Numerical Analysis of Menstrual Cycle Model with the Effect of Diabetes

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Abstract: *Menstruation is bleeding from the uterus is around only every 28 days, some women had menstruation sooner or later than that. As a result of changes in hormone levels, the two main types of LH and FSH. Relative to ovulation Diabetes is one of the factors that affect the balance of the hormone estrogen, a hormone that regulates ovulation caused menstrual irregularities, when there is no ovulation period. In this study, the above factors that affect the balance of hormones that control ovulation cycle are considered.*

Keywords: *activin, diabetes, equilibrium point, hormone, mathematical model, menstrual cycle*

1. Introduction

Menstrual period or in a word or commonly known as transliteration from English and Latin as Siemens (Mens) is bleeding from the uterus is around only every 28 days. Some women has come sooner or later than that. The average woman would begin menstruation at age 12-13 years, 1-2 years at menarche. This occurrence will be uneven because the function of the ovaries was not complete. Therefore, irregular ovulation in the first half of menstrual cycle occurs normally. Endometrial thickness shall be increased by the influence of the female hormone estrogen from the ovaries around the middle of the month. (About the 14th day of the month). Egg from the ovary on one side. Waits to be fertilized with sperm then mix the egg or embryo in the lining of the uterus in the second half of the menstrual cycle. After ovulation, there is a change of blood vessels and glands in the lining of the uterus. This is another type of estrogen from the ovaries as well. To support implantation of the embryo to grow a set. But in the past month fetus without fertilization [1]-[3] The Inter-hormones from the ovaries is lowered. As a result, the peeling of the lining of the uterus. (About day 28 of the menstrual cycle) became what is known as the period after menstruation. Ovarian hormone estrogens begin to build up. Start a new menstrual cycle. Born as a month or a month wandering around during puberty, which is. Age, the ovaries also produce hormones, both of them. Menstrual cycle occurs under the control of the endocrine system. Reproduction is needed mainly divided into three phases the distance follicular phase, ovulation and Michael Lu Shen Zhen. Or into long-term growth and secretion of menstruation. Counting the menstrual cycle begins on the first day of menstrual bleeding. Hormonal contraceptives with different ways will result in a change in hormones that regulate menstruation. This result is intended to contraception. When the hormone estrogen gradually. Increase in follicular phase. The menstrual blood is gradually reduced until it stops gradually thickened uterine lining. Fort follicles in the ovaries began to flourish under the coordination of the complex of several hormones. Over time, the follicular Michael, one will become dominant follicular Michael. By Michael follicular growth that comes, it will atrophy and die by the middle of the month. The rapid increase in LH levels 24-36 hours. For primary follicles to release the eggs out of the egg. After ovulation, this egg will last up to 24 hours if it not fertilized. While the rest of the follicular Michael major changes to the corpus luteum. Establishing progesterone State Road: Progesterone Inter-uterine lining make changes to support the implantation of the embryo to achieve a pregnancy, if it is not embedded within 2 weeks. Corpus luteum dissolves the levels hormone estrogen and progesterone State Road rapid decline. Endometrial break out a month [4]-[8] Hormonal disorders cause menstrual irregularities. May be caused by hormones, not enough to have endometrial into the period. The factors that cause hormonal imbalances are several factors such as:

- Changes in hormone levels during adolescence. or approach menopause age
- Diabetes, disorders of the thyroid gland. ; Or pituitary (Pituitary) or other disorders

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- obesity - stress
- exercise too hard
- Disorders of eating disorders such as anorexia, and so on. Selgrade et al[9] has studied mathematical models of the menstrual cycle. This article discusses the abnormal menstruation. Factors that cause the production of the hormone imbalance that factor related to diabetes that affects the production of hormones that cause irregular menstrual irregularities.

2. Mathematical Model

We present a mathematical model for the menstrual cycle in accordance with the factors that cause abnormal hormone doses. Mathematical model for the menstrual cycle is formulated by defining the variables as follows.

$\frac{dMeP_{LH}}{dt}$ Rate of change for the mass of stored LH in the pituitary at time t,

$\frac{dLH}{dt}$ Rate of change for the luteinizing hormone at time t,

$\frac{dMeP_{FSH}}{dt}$ Rate of change for the mass of stored FSH in the pituitary at time t,

$\frac{dFSH}{dt}$ Rate of change for the follicle stimulating hormone at time t,

$\frac{dMeM}{dt}$ Rate of change for the menstrual follicle state at time t,

$\frac{dMeSe}{dt}$ Rate of change for the secondary follicle state at time t,

$\frac{dMeP}{dt}$ Rate of change for the preovulatory follicle state at time t,

$\frac{dMeS_1}{dt}$ Rate of change for the early ovulatory scar at time t,

$\frac{dMeS_2}{dt}$ Rate of change for the late ovulatory scar at time t,

$\frac{dMeC_1}{dt}$ Rate of change for the development stages of corpus luteum at time t,

