A Case of Maternal and Perinatal Death in Neolithic Southern Vietnam, c. 2100–1050 BCE

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ABSTRACT Despite ostensibly elevated rates of young female mortality in the past, believed to be associated with the risks of pregnancy and child birth, surprisingly few cases of pregnant female burials are reported in the bioarchaeological literature. This paper describes and discusses the case of a young female who died and was interred with an unborn full-term breech foetus at the Neolithic site of An Son, southern Vietnam c. 2100–1050 BCE. Her exceptionally poor oral health, evidence for cribra orbitalia, linear enamel hypoplasia, small stature and compromised gynaecological competence, contributes to a differential diagnosis that explores a range of additional complications that may have contributed to the death of both mother and unborn child. An examination and appreciation of this case contribute to our knowledge of the reproductive age and health of young females in Neolithic Southern Vietnam and the challenges they faced during pregnancy and childbirth. Copyright © 2011 John Wiley & Sons, Ltd.

Key words: pregnancy; dystocia; death during childbirth; palaeopathology; Neolithic; Vietnam

Introduction

This paper describes and discusses arguably the earliest clear instance of the burial of a pregnant female and her full-term perinate in Neolithic southern Vietnam c. 2100–1050 BCE (Bellwood et al., in press). Young females tend to be over-represented in archaeological populations ostensibly due to the high mortality rate associated with pregnancy and childbirth (Högberg et al., 1987; Slaus, 2000; Joyce, 2001; Tocheri et al., 2005). Despite this general acceptance of the vulnerability of young females in the past, there are very few cases of pregnant women reported from archaeological contexts: two have been published from the United Kingdom (Hawkes & Wells, 1975; Wells, 1978), six from Spain (Agustí & Codina, 1992; Pol et al., 1992; Campillo et al., 1998; Malgosà et al., 2004; Seguí et al., 2005; Flores & Sánchez, 2007), four from Scandinavia (Sjøvold et al., 1974; Persson & Persson, 1984; Högberg et al., 1987) two from North America (Owsley & Bradtmiller, 1983) and one from Portugal (Cruz & Codinha, 2010) and Australia (Pounder et al., 1983).

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Given the risks associated with pregnancy and childbirth, why is there a dearth of direct archaeological evidence for maternal and perinatal mortality? Given that death of only the mother or only the child postpartum will be archaeologically invisible, we are only likely to identify cases where both the mother and perinate were buried together, evident only where the perinate was retained within the uterus. A stillbirth with subsequent, or simultaneous, death of the mother provides the option for separate mortuary treatments and the problem of archaeological invisibility of the event again. Apart from issues with the time of death of the mother and foetus, as well as potential differential mortuary treatments, it is possible that many cases of foetal remains in situ have been missed during excavation. There is also a risk of confusing foetal remains in the pelvic cavity as hand bones (as will be seen below), especially as the hands, if placed over or near the pelvis, often move and disarticulate in this area during decomposition. Mummiﬁed remains have provided clearer answers to questions of death due to or during childbirth. Ideal mummiﬁcation provides evidence of soft tissues, enlarged breasts, distended abdomens, ovaries, placenta and umbilical cords, in addition to foetal remains, evidence otherwise lost with skeletonised burials. Those that died during pregnancy provide an opportunity to
estimate both palaeohealth and maternal mortality (Ashworth et al., 1976; Cockburn et al., 1980; Arriaza et al., 1988) with well-preserved mummies being essentially undisturbed time capsules, freezing the last moments of life and first stages of death.

While obstetric issues are not always the central focus, evidence of females dying during pregnancy (Smith & Dawson, 1924; Ashworth et al., 1976) and being wrapped holding perinates (Ashworth et al., 1976) is documented. Arriaza et al. (1988) found that 14% (18/128) of the females aged between 12 and 45 years of age from a sample of 187 pre-Columbian female mummies from Northern Chile died from complications in childbirth, with three dying with the foetus still present in the uterus. Females excavated with in situ foetuses have been noted in Aebelholt cemetery, Denmark (Hoppa & Fitzgerald, 1999, p. 16) as well as the North American prehistoric Libben site (White & Folkens, 2005, p. 19). A pregnant woman with a foetus in breech position has been recorded at Kulubnarti in Sudanese Nubia (Sibley et al., 1992), while another paper suggests several Nubian females were found with foetal remains in their pelves (Smith & Wood Jones, 1910 Plate 38, Figure 5; Caldwell & Moloy, 1933, p. 480).

