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Support of pulmonary capillaries in avian lung

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Letter to the Editor

Everyone who is interested in bird respiration should be grateful to Dr. Maina for his extensive studies of the structure of the avian lung. However arguing from form to function in such minute structures as the air and blood capillaries is very challenging.

Our present studies stem from three basic observations:

1. Pulmonary vascular resistance in chickens is essentially unchanged in the face of large changes in pulmonary arterial and venous pressures (West et al., 2007). This suggests that avian pulmonary capillaries do not undergo recruitment and distension as do those in mammalian lung.
2. More recent (unpublished) morphometric studies of the caliber of the blood capillaries indicate that they are remarkably rigid over a large range of transcapillary pressures.
3. The walls of the capillaries are extremely thin and are of more uniform thickness than those of many mammals (Watson et al., 2007).

It seems reasonable to conclude from these observations that something is supporting the blood capillaries and the obvious candidate is the air capillaries that closely surround them.

However, inferring the loads on the air capillaries and the forces carried by their walls based on their ultrastructure is extremely uncertain. For example, the tension or compressive forces in their walls must be exquisitely sensitive to surface tension because of the very small radius of curvature of these structures. We have almost no information on this point except that the lung contains surfactant, and also trilaminar substance, the function of which is unknown. Therefore, inferences about the mode of support by the air capillaries must be very speculative.

A couple of additional points are warranted. First, although the air capillaries appear as thin struts in two-dimensional micrographs (like the spokes of a bicycle wheel), they are actually planes or sheets when considered in three dimensions. Their ability to support the blood capillaries is easier to accept if this is understood.

Next, although Maina states in his opening sentence that the blood capillaries and air capillaries are “astoundingly strong,” this is perhaps misleading. The capillary walls in the chicken have a mean thickness of less than 0.3 μm and the thickness of the epithelial cell

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connections of the air capillaries is somewhat less in places. To describe these wisps of tissue as “strong” seems odd. Rather, the architecture of the parenchyma is organized so that the loads are distributed in such a way that these delicate structures are not overstressed. An analogy is a geodesic dome designed by Buckminster Fuller where the complete structure has great rigidity but the individual struts are thin and light.

Finally our primary interest is in the physiology of the avian pulmonary circulation especially in comparison with that of mammals. Flying is a very energetic activity and presumably involves large increases in cardiac output. How these are tolerated by an essentially rigid pulmonary circulation raises intriguing issues. While we are trying to sort this out we hope that John Maina will continue with his elegant ultrastructural studies including freeze fractures and three-dimensional reconstructions.

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