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Transphyseal blood vessels exist in avian species

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INTRODUCTION

There is controversy about the existence of transphyseal blood vessels connecting the metaphyseal and epiphyseal vascular systems in the long bones of both man (Kuhn & Pritzker, 1973; Ogden, 1974) and avian species (Wise & Jennings, 1973; Nairn, 1975). Those authors who claim that transphyseal vessels do exist place a strong emphasis on the role of these vessels in the spread of acute haematogenous osteomyelitis from metaphyseal bone to the adjacent epiphysis and subsequently to the joint causing a secondary septic arthritis (Ogden, 1979; Nairn, 1975). The authors' laboratory has been studying osteomyelitis and septic arthritis in avian models and has a particular interest in the mechanism of bacterial spread from the bone to the adjacent joint. Whilst studying the blood supply to the growth plate in chickens with osteomyelitis the presence of transphyseal vessels was noted in normal uninfected chickens (Emslie, Fenner & Nade, 1984).

MATERIALS AND METHODS

Bone and cartilage samples were collected from the distal femora and proximal and distal tibiae of normal male broiler chickens at 4 weeks of age. Tissue samples were fixed in buffered formol saline, pH 7·0, for 5–7 days and decalcified for a further 2–3 days in 2·3 M formic acid before embedding in paraffin. Serial sections were cut at a thickness of 6 μm and stained with haematoxylin and eosin.

For ultrastructural studies, the tissues were fixed in 2·5 % glutaraldehyde in 0·05 M cacodylate buffer, pH 7·4, and postfixed in 1 % osmium tetroxide in the cacodylate buffer. Following dehydration specimens were embedded in Araldite after extra dehydration in propylene oxide. Sections were cut on a LKB ultramicrotome, stained with uranyl acetate and lead citrate, and examined with a Philips 201 transmission electron microscope at an accelerating voltage of 60 kV.

RESULTS

Light microscopy of the region of the growth plate in 4 weeks old chickens revealed three major types of blood vessel. The most predominant were metaphyseal vessels extending into the hypertrophic zone of the growth plate (Figs. 1, 2). Epiphyseal vessels were also observed and these extended into the zone of growth or hypertrophic layer. Occasionally vessels were observed to communicate with the metaphysis that extended from the epiphysis through the entire thickness of the growth plate (Figs. 1, 2). Sometimes these vessels communicated via a patent lumen (Fig. 2).

