Commentary On: Huxley AK and Angevine JB Jr. Determination of Gestational Age from Lunar Age Assessments in Human Fetal Remains. J Forensic Sci 1998;43(6):1254–1256.

Sir:

As a forensic anthropologist interested in fetal growth and development, I read with interest the recent *brief communication* by Huxley and Angevine (referenced above). The thrust of the article addresses the fact that developmental age in fetuses may be expressed in several ways. As forensic experts, we must convert clinical and anthropological data between methods to apply our research to questions of normal growth and viability. Confusion may result unless we properly define the methods used to express a specific period of time.

In the case of the Huxley and Angevine communication, a source of confusion arises from the use of the term "gestational age" to mean the use of solar, or calendar dates rather than lunar dates to describe the stage of development.

Developmental age is the level of embryonic or fetal maturation reached over a specific time period. The human gestational period lasts approximately 266 days. However, obstetricians and other clinicians usually calculate gestational age from the last normal menstrual period (LNMP). Therefore, obstetric dates are about two weeks longer than embryologic dates (fertilization age), or approximately 280 days. In current clinical parlance, developmental age reached during this 40-week period is referred to as "gestational age." Gestational age may be expressed in days, weeks, lunar months, or calendar months. A true lunar month is approximately $27^1/_3$ days. However, in this case, the term lunar month is more of a convention than an astronomical truth. In common usage, the term "lunar month" reflects the average duration of a biological cycle (menstruation), rather than a true lunar cycle. The 280 day gestational period is thus divided into ten 28-day periods, or "lunar" months. Calendar months are based on the solar year. When calendar months are used, it must be noted that human gestation calculated from the LNMP averages approximately 9.2 months, rather than the 9 months commonly cited by lay persons.

Nagele's rule calculates the "due date" by subtracting three calendar months from the first day of the last menstrual period and adding 7 days. The additional 7 days accounts for the time in excess of nine calendar months that average pregnancies last. While this calculation is only approximate, 95% will deliver within two weeks of the initial calculated due date (1). In clinical practice, due dates are often adjusted according to data obtained during pregnancy from sonography and other diagnostic tools.

Huxley and Angevine erroneously report the average calendar month as 31.1 days. Since the longest calendar months are 31 days, the average calendar month must necessarily be less than that figure. The solar year is, for practical purposes, considered to be $365^1/_4$ days, which yields an average of 30.44 days per month, not 31.1 as stated by the authors. I must assume their figure of 31.1 days arises from dividing the 280 days of the gestational period by 9—a commonly cited, but incorrect length of pregnancy.

The issue of viability arises in a sensitive, but critical forensic context. If techniques utilizing lunar months as an expression of gestational age must be converted to calendar months, we must be certain to apply correctly the math to reach a valid conclusion. The chart below follows Huxley and Angevine, but corrects the figure representing the average calendar month.

I tend to use lunar months in my fetal research. However, a better method might be the use of weeks to describe gestational age. The 280-day gestational period divides conveniently into 40 weeks and most clinical milestones in development have been documented and described in these terms.

TABLE 1—*Modified from Huxley and Angevine using corrected figure for average calendar month; comparability of lunar age and solar or calendar age by day of pregnancy.*

Days of Pregnancy	Lunar Months	Calendar Months	Days of Pregnancy	Lunar Months	Calendar Months
0	0.00	0.00	140	5.00	4.60
7	0.25	0.23	147	5.25	4.83
14	0.50	0.46	154	5.50	5.06
21	0.75	0.69	161	5.75	5.29
28	1.00	0.92	168	6.00	5.52
35	1.25	1.15	175	6.25	5.75
42	1.50	1.38	182	6.50	5.98
49	1.75	1.61	189	6.75	6.21
56	2.00	1.84	196	7.00	6.44
63	2.25	2.07	203	7.25	6.69
70	2.50	2.30	210	7.50	6.90
77	2.75	2.53	217	7.75	7.13
84	3.00	2.76	224	8.00	7.36
91	3.25	2.99	231	8.25	7.59
98	3.50	3.22	238	8.50	7.82
105	3.75	3.45	245	8.75	8.05
112	4.00	3.68	252	9.00	8.28
119	4.25	3.91	259	9.25	8.51
126	4.50	4.14	266	9.50	8.74
133	4.75	4.37	273	9.75	8.97
			280	10.00	9.20

Reference

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Authors' Response

Sir:

We appreciate Michael Warren's attention to the details of our brief communication published in the November 1998 issue of this journal. Warren suggests that we made two errors when dealing with issues critical to gestational or lunar age determination: calculation of lunar cycle length; and human fetal gestational length, which can be determined from date of conception or date of last (normal) menstrual period (LMP).