The aim of this paper is to describe and discuss the burial of a young female buried with an in situ foetus from a Neolithic cemetery site in southern Vietnam. A differential diagnosis is presented in order to explore the most parsimonious scenario consistent with the position and gestational age of the foetus, as well as the obstetric, and general, health of the mother.

Materials and methods

The mother–perinate pair (AS07H1M3a and b) was discovered close to the Vam Co Dong River at An Son, Long An Province, southern Vietnam. An Son is a large mound, originally about 160 m in diameter and more than 4 m high, first discovered by Malleret and Levy in 1938 (Malleret, 1963). Apart from the remains of an Oc Eo period (1st–6th century CE) temple, the mound primarily consists of Neolithic deposits dated to between c. 2100 and 1050BCE (Bellwood et al., in press). An Son has been excavated over several decades: 1978, 1997, 2004, 2007, and most recently in 2009 (when both authors attended).

AS07H1M3a and b were excavated in 2007 by archaeologists from the Long An Provincial Museum and the University of Social Sciences and Humanities, Ho Chi Minh City (Dang et al., 2008). Due to time constraints (a short 10-day excavation), while the cranium, appendicular skeleton and the os coxae were lifted individually, the thoracic and lower abdominal areas were lifted within a block of associated burial matrix. Upon examining pre-removal photographs of the burial, and freeing skeletal elements from the thoracic and abdominal region of the matrix block, one of us (AW) recognised the partial remains of an in situ and apparently unborn foetus. A search of individually bagged hand bones of the adult woman also revealed missing limb bones of the foetus.

Age-at-death of AS07H1M3a (the mother) was estimated by the pubic symphysis (Brooks & Suchey, 1990) and auricular surface (Buckberry & Chamberlain, 2002) of the os coxae. The level of epiphyseal fusion was assessed using Scheuer & Black’s (2000) standards. Age-at-death estimates derived from tooth wear scores (Scott, 1979) were entered into functions developed for ancient Vietnamese material (Oxenham, 2000). Sex was determined using sexually dimorphic characteristics of the skull and pelvis (Phenice, 1969; Ubelaker, 1989; Buikstra & Ubelaker, 1994, Walrath et al., 2004) and entered into sex estimation functions (Oxenham, 2000) based on sexual dimorphism of the mandible, humerus, femur and tibia.

For AS07H1M3b (the foetus), tooth formation and mineralisation was recorded after Ubelaker (1989). Although dental formation is considered less variable than long bone growth, the size and fragility of the mineralising teeth in perinates often means they are not recovered in archaeological contexts. The standards for tooth mineralisation are also likely less accurate than long bone length at perinatal age (Moorrees et al., 1963). Long bone length was used to establish an independent age estimate using linear regression equations based on foetuses of known gestational age (Scheuer et al., 1980; Scheuer & Black, 2000; Sherwood et al., 2000) and following other successful applications (Tocheri et al., 2005; Halcrow et al., 2008).

Results

AS07H1M3a is an adult female that was pregnant at the time of death with a perinate positioned in her abdominal – pelvic – upper leg area. Skeletal preservation was good with all elements represented and generally intact. The cranium was crushed resulting in some facial and maxillary distortion.

Age-at-death is estimated to be 15–23 years old, based on fusion of all epiphyses in the postcranial skeleton with the exception of the sternal end of the clavicles and posterior aspects of both left and right iliac crests. Moreover, all four M3s had fully erupted, although the sphen-occipital synchondrosis (basilar suture) was unfused.
Scheuer and Black (2000, p. 59) note basilar suture fusion in females occurs between 11 and 16 years, and given the other evidence for age-at-death may indicate she was only 15–16 years old. Her stature and extreme gracility would support this, although it is also possible that she simply experienced delayed fusion of the basilar suture. Her height was estimated to be between 144.2 and 146.4 cm using functions derived from Thai populations (Sangvichien et al., n.d.; Sangvichien et al., 1985). The range of stature for females from An Son was 144.2–147.6 cm (n = 2), while males was 166.6–179.9 cm (n = 2), suggesting significant height, at least, sexual dimorphism.

