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The Pattern of Neurovascular Development in the Forelimb of the Quail Embryo

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Abstract

Peripheral nerve and vascular patterns are congruent in the adult vertebrate, but this has been disputed in vertebrate embryos. The most detailed of these studies have used the avian forelimb as a model system, yet neurovascular anatomical relationships and critical vascular remodeling events remain inadequately characterized in this model. To address this, we have used a combination of intravascular marker injection, multilabel fluorescent stereomicroscopy, and confocal microscopy to analyze the spatiotemporal relationships between peripheral nerves and blood vessels in the forelimb of 818 quail embryos from E2 (HH13) to E15 (HH41). We find that the neurovascular anatomical relationships established during development are highly stereotypic and congruent. Blood vessels typically arise before their corresponding nerves, but there are several critical exceptions to this rule. The vascular pattern is extensively remodeled from the earliest stage examined (E2; HH13), whereas the peripheral nerves, the first of which enter the forelimb at E3.5–E4 (HH21–HH24), have a progressively unfolding pattern that, once formed, remains essentially unchanged. The adult neurovascular pattern is not established until E8 (HH34). Peripheral nerves are always found to track close and parallel to the vasculature. As they track distally, peripheral nerves always lie on the side of the vasculature away from the center of the forelimb. Neurovascular patterns have a hierarchy of congruence that is highest in the dorsoventral plane, followed by the anteroposterior, and lastly the proximodistal planes.

Keywords

neurovascular; nerves; blood vessels; endothelium; patterning; quail; forelimb; median artery



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