Each of Warren's points, while having merit, has underlying methodological complications. First, he states that a source of confusion arises about the use of gestational age to represent a source of solar dates, rather than lunar dates, for describing the age of a fetus. Although he did not show his calculations, we assume that he arrived at this value by the following: 365.25 days/12 months = 30.43 days per month. Olivier and Pineau (1,2; French anatomists not lay persons as to dating fetuses), chose to define a gestational month as 31.1 days. The formula for this calculation is as follows: 280 days/9 "mois civils" = 31.1 days. Having followed these researchers and expanded on their published Table 3, we chose to keep their calculations. We expanded but did not substantially alter their published table when we listed conversion between gestational age and lunar age prior to four-and-a-half months.

As Olivier and Pineau's publications serve as indirect major references for forensic specialists who practice forensic fetal osteology, it is essential to know their underlying relationship between lunar months and "civil" months. When scientists change Olivier and Pineau's dates by modifying their charts without addressing their (and indirectly our) calculations, it puts other researchers at risk for interpretational errors. For instance, someone who feels competent in forensic fetal osteology could apply the work of Olivier and Pineau, figure 36 in Stewart's *Essentials of Forensic Anthropology* (3) and assume that 10 lunar months is comparable to 9.2 gestational months with Warren's conversion chart, not 9.0 gestational months using Olivier and Pineau's original definition. In such an instance, we agree with Warren that a source of confusion has arisen.

It is of utmost importance to realize that the primary references on forensic fetal osteology used by forensic anthropologists—Olivier and Pineau (1,2), Fazekas and Kosa (4), Weaver (5)—are based on underlying assumptions that the specimens used to develop these standards were free of complications and represent viable, living fetuses that follow normal gestational lengths and normal growth and development curves. These fetuses were assigned ages by known gestational age and/or through estimation from external dimensions of the fetus.

One must consider that a great deal of variability exists that can influence the age of the fetus: length of ovarian, and therefore, uterine cycle (6–8); variation in gestational length, coupled with populational differences (9–14), recollection of dates associated with conception or LMP (10,15–16), migration and implantation of the zygote (17–22) and stressors of intrauterine growth (16,22–27). Clinicians can assess gestational age through use of biometric assessment, such as the Ballard score based on neuromuscular and physical maturity (28). Forensic anthropologists, usually working with much less material than clinicians, attempt to assign precise, accurate age to the fetus at time of fetal demise, yet this precise assignment is problematic when one cannot completely account for the factors that create underlying variability. Consequently, alterations in gestational duration and fetal growth and development may affect fetal age determination. Under some circumstances, the forensic anthropologist may want to consider his or her limitations and consult another specialist, such as an obstetrician.

Given these comments, the reader is advised to read Olivier and Pineau's original work and to reread both our article and Warren's commentary. Both we and Warren agree that pregnancy lasts an average of 280 days, whether calculated in lunar or gestational months. Both sets of calculations begin at conception rather than LMP and both end at 280 days. Warren's conversion chart accounts for a calendar month of 30.44 days, while our conversion chart is based on Olivier and Pineau's civil month. If using our chart, please keep in mind that the nine-month gestational period is based on 31.1 days. If using Warren's chart, please do not directly compare it to Olivier and Pineau without intermediate conversion between 30.44 to 31.1 days. While we agree with him that the math must be correctly applied to arrive at a valid conclusion for the age of the fetus, correction for dates based on the 30.44 days is inherently risky, since some of the very standards used by forensic anthropologists—Olivier and Pineau—have an inherent bias of 31.1 days. Perhaps, as Warren suggested, the forensic scientist should move away from gestational months to gestational weeks, which are based on 7 calendar day cycles. In closing, we chose to follow Olivier and Pineau's standard convention rather than modify same and thereby introduce another source of potential error.

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