Vertical head-down posture of the fetus may explain the rapid brain evolution in humans and other primates

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Abstract

Evolutionary cerebrovascular consequences of upside-down postural verticality of the anthropoid fetus have been largely overlooked in the literature. This working hypothesis-based, narrative review postulates that the rapid evolution of the human brain has been promoted by fetal head-down position due to maternal upright and semi-upright posture. Habitual vertical torso posture is a feature not only of humans, but also of monkeys and non-human apes that spend considerable time in sitting position. Head-down position of the fetus may have caused physiologic craniovascular hypertension that stimulated expansion of the nourishing intracranial vessels and acted as an epigenetic physiological stress, which enhanced neurogenesis and eventually, along with other selective pressures, led to the progressive anthropoid brain enlargement. This article collaterally opens a new insight into the conundrum of high cephalopelvic proportions (i.e., the tight fit between the pelvic birth canal and fetal head) in phylogenetically distant lineages of monkeys, lesser apes, and humans. Low cephalopelvic proportions in non-human great apes could be accounted for by their energetically efficient horizontal nest-sleeping and consequently by their larger body mass compared to monkeys and lesser apes that sleep upright. It can be further hypothesized that brain size varies in anthropoids according to the degree of exposure of the fetus to postural verticality. The supporting evidence for this postulation includes a recent finding that in fossil hominins cerebral blood flow rate increased faster than brain volume. The approaches for testing the hypothesis include experimentation with avian embryo position *in vitro*, comparative cephalometry of vertex-breach twins, and Doppler assessment of the fetal cerebral circulation in maternal upright and horizontal posture. The current report opens a perspective for further related research on circadian postural behavior, obstetrics, and fetal postural cranial hemodynamics in humans and other primates. It may also be possible to expand the introduced hypothesis into a universal theory of epigenetically enhanced embryonic/fetal cerebral neurogenesis as a driver of evolutionary encephalization.

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Figures

Figure 1. Evolutionary endocranial volume (ECV) change in hominins (see supplementary MS Excel file for details).

Figure 2. Phylogenetic position of the species discussed in the current article.

Figure 3. Comparison of cephalopelvic proportions of some anthropoid species (see Figure 2) after Schultz.⁴⁰

Figure 4. Comparison of a possible phylogeny **(a)**, cephalopelvic proportions **(b)**, endocranial volume **(c)**, and probable fetal position according to circadian periods of habitual maternal body postures **(d)** of the same anthropoids as in Figures 2 and 3.

Figure 5. Illustrative comparison of evolutionary brain expansion in hominins **(a)** and antenatal brain growth in humans **(b)** by using exponential curve fitting.

Supplementary material

1. Supplementary MS Excel file “Data file. Fetal verticality and encephalization”
2. Supplementary figures

Supplementary figure S1. Cephalic presentation of human fetus. Used with permission.

Supplementary figure S2. Head-down tilt of a fetus at 37 weeks' gestation. Used with permission.