Conception probabilities at different days of menstrual cycle in Chinese women

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Objective: To investigate the conception probability among Chinese women.

Design: Prospective observational study.

Setting: Clinics in hospitals and family planning institutes in 10 provinces and cities.

Patient(s): A total of 851 healthy married women aged 18–35 years with normal menstrual cycles who wish to have babies and with no contraception.

Intervention(s): Urinary LH was measured around days of expected ovulation for 7 days. The Barrett and Marshall model was used for calculation of conception probabilities on each cycle day from day −5 to day +1 in women with multiple episodes of intercourse.

Main Outcome Measure(s): Pregnancies in 1, 3, and ≥6 months.

Result(s): A total of 851 women with 2,055 cycles were analyzed. In 489 cycles there was only one episode of intercourse. A total of 601 pregnancies occurred. The conception probabilities from days in relation to ovulation −5 to +1 for a single episode of intercourse were 0.216, 0.102, 0.236, 0.233, 0.388, 0.293, and 0.386, respectively, and for multiple episodes they were 0.254, 0.271, 0.293, 0.365, 0.315, and 0.284, respectively, with the peak value at day −1. Recalculation of the efficacy of emergency contraception with low-dose mifepristone with the present conception probabilities showed higher efficacy.

Conclusion(s): Conception probabilities among Chinese women are different from those in the literature. Further comparative studies are needed to confirm an ethnic difference. (Fertil Steril® 2010;94:1208–11. ©2010 by American Society for Reproductive Medicine.)

Key Words: Conception probability, menstrual cycle, emergency contraception

Probability of conception has been often used in studies of the efficacy of certain contraceptives, such as in studies of levonorgestrel pills or mifeprisone pills for emergency contraception. In 1967, Barrett and Marshall (1) conducted the first study among 241 women in 2,191 menstrual cycles on the risk of conception on different days of menstruation and produced a formula for calculation of conception probability. Later, between 1994 and 2001 many articles on timing of intercourse in relation to ovulation were published (2–8). In 1980, Dixon et al. (9), based on the weighted average of three previous studies of conception probability, assessed the efficacy of ethinyl estradiol and conjugated estrogens as postcoital contraceptives. Later, Trussell et al. (10) updated the estimates of effectiveness of emergency contraception with the Yuzpe method. These estimates of conception probability were often referred to in many other studies of emergency contraception, even in many Chinese studies. Often, the question is raised of whether these reference data from Western countries are relevant to Asian women. Could the high numbers of population in China indicate a higher fertility in nature? Is there an ethnic difference in fecundity between Asian and caucasian women? The objective of the present study was to try to find the conception probability on each menstrual cycle day among a population of Chinese women and to compare it with those of Western women.

MATERIALS AND METHODS

Subjects

Ten clinical centers in Beijing, Shanghai, Tianjin, Qingdao, Nanjing, Chengdu, Shengyang, Guangzhou, and Baotou were selected. Women recruited were based on admission criteria set in the study protocol: healthy married women in the age group of 18–35 years with regular menstrual cycles of 25–35 days and without systemic or gynecologic diseases. No contraceptive methods were used during the study period, and the women had the desire to get pregnant. General physical and pelvic examinations were performed at admission. Husbands were known to be healthy and fertile by fertility history, i.e., had fathered a baby or abortion before. No clinical sperm tests were performed.

Methods

Institutional Review Board approval and approval from ethical committees were obtained from each participating institute. Official approval and financial support were obtained from the Department of Science and Technology of State Population and Family Planning Commission in China.

Methods for Defining Cycle Day in Relation to “Ovulation”

1. Conventional method of “ovulation day” calculation by subtracting from the date of the next menstruation by 14.
The method for calculation of probability

Because we did not require the women to limit their sexual intercourses to only one episode during the cycle, we applied the classic calculation formula of Barrett and Marshall (1) in our analysis. Barrett and Marshall proposed a biologically plausible model, specifying that the batches of sperm introduced on different days behave independently. Under this model the probability of conception in a given menstrual cycle is:

\[
\Pr(\text{conception in cycle } k | \{X_k\}) = 1 - \prod_{i} (1 - P_i)^{X_i}.
\]

The parameter \( P_i \) is interpretable as the probability that conception would occur following intercourse on day \( i \) only. The model (1) can be written as a generalized linear model:

\[
\ln \left( \frac{1}{1 - \Pr(\text{conception} | \{X_k\})} \right) = \sum_i \ln(1 - P_i) X_i
\]

The coefficients \( \ln(1 - p_i) \) in this log-linear model can be estimated by using the method of maximum likelihood.