$\frac{dMeC_2}{dt}$ Rate of change for the development stages of corpus luteum at time t,

$\frac{dMeC_3}{dt}$ Rate of change for the development stages of corpus luteum at time t,

$\frac{dMeC_4}{dt}$ Rate of change for the development stages of corpus luteum at time t,

Dynamical equations of the mathematical model for the menstrual cycle can be explained as follows[10]-[11]:

$$\frac{dMeP_{LH}}{dt} = \frac{V_{1,LH} + \frac{V_{2,LH}\left[E(t)\right]^8}{\left[K_{nLH}\right]^8 + \left[E(t)\right]^8}}{1+P(t)/K_{aLH,p}} - \frac{k_{LH}\left[1+cl_{LH,p}P(t)\right]MeP_{LH}}{1+cl_{LH,E}E(t)} \tag{1}$$

$$\frac{dLH}{dt} = \frac{1}{v}\left[\frac{k_{LH}\left[1+cl_{LH,p}P\left(t\right)\right]MeP_{LH}}{1+cl_{LH,E}E\left(t\right)}\right] - A_{LH}LH \tag{2}$$

$$\frac{dMeP_{FSH}}{dt} = \frac{V_{FSH}}{1+Ac\left(t\right)/K_{aFSH,Ac}} - \frac{k_{FSH}\left[1+cl_{FSH,p}P\left(t\right)\right]MeP_{FSH}}{1+cl_{FSH,E}\left[E\left(t\right)\right]^2} \tag{3}$$

$$\frac{dFSH}{dt} = \frac{1}{v}\left[\frac{k_{FSH}\left[1+cl_{FSH,p}P\left(t\right)\right]MeP_{FSH}}{1+cl_{FSH,E}\left[E\left(t\right)\right]^2}\right] - A_{FSH}FSH \tag{4}$$

$$\frac{dMeM}{dt} = bFSH+\left[j_1FSH-j_2LH^{\alpha}\right]MeM \tag{5}$$

$$\frac{dMeSe}{dt} = j_2LH^{\alpha}MeM+\left[j_3LH^{\beta}-j_4LH\right]MeSe \tag{6}$$

$$\frac{dMeP}{dt} = j_4LHMeSe-j_5LH^{\gamma}MeP \tag{7}$$

$$\frac{dMeS_1}{dt} = j_5LH^{\gamma}MeP-j_6MeS_1 \tag{8}$$

$$\frac{dMeS_2}{dt} = j_6MeS_1-j_7MeS_2 \tag{9}$$

$$\frac{dMeC_1}{dt} = j_7MeS_2-j_8MeC_1 \tag{10}$$

$$\frac{dMeC_2}{dt} = j_8MeC_1-j_9MeC_2 \tag{11}$$

$$\frac{dMeC_3}{dt} = j_9MeC_2-j_{10}MeC_3 \tag{12}$$

$$\frac{dMeC_4}{dt} = j_{10}MeC_3-j_{11}MeC_4 \tag{13}$$

where

$$E\left(t\right)=\left(\frac{es_0}{\zeta_1}+\frac{es_1MeSe(t)}{\zeta_2}+\frac{es_2MeP(t)}{\zeta_3}+\frac{es_3MeC_4(t)}{\zeta_4}\right)Re$$

$$P\left(t\right)=ps_0MeC_3(t)+ps_1MeC_4(t)$$

$$Ac\left(t\right)=as_0+as_1MeC_3(t)+as_2MeC_4(t)$$

Where the parameters in the above equations are defined as follows:

E is the estradiol

P is the progesterone

Ac is the activin concentration in the blood

v is the blood volume

$\alpha,\beta,\gamma,b,j_1,j_2,j_3,j_4,j_5,j_6,j_7,j_8,j_9,j_{10},j_{11}$ are the parameters for the ovary

es_0, es_1, es_2, es_3, ps_0, ps_1, as_0, as_1, as_2 are the parameters for these auxiliary equations (1)-(13).

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3. Numerical Results

In this section, we analyze the model given by equation (1)-(13). The trajectories of the solutions when the parameter values will lead to equilibrium state are shown in the following figures.

