Blow 'em up! An experimental approach for sauropod necks

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The cervical vertebrae of sauropods were surrounded and invaded by numerous pneumatic diverticula and air sacks. These pneumatic structures certainly saved weight in the long sauropod neck beam. However, it was also hypothesized that pneumatic structures might contribute to the stabilization of the sauropod neck. We tested this hypothesis with a model of a plain coil chain, modelling a sauropod neck segment with five Styrodur blocks and different arrangements of air sacs, modelled with balloons. The Styrofoam blocks were connected with a polyester belt to form a 65 cm long chain, fixed at a vertical pivot board. The balloons were tied along the Styrodur chain by gauze bandage, in positions where the major pneumatic systems in sauropods are supposed to be. The balloons were inflated through a two way valve, allowing to measure their internal pressure with a manometer. To quantify loads, a cup was fixed at the distalmost segment and filled with iron powder until a defined amount of curvature was achieved.

The experiment shows that a support effect is evident already with one ventral balloon. The support effect increases if a second ventral and a dorsal balloon are added. The presence or absence of intersegmental compression support elements, pressure changes within the balloons, a proximal fixation of the balloons or their fixation at their respective segments, and the degree of segmentation of the balloon all changed the supporting effect and load capacity of the chain beam.

The conclusions drawn from this experiment for the support capabilities of pneumatic systems in the neck of sauropods hinge on the specific reconstruction of the extension of the pneumatic diverticula: Support is only possible, if pneumatic diverticula are reconstructed to extend beyond their bony bed on the vertebral surface. The support effect of intersegmental pneumatic diverticula would be larger than that of intrasegmental ones. If pneumatic diverticula are reconstructed as large hose-like structures wrapped by a peripneumatic fascia laterally and dorsally adjacent to the vertebrae, a large support effect would be the consequence.

The idea of a contribution of a pneumatic bracing of saurpod necks is consistent with other tendinomuscular and osseous bracing elements of the sauropod neck beam. The obligatory presence of other than pneumatic bracing structures indicates that pneumatic diverticula could not achieve neck support alone. If it is assumed that the cervical pneumatic system of sauropods contributed to neck support, volume and pressure regulation mechanisms in this pneumatic system must have been present as well. Then, the pneumatic system could have been even utilised to move the neck beam from side to side at exceedingly low energetic cost.