An example of calculating conception probability with multiple episodes of intercourse in one menstrual cycle is given as in the following. The log-linear model gives the following results: The probabilities with multiple episode from day –7 to +1 are, respectively: –7 = 0.185; –6 = 0.224; –5 = 0.257; –4 = 0.254; –3 = 0.271; –2 = 0.293; –1 = 0.365; 0 = 0.315; and +1 = 0.284.

\[
1 - P = \exp \left[ -1.3465 - 0.3385X_\cdot - 0.1491X_{-4} - 0.014X_{-5} - 0.0251X_{-4} + 0.0399X_{-3} + 0.1181X_{-2} + 0.3396X_0 + 0.19X_5 + 0.0883X_1 \right]
\]

Statistical Analysis

We used SAS software to calculate the probability of conception according to the Barrett and Marshall model.

RESULTS

A total of 861 healthy married women with regular menstruation of 28–35 days were recruited. They were followed-up monthly for at least 3 months; those who became pregnant in the first month after admission were considered to have completed the study. Some were followed-up continuously for 6 or more cycles. A total of 2,177 cycles were observed.

In the study profile, the number of women recruited was 861 with 2,177 menstrual cycles observed. There were seven women lost in follow-up and three women excluded for violation of protocol, A total of 122 cycles were invalidated. At the end of the study, 851 women and 2,055 cycles entered into analysis.

Baseline Characteristics

The baseline characteristics of all women recruited are shown in Table 1.

The baseline data show that all of the women recruited were in normal range of age, weight, height, and body mass index, and their menstrual cycles were regular and normal.

Outcome of Pregnancies at Different Months of Follow-Up

Among the total 601 pregnancies in this study, 258 (42.94%) occurred at the first month, 232 (38.6%) at the third month, and 111 (18.47%) at the sixth month or later. The continued pregnancies at month 1, month 3, and month ≥ 6 follow-up periods were 244 (42.0%), 227 (39.1%), and 110 (18.9%), respectively. Spontaneous abortions were few: A total of ten occurred with nine at the first month and one at the third month. Six induced abortions occurred, with three at the first month, and two at 3 months, and one at ≥ 6 months. The outcome of four pregnancies were unknown. Because the follow-ups were scheduled only for 6 months, the pregnancy rate is unknown after 6 months. Over 96% (581 pregnancies) continued their pregnancies.

Pregnancies in Relation to Number of Episodes of Intercourse

A total of 601 pregnancies occurred among 851 women from 2,055 cycles. The number of pregnancies in relation to number of episodes of intercourse is as follows: 489 cycles (23.8%) with only one act per cycle had 151 pregnancies (25.1%); 1,349 cycles (67.8%) with 2–4 acts of intercourse per cycle had 394 pregnancies (65.5%); and 172 cycles (8.4%) with ≥ 5 acts of intercourse had 56 pregnancies (9.3%). The pregnancy/cycle rate with one act was 0.309, with 2–4 acts was 0.283, and with ≥ 5 acts was 0.326. The total pregnancy rate per cycle was 0.292. There was no statistical difference in pregnancy rate with number of episodes of intercourse. The pregnancy rate clearly shows that higher pregnancy rate is not a result of more acts of intercourse.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
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<tr>
<td>Age (y)</td>
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<td>1.40</td>
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<td>Cycle length (d)</td>
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<td>2.19</td>
<td>24.00</td>
<td>37.00</td>
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<tr>
<td>Bleeding (d)</td>
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<td>1.23</td>
<td>2.00</td>
<td>8.00</td>
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<tr>
<td>Age of husband (y)</td>
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<td>30.12</td>
<td>3.65</td>
<td>22.00</td>
<td>47.00</td>
</tr>
</tbody>
</table>

Note: Among the 851 women, in previous history there were 100 live births (11.75%), 343 induced abortions (40.3%), 82 spontaneous abortions (9.8%), and 10 (1.1%) results unknown.

Conception Probability in Relation to Timing of Intercourse

Conception probability on different days of a menstrual cycle is easy to define when there is only one act of intercourse on a certain day of a menstrual cycle, but in reality most of the women have multiple acts in one menstrual cycle. Therefore, it is difficult to define which is the exact day of conception. We tried to analyze separately those with a single act and those with multiple acts.

Pregnancies with only one episode of intercourse Based on 489 menstrual cycles with a single act of sexual intercourse, the results of conception probabilities from day −7 to day +1 are shown in Table 2.

Pregnancies with multiple episodes of intercourse within one cycle The conception probability on different days of the cycle was calculated according to the Barrett and Marshall model (1): The parameter $P_i$ is interpretable as the probability that conception would occur following intercourse on day $i$ only. The results of 1,566 cycles with multiple acts of intercourse were calculated. The probabilities from day −7 to day +1 were, respectively, 0.185, 0.224, 0.257, 0.254, 0.271, 0.293, 0.30, 0.14, and 0.07 on days −2, −1, 0, and +1, respectively. In 1995, Wilcox et al. (4, 5), using urinary estrogen and pregnandiol glucuronides as a reference point, observed 192 pregnancies among 221 women in 625 cycles. The conception probabilities from days −4 to +1 were 0.08, 0.17, 0.08, 0.36, 0.34, and 0.33, respectively. In the present study, we observed 2,055 cycles in 851 women using urinary LH as a reference point. The conception probabilities from days −6 to +1 were, respectively, 0.78, 0.216, 0.101, 0.235, 0.233, 0.387, 0.293, and 0.385. A total of 601 pregnancies occurred.