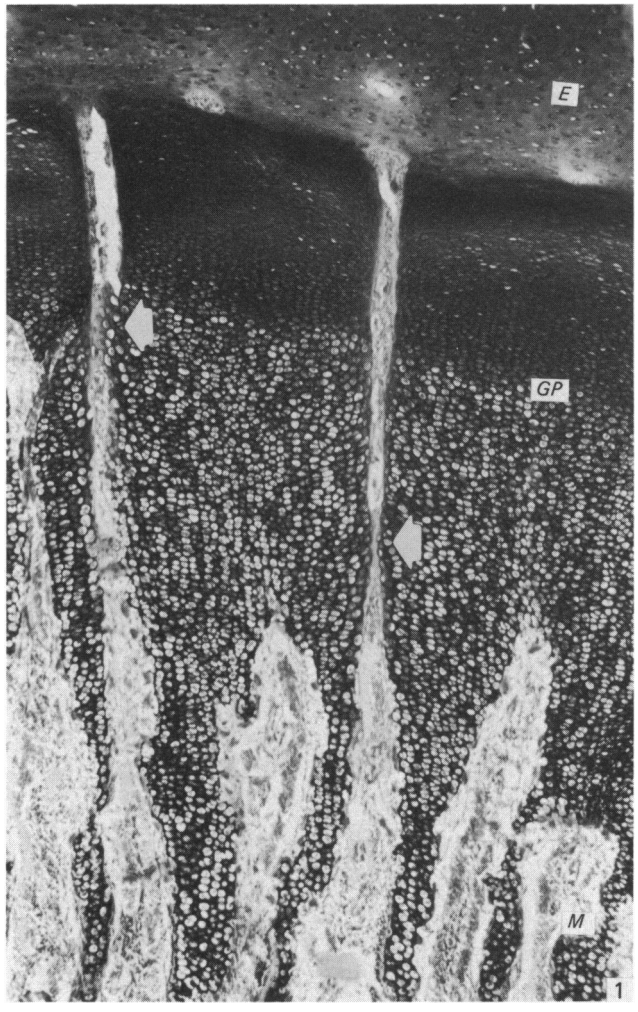

Fig. 1. Light micrograph of epiphyseal cartilage (*E*), growth plate cartilage (*GP*) and metaphysis (*M*) from the distal tibia of a 29 days old chicken. Two 'transphyseal' vessels are present. They connect via 'eosinophilic streaks' (arrows) and not by a patent lumen. Haematoxylin and eosin. ×64.

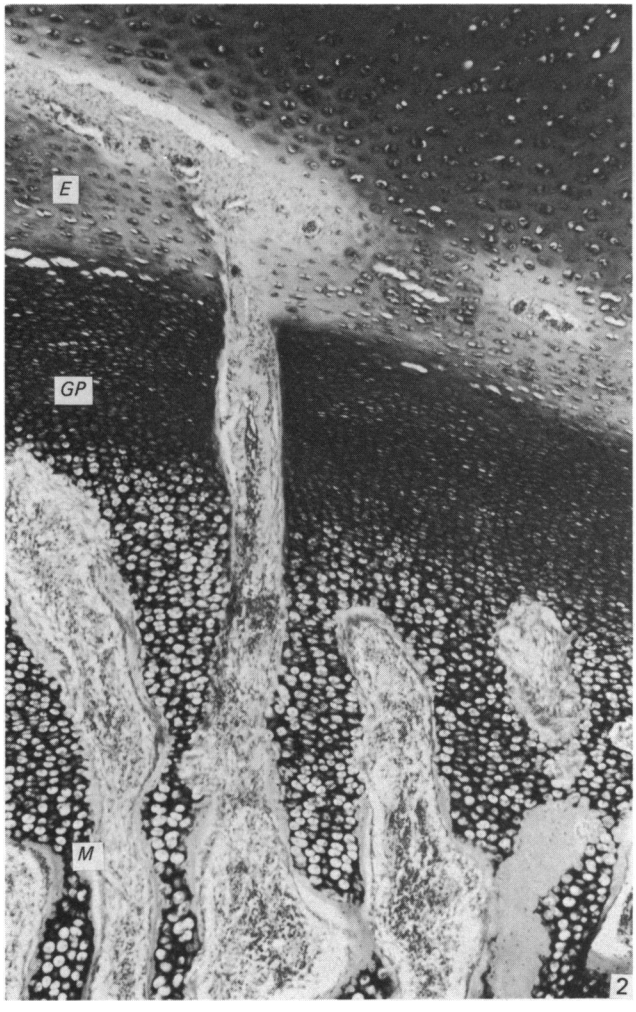

Fig. 2. Light micrograph of epiphyseal cartilage (*E*), growth plate cartilage (*GP*) and metaphysis (*M*) from the distal tibia of a 29 days old chicken. A 'transphyseal' vessel is present that *does* join the epiphysis with the metaphysis via a patent lumen that would allow the passage of bacteria in acute haematogenous osteomyelitis. Haematoxylin and eosin. × 80.