Due to postmortem crushing of the cranium, portions of the maxillary alveolar bone was not assessable. Nonetheless, and despite her youth, AS07H1M3a had already lost three teeth antemortem with associated resorption of the alveoli. She had a very aggressive case of caries, presenting with 20 carious lesions (nine maxillary and eleven mandibular), often manifesting on both the mesial and distal interproximal surfaces (four teeth). Gross caries had completely obliterated the crown of four teeth and half of the crowns of the two remaining mandibular molars were destroyed. There were two alveolar abscesses at the site of the right P₄ and right M₂. Linear enamel hypoplasia, a non-specific indicator of childhood stress, was present on the maxillary central incisors and the mandibular central and lateral incisors. The right eye orbit was complete, as was the anterior third of the left, and both displayed evidence of un-remodelled cribra orbitalia.

The right transverse process of the 5th lumbar vertebra is enlarged, and a bony mass protrudes from the process anteroinferiorly facilitating a pseudoarticulation with the detached (bipartite) superoposterior aspect of the right ala (Figure 1). The left superior articular facet of the sacrum is rudimentary, lacks normal curvature and is on a coronal orientation creating an unstable articulation with the left inferior articular facet of L₅.

The right superior articular facet of the sacrum is larger, curved and appropriately orientated in order to articulate with the inferior articular facet of L₅.

The pelvis was reconstructed and measurements of the pelvic inlet, mid-pelvis and pelvic outlet were taken following Sibley et al. (1992). AS07H1M3a's pelvis was slightly flattened and brachypellic with an inlet index of 76.7 (sagittal × 100/transverse). The sagittal diameter of the pelvic inlet was 8.4 cm, the middle pelvic plane 10.1 cm and the pelvic outlet 10.1 cm.

AS07H1M3b, the foetus, presented in an apparent breech position within the lower abdominal region of the mother (Figure 2). The cranium of the foetus was below the mother's right lower ribs and the postcranial skeleton of the foetus extended down toward the mother's pelvis. A left femur was positioned within the mother's pelvic cavity and a tibia was positioned beside the lesser trochanter of the mother's right femur. It is possible that there were more bones in the pelvic cavity that were accidentally removed during excavation. The foetus was well preserved with almost all the elements present. The right pars lateralis was concreted to the anterosuperior portion of the shaft of the 10th right rib of the mother, near the sternal end (Figure 3).

Dental mineralisation was limited within the alveoli of the unfused mandible. The buds of the central and lateral incisors and canines were present (the maxillary buds were between 4 and 4.5 mm long), while the cusps of the molars were just forming but had not completely united to form an occlusal surface. The foetus was aged at 38 gestational weeks, based on tooth mineralisation and long bone length, which is consistent with a full-term pregnancy.
Discussion

The following discussion of AS07H1M3a and b seeks to determine if this is a probable case of simultaneous (or near) death of both mother and unborn child and if any contributing factors, either maternally or foetally mediated, can be discerned. AS07H1M3a presented with a full-term foetus in breech position. She was a gracile woman of small stature who suffered from physiological stress as a child and serious oral disease before death. AS07H1M3a also had a brachypelvic pelvis and an accessory pseudoarticulation between the transverse process of her L5 and sacral ala. The multiple indicators of stress seen in this woman are mirrored in many other bioarchaeological descriptions of females who died during pregnancy or childbirth: several manifesting caries and antemortem tooth loss (Owsley & Bradtmiller, 1983; Malgosia et al., 2004; Seguí et al., 2005; Flores & Sánchez, 2007; Cruz & Codinha, 2010), one with linear enamel hypoplasia (Pounder et al., 1983), two having spondylolysis of L5 (Seguí et al., 2005; Flores & Sánchez, 2007), one with a sacral deformity (Pounder et al., 1983) and deformed sacroiliac articulations noted in one individual (Wells, 1975). In two mummified cases, there was evidence for porotic hyperostosis in one, and pneumonitis and a collapsed lung in the other (Arriaza et al., 1988).

Given that general maternal health was not the key focus in many works reporting deaths in pregnancy and childbirth, it is possible that not all occurrences of pathologies are dealt with. However, the prevalence of caries and antemortem tooth loss in many cases are interesting considering the recent discussion of the negative impact of transitioning to an agricultural subsistence economy and high birth rates on women’s oral health (Lukacs & Largaespada, 2006; Lukacs, 2008; Fields et al., 2009; Ferraro & Vieira, 2010; Watson et al., 2010). Elevated rates of caries have been seen in at least one Southeast Asian assemblage with evidence of extremely high levels of fertility (Domett & Oxenham, 2011; Oxenham & Domett, 2011). AS07H1M3a’s aggressive case of caries, abscessing and antemortem tooth loss was possibly exacerbated by her pregnancy and would have contributed to her poor general health.