In the present study, urinary LH was used, which could be a more sensitive indicator to detect ovulation. The figures for conception probabilities varied widely, even in the same early pregnancy study by different authors. It may not be reasonable to compare the data, because there are many differences in the designs of the studies, in the methods used as reference point of ovulation, and methods of statistical analysis and calculation. Even though the data from

DISCUSSION

Conception probabilities are studied widely in Western countries, but not in China. This is the first study carried out in different cities of China with the purpose of comparing the probabilities between Chinese and Western women. We reviewed the most important studies on conception probabilities, including the British study and the North Carolina Early Pregnancy Study to compare with those from the present study (1–3). Different reference points of estimated ovulation were used, mostly basal body temperature (BBT) or estimation of urinary metabolites of estrogen or progesterone. Barrett and Marshall (1) in 1969 first studied, in 241 women with 2,191 cycles, the conception probabilities on cycle days −4 to +1 using BBT as the reference point. The results showed conception probabilities of 0.13, 0.20, 0.17, 0.30, 0.14, and 0.07 on days −4, −3, −2, −1, 0, and +1, respectively. In 1994, Weinberg et al. (2, 3), in the North Carolina Early Pregnancy Study, studied 146 women in 471 cycles with urinary estrogen glucuronide as a reference point. The study observed 141 pregnancies, and the conception probabilities were 0.044, 0.10, 0.155, 0.148, 0.205, and 0.179 on days −4, −3, −2, −1, 0, and +1, respectively.

![FIGURE 1](image_url)

Pregnancy rates with single and multiple episodes of intercourse in one menstrual cycle are shown. The lines represent the pregnancy rates with a single episode (diamonds) and multiple episodes (squares) of intercourse during the menstrual cycle from day −7 to day +1 in relation to ovulation.
the present study showed higher conception probabilities from day −7 to day +1, it is difficult to show whether there is any statistical significance with those in the literature. The factors that affect the conception probabilities are complicated. It is not possible to measure the underlying biologic factors with the indicators shown in the studies. Therefore, the results shown in this study could only give a suggestion of possible ethnic differences between Asian and Western populations.

Another interesting point is that in this study, one-fourth of pregnancies occurred with a single episode of intercourse, and there was no increase of pregnancy rates with multiple acts of intercourse. This could be explained by the fact that the occurrence of pregnancy depends on the timing of intercourse, rather than on the number of episodes. The concept of more chances of pregnancy with more acts of intercourse may be misleading. To have an act within the window of conception is more important, as observed in the present study. Besides, more frequent acts may affect the quality of sperm. Among the total of 601 pregnancies in this study, over 81.5% of pregnancies occurred in the first 3 months. This could also indicate a higher fecundity in Chinese women.

We tried to reanalyze the data from our earlier studies of emergency contraception with low dose mifepristone (11), where we had calculated the expected pregnancies based on the conception probabilities of Dixon et al. (9). We tried to apply the conception probability from the present study to recalculate the expected pregnancies and evaluate the efficacy of preventing unwanted pregnancy. Table 3 shows the difference in results: With Dixon et al.’s data the efficacy was 82.72%, whereas with the present data the efficacy was 93.66%. Similarly we tried to recalculate the published results of Ho and Kwan (12) using the conception probabilities of the present study, and a difference in efficacy was also found: 90.24% instead of 58.1%, as shown in Table 3.

Trussell et al. (10) had mentioned that in a comparative study of the efficacy of emergency contraception with the Yuzpe method, the Chinese study by Ho and Kwan (12) has the lowest efficacy, and the authors mentioned that one of the reasons could be ethnic difference. It is also interesting that in a World Health Organization study (13) of 12 years’ follow-up of intrauterine device users in multicountry centers, it was found that the Chinese centers had significantly higher failure rates than non-Chinese centers. No reason was given in that article. Could the higher conception probability among the Chinese population be one of the reasons for the difference? From the results of the present study, we find that the conception probability on cycle days of a menstrual cycle in Chinese women is higher, which may indicate a higher fecundity of Chinese women. The results also show that the pregnancy rates with a single act of intercourse are similar to those with multiple acts in one cycle. Also, almost 80% of pregnancies occurred in the first 3 months of marriage if no contraception is adopted, which may also indicate a higher fecundity in Chinese women. Nevertheless, although the study collects a large amount of information from Chinese women, further comparative studies of different ethnic populations are needed to draw a sound conclusion. In addition, the message from this study calls for awareness that effective contraceptive methods and provision of high-quality family planning services are particularly important to the Chinese population, which may have higher natural fecundity.

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## REFERENCES