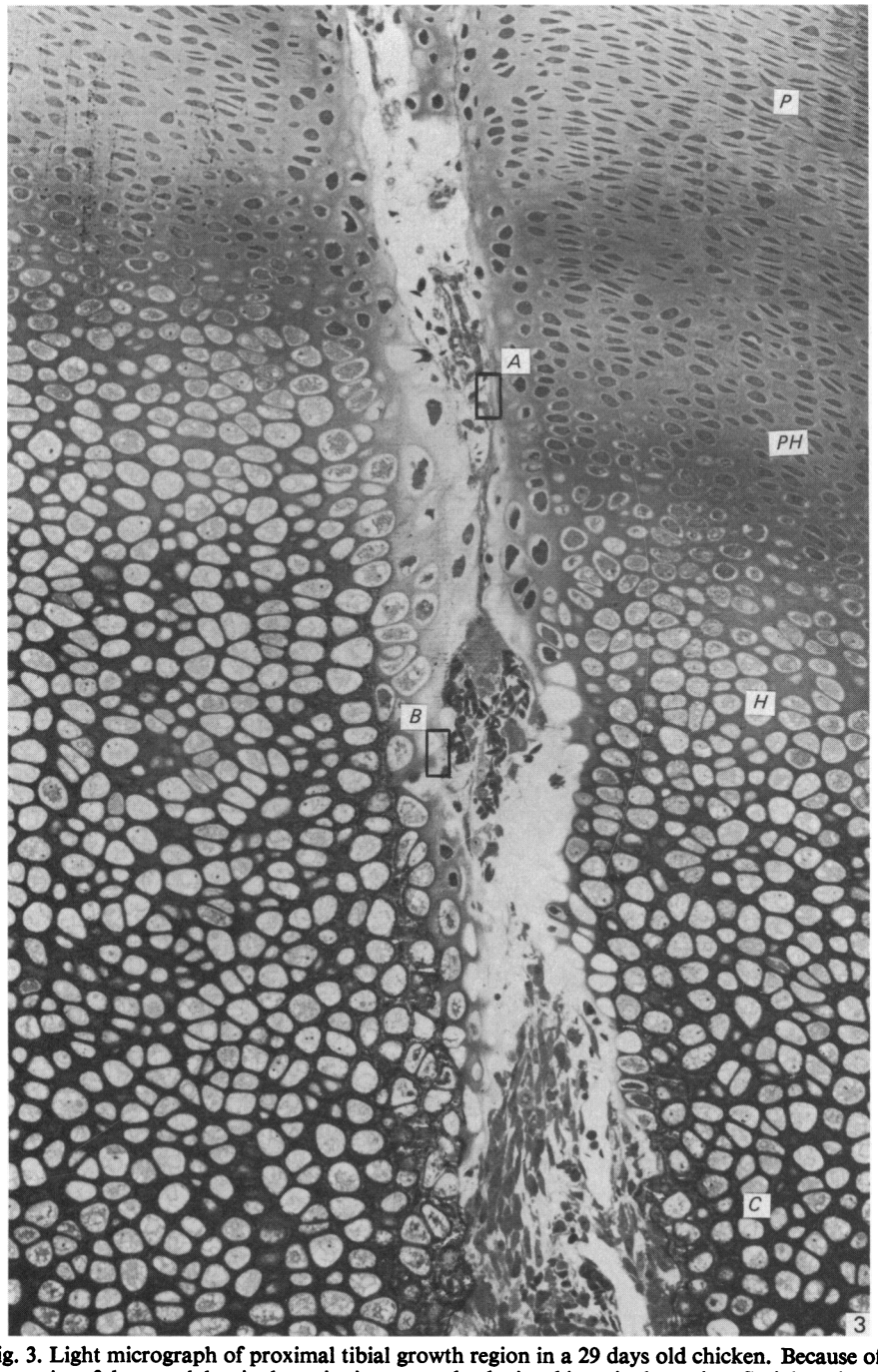

Fig. 3. Light micrograph of proximal tibial growth region in a 29 days old chicken. Because of tortuosity of the vessel, luminal continuity cannot be depicted in a single section. Serial sections, however, can confirm the patency of transphyseal vessels. The regions marked *A* and *B* are those which are shown in Figures 4 and 5 after subsequent electron microscopy of this specimen. *P*, proliferating layer; *PH*, prehypertrophic layer; *H*, hypertrophic layer; *C*, calcifying zone. Toluidine blue. × 236.

