News and Views

The shoulders follow the head: postcranial constraints on human childbirth

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Although the significance of human childbirth as an important source of selection on human pelvic morphology has been recognized for many years (Krogman, 1951; Washburn, 1960), it has only been in the last few decades that the morphology of fossil hominids was analyzed with this in mind (Leutenegger, 1982, 1987; Berge *et al.*, 1984; Tague & Lovejoy, 1986). Recent fossil discoveries (Walker & Ruff, 1993; Ruff, 1995) and new reconstructions of old fossils have again focused attention on how early hominids gave birth and how the modern human pattern of birth evolved. In all of these analyses, the shape of the bony pelvis is reconstructed or estimated, neonatal cranial size is estimated (generally from average adult brain size and from information on infant/adult size ratios) and the mechanism of birth is inferred from an analysis of cephalopelvic proportions and relationships (for descriptions of modern human birth and discussions of reconstructions of birth from the fossil record, see Leutenegger, 1982, 1987; Berge *et al.*, 1984; Tague & Lovejoy, 1986, 1998; Trevathan, 1987; Rosenberg, 1992; Ruff, 1995; Rosenberg & Trevathan, 1996).

These approaches have been productive and we know far more about the evolution of human childbirth than we did 30 years ago, but attention has been focused on only *one* of the constraints affecting the birth process: the size of the neonatal head. For example, Tague & Lovejoy (1986) reconstructed the bony birth canal of A. L. 288-1 (Lucy) as transversely flattened at all pelvic planes (inlet, midplane and outlet) and inferred from this that the mechanism of birth in australopithecines was unique (see also Rosenman *et al.*, 1999). The birth canal was adequate to allow passage of an infant cranium approximately the size of a living chimpanzee, but *only* if the infant's head entered occiput transverse with asynclitism, and exited occiput transverse, without the rotation distinctive of modern humans. Although their reconstruction was questioned by Häusler & Schmid (1995), in part on the grounds that A. L. 288-1 may have been male, Tague & Lovejoy's (1998) subsequent work shows convincingly that both A. L. 288-1 and Sts 14 are female and that their birth canals are obstetrically adequate "even with an inferred newborn brain size for *A. afarensis* that is likely overestimated." We agree with their reconstruction of the pelvis, and with their interpretation that the flat (or platypelloid) australopithecine birth canal would have restricted fetal head rotation at all levels within the canal, and that birth must have proceeded as they suggest, i.e., with the head not rotating during its passage.

We disagree, however, with a common interpretation of their proposal, which is that

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fetal rotation did not occur along *any* dimension of the fetus during its passage through the birth canal (for example, Ruff, 1995; but see Häusler & Schmid, 1995:378). This distinction is important because in modern obstetrical discussion "fetal rotation" describes the passage of both head and shoulders through the birth canal. The large size of the infant head relative to the mother's bony birth canal is certainly one reason for the rotational pattern seen in modern humans, but a significant additional source of difficulty comes from the passage of the infant's broad, relatively inflexible shoulders which must follow the head through the birth canal. In fact, fetal rotation is often described in two stages. Internal rotation of the fetal head occurs when the head turns transversely at midpelvis and the shoulders remain in an oblique or transverse position. External rotation of the head occurs when the fetal head has emerged from the birth canal and is "really the outward manifestation of the internal rotation of the shoulders" (Oxorn, 1986:102). Shoulder dystocia in living humans occurs when the shoulders fail to traverse the pelvis after delivery of the head (Smeltzer, 1986) and can lead to such problems as asphyxia, injury to the brachial plexus, death of the infant, uterine rupture, excessive blood loss and death of the mother (Lipscomb, 1994; Trevathan, 1988). Because the long axis of the shoulders is perpendicular to the long axis of the infant head, the infant's body must also rotate as it passes through the birth canal so that the shoulders can navigate the tight space. Thus, the mechanism of birth in modern humans represents an adaptation to the passage of *both* a large neonatal head and broad, rigid, neonatal shoulders.[1]

[1]In fact, rotational birth *per se* is not unique to humans—we know from Stoller's (1995) work that, contrary to longheld assumptions, birth in monkeys also involves rotation through the birth canal, though of a different sort than is seen in humans.