The reproductive health of AS07H1M3a can be approached through an examination of her pelvic morphology and any observed pathologies. Female pelvic dimensions are highly variable with several typologies having been suggested, the most enduring presents four types based on the shape of the inlet: gynecoid, android, anthropoid and platypelloid (Caldwell & Moloy, 1933); while the second describes four types based on the ratio between the sagittal and transverse diameters of the inlet: dolichopellic, mesatipellic, brachypellic and platypellic (Greulic & Thoms, 1938). It has been argued that a flattening of the pelvic inlet occurs in response to nutritional stress (Greulic & Thoms, 1938, Thoms, 1947), and evidence supporting this has been seen in archaeological populations (Cook, 1984; Sibley et al., 1992). Sibley et al. (1992) found 58% of their Sudanese Nubian females had brachypelvic shaped pelves, with dimensions that would be considered pathological by modern standards; this population also suffered nutritional stress evidenced in growth retardation, porotic hyperostosis, enamel hypoplasia and high infant mortality. AS07H1M3a’s un-remodelled cribra orbitalia and evidence for LEH is arguably suggestive of nutritional stress of some form, an infection or a combination of both.

The anterior and transverse diameters of the inlet and the posterior sagittal measurement of the midplane are contracted in AS07H1M3a compared to modern clinical standards (Cunningham & Williams, 2001) (Table 1). If the foetal biparietal diameter is larger than the inlet, midplane or outlet diameter of the mother it can cause complications in delivery, if both the anterior–posterior and transverse diameters of the same plane are contracted, dystocia is even more common (Cunningham & Williams, 2001, p. 436). Notwithstanding, this woman was of small stature with a pelvis smaller than modern standards and brachypelvic, or slightly flattened anteroposteriorly, in morphology. Brachypelvic pelves often occur in females of small stature although they will also usually have smaller proportioned babies (Cunningham & Williams, 2001). It is also worth noting that contemporary rural farming women in Vietnam have small for gestational age neonates (Graner et al., 2010). However, the size of the neonate needs to be considered alongside others.

Figure 3. Right pars lateralis (arrow indicates jugular and condylar limbs) concreted to the anterosuperior aspect of the shaft of the 10th right rib of the mother.
factors such as the position of the foetus prior to birth, which is discussed below. The prognosis for the successful delivery of a full-term foetus in a female with a moderately contracted pelvis is tentative, with a female with a severely contracted pelvis the prognosis is considered poor (Cunningham & Williams, 2001).

Apart from having a somewhat flattened pelvis, AS07H1M3a had at least one significant pathology associated with the pelvic region. Weight is distributed at the lumbosacral joint through three mechanisms, anteriorly through the vertebral bodies, intermediately through the transverse processes and posteriorly through the articular facets. It has been found that if the articular facets are rudimentary, accessory articulations through the transverse processes are a common compensatory mechanism for load sharing (Mahato, 2010a; Mahato, 2010b). It is suggested that the accessory pseudoarticulation between the right transverse process and ala occurred as an accessory weight distribution mechanism to compensate the weak, unstable left articular facets between the L5 and sacrum. The specific aetiology or symptoms of the woman’s pseudoarticulation are not known; however, this is a variant of what is often referred to as Bertolotti Syndrome and can be associated with considerable lower back pain (Elster, 1989; Bron et al., 2007). It would seem unlikely to have had an adverse affect on her ability to carry a pregnancy to full term or successfully give birth.

Having discussed AS07H1M3a’s gynaecological health, the apparent positioning of the full-term foetus needs to be examined. The mother and child represent a primary burial which is evidenced by the retention of the articulation of labile joints and maintenance of anatomical integrity of contiguous bones. The movement of the skeletal elements as an individual decomposes is dictated by gravity and the space created by the soft tissue decomposition, the amount of movement is dependent on the environment the individual was buried in (Duday & Guillon, 2006; Willis & Tayles, 2009). There is skeletal evidence that the mother was wrapped, relatively tightly before interment.