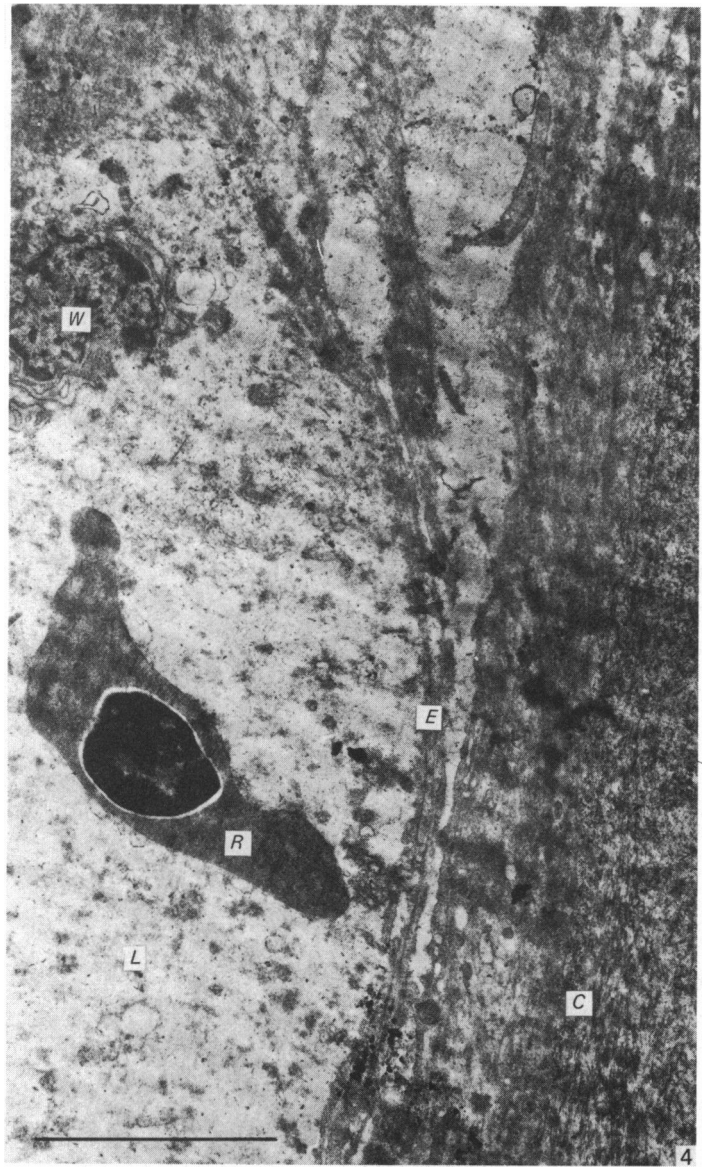

Fig. 4. Transmission electron micrograph of part of the transphyseal vessel indicated in Figure 3 in the region of box *A*. Note the continuous endothelial lining which separates the blood cells in the lumen from the surrounding cartilage. *W*, white blood cell; *R*, red blood cell; *E*, endothelial cell; *C*, cartilage matrix; *L*, lumen of vessel. Bar, 5 μm.