As pointed out by Trevathan (1988), broad, relatively inflexible shoulders occur in living apes and humans and may have been primitive for hominoids as part of the adaptation to generalized suspensory locomotion and increased shoulder mobility. Table 1, taken largely from Schultz (1949), gives data on newborn head and shoulder dimensions as well as maternal pelvic inlet size. (Although this table is frequently cited, the shoulder data are usually not included and the implications of those data are often ignored.) It is obvious that the living great apes and humans all have wide shoulders. The great apes apparently do not experience difficulties in delivering the shoulders because of their large maternal and relatively small infant body sizes. As Table 1 shows, human infants have such wide shoulders that they cannot enter the pelvic inlet in the anterior–posterior position without great difficulty.

It is reasonable to assume that early hominids also exhibited the characteristic great ape and human shoulder morphology. This would mean that although the neonatal head most probably passed through the birth canal without rotating, the shoulders which followed that head would probably not have been able to pass through without changing orientation. In other words, the same pelvis that would have required the infant head to enter and exit facing transversely would have also required rotation in order for the infant's broad, rigid shoulders to follow. Although we have followed Tague & Lovejoy's (1986, 1998) hypothesis about australopithecine birth, other hypotheses of australopithecine birth (Berge *et al.*, 1984; Häusler & Schmid, 1995) *do* involve internal rotation of the fetal cranium. Regardless of which of these is correct, our argument about rotation of the fetal shoulders would hold.

The mechanism of birth in australopithecines probably was unique (Rosenberg, 1992; Tague & Lovejoy, 1986, 1998; Trevathan, 1987) and it may well be that the modern pattern of rotational birth did not

Table 1 Adult female pelvic inlet dimensions and newborn dimensions for selected primate species*

Species	Adult female pelvic inlet dimensions (mm)			Newborn dimensions (mm)						
				Head			Shoulder			
	N	M–L	A–P	*N*	Length	%M–L	%A–P	Breadth	%M–L	%A–P
Ateles geoffroyi	7	54·4	90·3	8	66·9	123	74	50·4	93	56
Macaca mulatta	41	50·9	67·7	28	66·3	130	98	49·2	97	73
Nasalis larvatus	15	51·8	71·5	1	64·0	124	89	59·0	114	82
Hylobates lar	87	55·9	78·7	6	64·2	115	82	51·2	92	65
Pongo pygmaeus	26	102·5	149·6	4	84·1	82	56	81·8	80	55
Pan troglodytes	29	98·0	149·5	9	83·0	85	55	84·9	85	57
Gorilla gorilla	10	122·6	175·7	4	97·0	79	55	92·0	75	52
Homo sapiens	10	121·6	112·9	10	123·8	102	110	118·3	97	105

*After Schultz (1949:415).
M–L—medio–lateral dimension of the pelvic inlet (greatest transverse breadth between the arcuate lines).
A–P—antero–posterior dimension of the pelvic inlet (symphysion–promontorium).
Newborn head length—maximum length of the cranium from glabella.
Newborn shoulder breadth—breadth across the acromial points.
%M–L—ratio of newborn head or shoulders to M–L dimension of pelvic inlet.
%A–P—ratio of newborn head or shoulders to A–P dimension of pelvic inlet.

appear until the late Middle Pleistocene with the increase in cranial capacity, as Ruff (1995) has suggested. Since the shoulders follow the head in all vertex presentations, however, it is also likely that some sort of neonatal rotation would have been necessary for even the earliest hominids. An understanding of the evolution of modern human childbirth requires a consideration of *all* constraints on the birth process. The focus on cranial size is probably a consequence of the importance of this constraint in modern humans. However, in australopithecines (as well as in many discussions of modern humans and nonhuman primates[2]) the importance of the shoulders as a significant constraint in birth may have been underestimated.

[2]For example, the data presented for *Nasalis* in Table 1, although a sample size of only one newborn specimen, suggest that these monkeys may also exhibit fetal rotation during delivery.

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