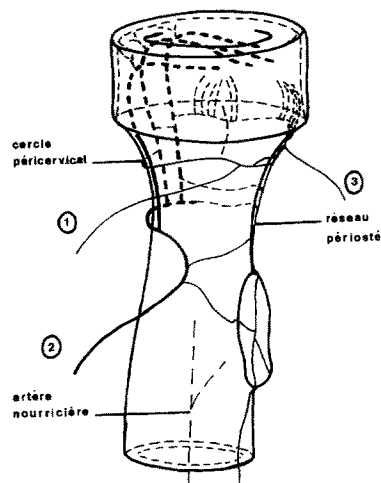


Fig. 8
The cervical periosteal vascularisation and the intra-epiphyseal vascularisation: three-dimensional view

La vascularisation périostée cervicale et la vascularisation intra-épiphysaire. Vue tridimensionnelle

(Fig. 5). However, the standard method for study of the intra-osseous circulation remains Spalteholz's diaphanisation technique. Two vascular patterns were found. The former defines that which is demonstrated radiographically after the injection of red lead (Figs. 6,7).

a) A lateral periosteal branch (Fig. 8), transverse, hemicircumferential and originating from the pedicles of the recurrent radial a., gives rise in the dorsolateral region of the neck to three or four ascending longitudinal parallel branches which reach to the osteochondral junction. Here, they curve through 90° and enter the spongy substance of the epiphysis, which they traverse diametrically to reach the ventromedial region of the head. In this course they remain tangential to the base of the articular fovea of the head of the radius. They give rise (Fig. 9) to a vascular arborisation, particularly dense in the dorsolateral region of the head, which supplies the cancellous substance as far as the articular cartilage.

In the dorsal part, as well as in the ventromedial region, some small per-

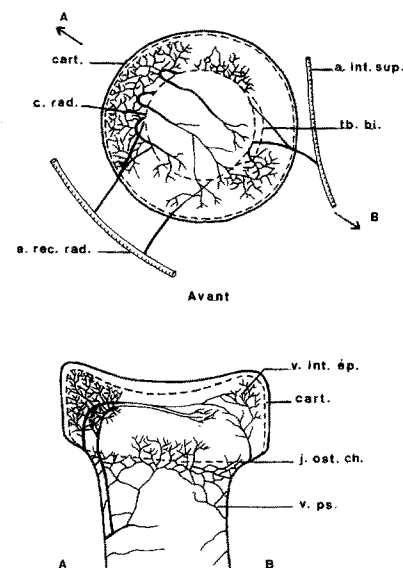


Fig. 9

Above: axial view of radial head, showing the three transverse intra-epiphyseal vessels and the most vascularised cancellous zones. Below: section along axis AB, posterior part of section. Note tangential direction of main epiphyseal vessels at circumference of fovea of head of radius and their anastomosis with the ventromedial vessels. *a.int. sup.*: superior interosseous a.; *a. rec. rad.*: recurrent radial a.; *cart.*: articular cartilage; *c. rad.*: radial neck; *j. ost. ch.*: osteochondral junction; *tb. bi.*: tuberosity of radius; *v. int. ép.*: intra-epiphyseal vessels; *v. ps.*: periosteal vessels

En haut : vue axiale d'une tête du radius. On retrouve les trois vaisseaux intra-épiphysaires transversaux et les trois zones spongieuses plus vascularisées. *En bas* : coupe selon l'axe AB, partie postérieure de la coupe. Noter la direction tangentielle au fond de la fossette articulaire de la tête du radius des vaisseaux épiphysaires principaux et leur anastomose avec les vaisseaux ventromédiaux. *a. int. sup.* : a. interosseuse supérieure ; *a. rec. rad.* : a. récurrente radiale ; *cart.* : cartilage articular ; *c. rad.* : col radial ; *j. ost. ch.* : jonction ostéochondrale ; *tb. bi.* : tubérosité du radius ; *v. int. ép.* : vaisseaux intra-épiphysaires ; *v. ps.* : vaisseaux périostés

ioseal branches penetrate a little way, but in the ventromedial region there is a limited zone where these small branches anastomose with the terminations of the three or four main branches. On the contrary, there is no communication between these periosteal branches and the nutrient a. of the shaft.

b) The other arrangement is less systematised (Fig. 10). The central part of the head is the site of a rich capillary

plexus, 1-1.5 cm in diameter, in continuity with the branches of the nutrient a., though without the individualisation of major branches and without any definite communication with the periosteal plexus. However, this gives off fine branches all around the osteochondral circumference which enter the bone and break up into capillaries to a depth of 1-2 mm.

The first arrangement was found in 9 of the 11 diaphanised specimens, and the second in two.

Discussion

The vascularisation of the proximal radial epiphysis appeared relatively constant, both in its extra-osseous supply and in its intra-epiphyseal pattern. The most important zone for vascularisation of the head seems to be the dorsolateral periosteal layer at the dorsolateral aspect of the neck, the site of penetration of the main intra-epiphyseal branches. However, this zone is not exclusive, since in either type of intra-epiphyseal vascularisation demonstrated, almost all of the circumference of

the osteochondral junction was the site of small periosteal branches penetrating the head.

Fractures of the head of the radius in the adult - unlike those in children - rarely lead to necrosis. Though this possibility is sometimes mentioned [2], it has not been the subject of any detailed study, whether after conservative or surgical management. The displacement is usually posterolateral, with preservation of the main vessel-bearing periosteal layer. Sometimes they are comminuted, but the often small fragments remain pedicled on their periosteum.

These two situations, with preservation of the vessel-bearing layer in the first case and of the small periosteal vessels of the osteochondral junction in the second, may explain the rarity of development of posttraumatic necrosis of the radial head. However, since a number of these more displaced fractures are treated by resection, whether or not followed by arthroplasty, there is no way of assessing the natural history of these radio-clinical types, and this should qualify our concept of the rarity of development of necrosis.

Conclusion

The essential part of the blood supply of the head of the radius derives from the dorsolateral periosteum of the neck. This may explain, at least for the types of fracture with posterolateral displacement, the small risk of development of posttraumatic necrosis.

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