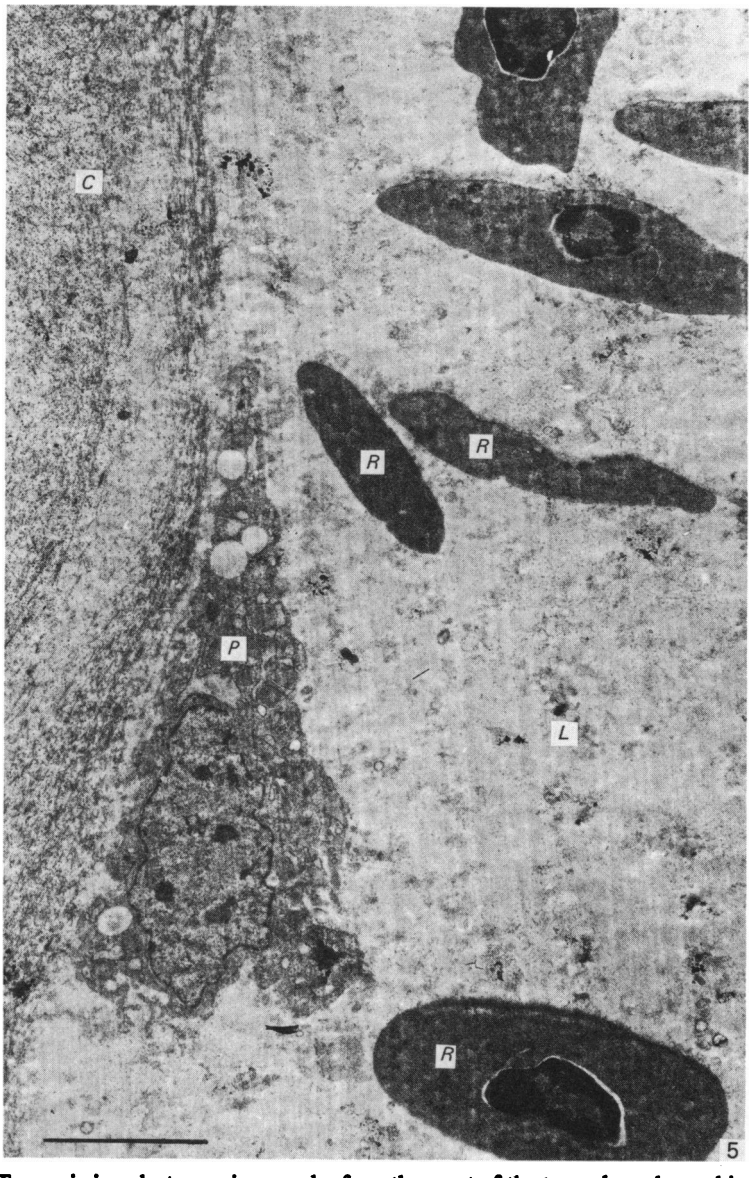

Fig. 5. Transmission electron micrograph of another part of the transphyseal vessel in Figure 3 in box *B*. Note the perivascular cell between the luminal red cells and the surrounding cartilage. *R*, red blood cell; *P*, perivascular cell; *C*, cartilage matrix; *L*, lumen of vessel. Bar, 5 μm.

One such transphyseal vessel (Fig. 3) was examined using electron microscopy. Representative zones are shown in Figures 4 and 5 indicating the presence of erythrocytes in an endothelialised lumen which transgresses the growth cartilage.

DISCUSSION

Trueta (1959) and Ogden (1974) maintain that transphyseal blood vessels exist in man though their presence is dependent on the age of the individual. They suggest that these vessels can be found in neonates and infants but become less prominent during childhood. However, other authors claim that the human growth plate is an effective barrier between the metaphysis and the epiphysis (Kahn & Pritzker, 1973).

Nairn (1975) stated that the metaphyseal and epiphyseal blood streams do communicate across the avian growth plate. Conversely, other workers have averred that epiphyseal and metaphyseal vessels do not connect and therefore cannot communicate in avian long bones (Lutfi, 1970; Wise & Jennings, 1973). More recently Howlett, Dickson & Sheridan (1984), working with 7 weeks old chickens, observed that while metaphyseal and epiphyseal vessels do connect via 'eosinophilic streaks', they do not communicate with each other via a patent lumen.

In direct contrast to the findings of Lutfi (1970) and Wise & Jennings (1973), it is firmly established here, in 4 weeks old chickens, that the metaphyseal and epiphyseal vascular networks do connect across the growth plate. Furthermore, we believe that patent communication between metaphyseal vessels does occur in these animals.

These transphyseal vessels may play an important role in the spread of infection from bone to joint. The authors' unpublished studies have demonstrated continuity of abscesses between metaphyses and joints in chickens. The lack of detection of these vessels is possibly due to the difficulty of sectioning the vessel along the correct plane for its entire length. However, as with the situation in man described by Trueta (1959) and Ogden (1974), the presence of transphyseal vessels in chickens is probably age-dependent and they may only occur in very young animals. This age-dependent anatomical feature may explain why previous authors have failed to detect these vessels.

SUMMARY

The distal femora and proximal and distal tibiae of 4 weeks old broiler chickens have three main types of blood vessels in the growth plate region – metaphyseal, epiphyseal and transphyseal. The transphyseal vessels extend across the entire thickness of the avian growth plate and provide a means of luminal communication between the metaphysis and epiphysis.

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