GETTING HIP: Babies, Brains and Bipedality in Human Pelvic Evolution

My interest is in paleo-obstetrics and paleo-pediatrics. Specifically, I would like to understand when and how humans came to give birth in the complicated, risky, awkward and even uncomfortable way that we do, to babies who are quite helpless at birth and large in body size. Human childbirth differs from birth in our closest primate relatives in several ways. In humans, the baby’s head is large relative to the size of the birth canal, leading to the potential of what obstetricians call cephalo-pelvic disproportion. The human birth canal (or pelvic aperture) is a curved tunnel of changing cross-sectional shape. In order to negotiate its way through, the neonatal head typically makes a series of rotations emerging from the mother’s body in the occiput anterior position, that is, with the back of the baby’s head – the occiput, toward the front of the mother’s body. Put another way, the baby emerges facing the opposite direction from the mother, making it difficult for the mother to assist the baby herself. Because of the mechanics of this way of giving birth, it is associated with an unusual behavior in humans: we almost invariably give birth in a social context, with the assistance of others. Attendants, whether they are midwives, obstetricians, close relatives or friends, can improve the outcome of the birth process by assisting the mother and infant in a variety of ways. Assistance during birth is not generally seen in other primates or other mammals; in fact, most tend to give birth alone away from the group and at night.

The shape of the pelvis is one part of the story of the evolution of human childbirth. The traditional story of pelvic anatomy in humans is described as an “obstetrical dilemma” in which the human pelvis represents a balance between two conflicting sources of selection, bipedalism (walking on two legs) which favors a narrow pelvis and childbirth which favors a spacious, wide one. Our understanding of how the rotational mechanism of birth and infant helplessness evolved from a condition more typical of apes rested for many years on two fairly complete female australopithecine pelvic fossils, one from South Africa (Sts 14) and one from East Africa (A.L. 288-1). These early hominins were bipedal but small-brained creatures. Both fossils show that early hominin anatomy was characterized by a pelvis that was broad overall and also flat (or platypelloid) at all levels of the birth canal. This means it was significantly different from both modern apes (whose pelvis and birth canal are long from front to back and relatively narrow from side to side) and modern humans (in which the cross-sectional shape changes along the length, being broad and flat at the inlet, switching further down to being narrow and long, and then returns to a rounder cross section at the outlet). Some scientists have suggested that the australopithecine mechanism of birth was also different from that seen in either modern apes or modern humans. They argued that in these early hominins, the neonatal head entered the inlet of the mother’s birth canal facing to the side, as modern humans do, but then did not rotate (indeed, they argued that it could not rotate) as it passed through the middle part of the canal and outlet. This unique mechanism of birth is not surprising given the mosaic nature of australopithecine morphology, with a mixture of some human-like traits (like the bipedal form of locomotion) and others that were ape-like (such as the ape-sized brain). Presumably, the rotational mechanism of
birth that we see in modern humans evolved after australopithecines, probably as a concomitant of increasingly larger neonatal brains as large brains evolved after about 2.0 million years ago.

In addition to childbirth, pelvic morphology is also of course constrained by locomotor mechanisms as well other important functions of the pelvis such as its role in visceral support. In the last few decades, the human fossil record of pelvic anatomy from the time period following the early australopithecines has expanded dramatically, especially with respect to female individuals, whose morphology is more relevant to an understanding of childbirth than that of males! We now know that a broad pelvis like that seen in australopithecines is also typical of later hominins, including early Homo. While that morphology certainly did not evolve in order to accommodate a large neonatal brain, it did have obstetric consequences and it is likely that the mechanism of birth changed as a result of that morphology.