It should be noted that while the final position of the foetus was definitely in a breech presentation, its exact position prepartum is not known, as it has probably moved postmortem. It may be argued that the foetus is too high in the abdominal area to be considered engaged at term; however, in a healthy nulliparae pregnancy, if the inlet is contracted, descent does not usually take place until after the onset of labour, if at all (Cunningham & Williams, 2001, pp. 436–437). The foetus would also certainly have moved during decomposition. The movement of the mother’s right arm, originally over the abdomen, was caused by distension
The foetus was likely in a footling breech position, with its lower limbs extended, so the feet are presenting (Arulkumaran et al., 2004). A healthy foetus will usually change presentation to cephalic at about 32 weeks due to the size of the foetus and changes in the uterine environment (Cunningham & Williams, 2001, p. 296); however, breech presentations occur in about 3.5% of term pregnancies in contemporary populations (Stoelting et al., 2008). There are several maternal, placental and foetal conditions that can predispose a breech presentation, the maternal ones include: multiparity, polyhydramnios, oligohydramnios, uterine abnormalities or a contracted pelvis, placental issues include: implantation on the cornu-fundus of the uterus and placenta previa, finally, foetal conditions are: prematurity, multiple gestations, short umbilical cord, hydrocephaly, anencephaly and intrauterine foetal death (Arulkumaran et al., 2004; Stoelting et al., 2008). The prognosis for vaginal deliveries of breech presentation births is poor, with increased maternal and foetal morbidity and mortality (Sekulic, 2000; Stoelting et al., 2008).

It would seem that polyhydramnios, oligohydramnios, uterine abnormalities, implantation on the cornu-fundus or placenta previa are unlikely causes of the breech position as AS07H1M3b appears to have grown to full term and is not small for gestational age, while the age of the mother and the state of her pelvis tend to rule out multiparity. The foetus may have been hydrocephalic or anencephalic, but the state of the cranial remains prevents such an assessment. It is worth considering the possibility of multiple gestation.

It is very common for breech presentations to be associated with twinning, with one foetus positioned cephalic and the other noncephalic occurring in 35–40% of twin gestations (Chervenak et al., 1984; Thompson et al., 1987; Grisaru et al., 2000). It is possible that AS07H1M3a was carrying twins and successfully delivered one, but died with the other still in utero, as was seen in one of the Chilean mummies (Arriaza et al., 1988). Two other cases of twins have been mentioned in the archaeological literature (Owsley & Bradtmiller, 1983; Halcrow & Tayles, 2010). This may explain why the perinate presents in the breech position on the right side of the abdomen, although movement to this position could equally be explained by postmortem repositioning in the distended abdomen during decomposition. There is no way of confirming whether it was a case of unsuccessful twinning delivery without any soft tissue preservation.

In speculating on events plausibly associated with the death of AS07H1M3a, it is worth noting that if this was a protracted labour, a combination of maternal and foetal dystocia with a breech presentation and a constricted pelvis, it is possible that the continual contractions caused a rupture and fatal haemorrhage of the uterine muscle. Alternatively, if this was a case of twinning, the mother may have suffered secondary uterine inertia and could not give birth to the second foetus. In either of these cases, AS07H1M3a may have died from maternal exhaustion, or if these events led to the intrauterine death of the perinate, she could have eventually contracted an infection of the uterine contents causing sepsis, hyperthermia, tachycardia and eventually cardiac arrest (Malgosa et al., 2004). These possible causes of death are directly related to childbirth, and it is also quite plausible that she died before the commencement of labour due to some other illness (or trauma for that matter) brought on by a compromised immune system due to her fragility, e.g., pneumonia, malaria, typhoid or a range of other infectious diseases.

Conclusions

The purpose of this paper was to examine the earliest corroborated instance of the burial of a mother and unborn child in Neolithic Vietnam. The discussion explored a range of potentially contributory factors to the death of this very young mother and her unborn full-term baby. Rampant oral disease in concert with the effects of physiological stress in her childhood may have negatively impacted on her constitution to a significant degree, even before her pregnancy. The pregnancy of this young female, regardless of pre-existing frailties, would only have further drained her physical and emotional resources. Additionally, her small size and compromised gynaecological health (contracted pelvis in particular) may have been contributing factors to her, and the full-term foetus’, eventual death. Whatever the confounding effects of her own underlying health and compromised gynaecological competence, the breech presentation of her baby no doubt exacerbated an already less than ideal
situation. The case of AS07H1M3a and her unborn baby provides a glimpse of the reality of pregnancy-related mortality, and in this instance, a raft of potentially underlying causes, in a small Neolithic community living several thousand years ago in Southern Vietnam.

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