The recently described material from Malapa, South Africa, dated to almost two million years ago and attributed to *Australopithecus sediba* shows some aspects of modern pelvic morphology in a relatively small brained hominin leading the describers to conclude that those features did not evolve as obstetric adaptations. A bit later in time, the Gona specimen from 0.9-1.4 million years ago in Ethiopia shows that in *Homo erectus* females, the pelvis had expanded somewhat anterior-posteriorly compared to the ancestral condition, presumably to allow for rotational birth in this more encephalized (large-brained) species. Previously, our knowledge of obstetric-related anatomy in *Homo erectus* was based almost entirely on a fragmentary, juvenile, male specimen (WT 15000). In the later part of the human fossil record, the male pelvis from Sima de los Huesos in Spain, the female pelvis from Jinniushan in northeastern China (260,000 BP) and a number of more recent Neandertal specimens from Europe and the Middle East make it clear that by the middle/late Pleistocene the pelvis had expanded to accommodate large neonatal brains and presumably that a rotational mechanism of birth had evolved. This suggests that the benefits of birth assistance may have already evolved by this time and that humans have been giving birth the way we do today (or at least the way we did before the medicalization of childbirth in industrialized nations in the twentieth century) for something on the order of hundreds of thousands of years.

Several recent pieces of evidence aside from pelvic morphology are important to an understanding of the evolution of human childbirth and may serve to help us tease apart constraints other than encephalization that contribute to the evolution of changes in the human obstetric mechanism. Often, it is assumed that selection on the human pelvis because of obstetric constraints means that the infant head must have been large at birth. But the infant head is not the only constraint on the birth process. At least two other aspects of newborn anatomy are also crucial. First, in modern humans, the baby’s shoulders also often present a significant challenge to women in childbirth. When shoulders become impacted in the birth canal (shoulder dystocia), birth injuries to the infant can result in permanent damage in the form of brachial plexus injury, resulting in paralysis or palsy and prolonging the labor, and thus leading to higher risk for complications such as hemorrhage. Obstetricians and midwives are
often able to perform a number of low-tech maneuvers that can alleviate the obstruction without damage to the infant or mother. Humans and apes (and of course, early hominins) have broad, rigid shoulders which make us particularly vulnerable to shoulder dystocia and this would have been true of early hominins and early Homo as well. Second, we know that human babies are born at an early stage of development (with a smaller percentage of adult brain growth completed than in our ape relatives). Ashley Montagu referred to the newborn human as an “extero-gestate fetus” for the first three months after birth. We can buffer our relatively helpless infants from the environment with a variety of cultural means (blankets, cradle boards, houses, etc.). But our babies are also larger in body size relative to the size of their mothers than the other great apes. This means that humans give birth to babies that are “needy” in the sense of being immature and vulnerable, but also large in size. No wonder they need such an investment of parental and other care giver attention! DeSilva has shown that the size relationship that we see between mothers and newborns in humans today probably extends back in human evolution as early as australopithecines. So, even though australopithecines were giving birth to small-brained babies, those babies were probably broad-shouldered and large in body size and may have presented significant obstetrical challenges to their mothers. So, I would caution against assuming that selection from obstetric constraints only occurs because of selection from encephalized babies.

Finally, observations of primate birth outside the laboratory are extremely rare. This is because of the fact, mentioned above, that primate mothers seek seclusion – from members of their own species, from possible predators and from primatologists who would like to observe them! However, recent observations of birth in both monkeys and chimpanzees in laboratory conditions suggest that our assumptions about the way these primates give birth may be incorrect. Stoller observed several different monkey species giving birth and noted that the infants often rotated as they passed through the birth canal, although in a different way from that typical of humans. Last spring, Hirata and colleagues published observations of chimpanzee birth. Contrary to expectations, these three chimpanzee mothers gave birth with the infant emerging in an occiput anterior position, something that was previously thought to be unique to humans. These new data suggest that our assumptions about the primitive condition for aspects of the birth mechanism in hominins may be incorrect and should lead us to re-examine the mechanism of birth postulated for australopithecines as the primitive hominin condition.

Pelvic anatomy in humans strikes a particularly challenging balance between the conflicting sets of selective constraints under which we have evolved. The idea that pelvic anatomy represents a compromise to the constraints of bipedalism and brain size is clearly too simple a model. Other aspects of our biology have also responded to the constraints of giving birth to a large-brained, large-bodied, broad-shouldered, bipedal infant. The fact that we are cultural animals who can buffer helpless babies from the environment and help one another through the challenges of childbirth has allowed evolution to change both the timing of birth (with respect to infant development) and the mechanism of birth. We have to understand the
evolution of the pelvis in humans and our ancestors in the context of this multi-dimensional evolutionary process.

Karen Rosenberg
Department of Anthropology
University of Delaware
Newark, DE 19716
krr@udel.edu