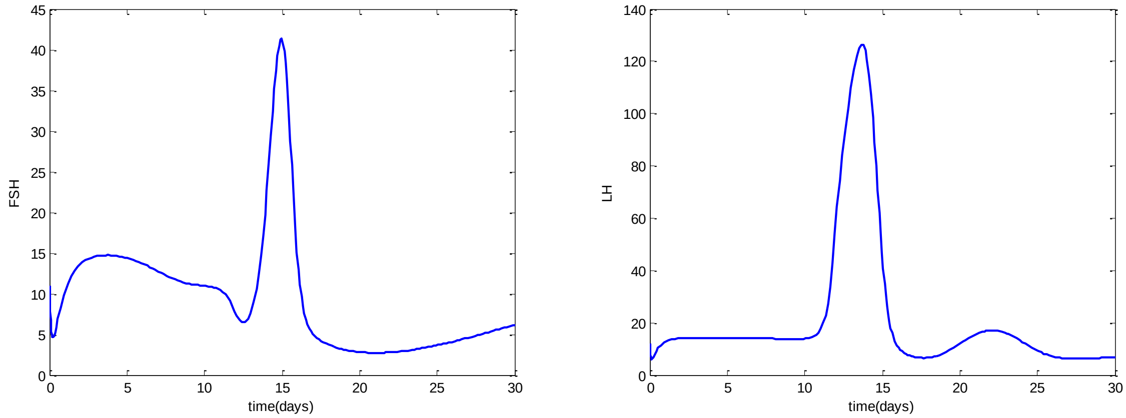

Fig. 1: is blood sugar under 70 mg/dl(low blood sugar levels), found that the LH hormone is highest at day 14 and FSH hormone is highest at day 15.The values of parameters are $K_{aLH,p} = 31.22\,ng/mL$, $k_{LH} = 2.49\ day^{-1}$, $V_{1,LH} = 1263.4\ IU/day$, $cl_{LH,p} = 0.07\,mL/ng$, $cl_{LH,E} = 0.0049\ mL/pg$, $A_{LH} = 14\ day^{-1}$, $A_{FSH} = 8.21\ day^{-1}$, $V_{FSH} = 5700\ IU/day$, $K_{aFSH,Ac} = 641\ IU/mL$, $k_{FSH} = 7.29\ day^{-1}$, $cl_{FSH,p} = 644 mL/ng$, $\gamma = 0.0202$, $\alpha = 0.7736$, $cl_{FSH,E} = 0.16\ mL/pg$, $K_{nLH} = 360 pg/mL$, $V_{2,LH} = 91000\ IU/day$, $\beta = 0.1566$, $LH[0] = 40$, $MP_{LH}[0] = 12$, $FSH[0] = 20$, $MeP_{FSH}[0] = 11$, $MeM[0] = 1$, $MeSe[0] = 5$, $MeP[0] = 1$, $MeS_1[0] = 1$, $MeS_2[0] = 1$, $MeC_1[0] = 1$, $MeC_2[0] = 1$, $MeC_3[0] = 1$, $MeC_4[0] = 1$.

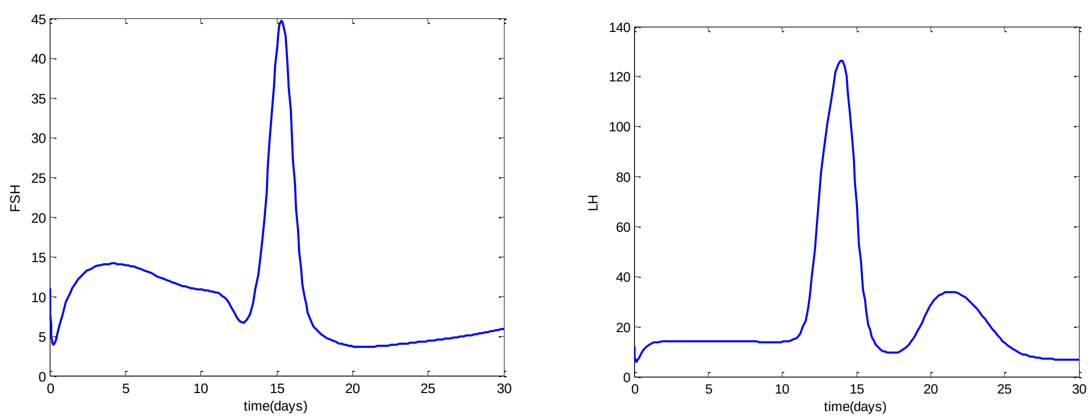

Fig. 2: is blood sugar 80-100 mg/dl(normal blood sugar levels), found that the LH hormone is highest at day 14 and FSH hormone is highest at day 16.The values of parameters are $K_{aLH,p} = 31.22\,ng/mL$, $k_{LH} = 2.49\ day^{-1}$, $V_{1,LH} = 1263.4\ IU/day$, $cl_{LH,p} = 0.07\,mL/ng$, $cl_{LH,E} = 0.0049\ mL/pg$, $A_{LH} = 14\ day^{-1}$, $A_{FSH} = 8.21\ day^{-1}$, $V_{FSH} = 5700\ IU/day$, $K_{aFSH,Ac} = 641\ IU/mL$, $k_{FSH} = 7.29\ day^{-1}$, $cl_{FSH,p} = 644 mL/ng$, $\gamma = 0.0202$, $\alpha = 0.7736$, $cl_{FSH,E} = 0.16\ mL/pg$, $K_{nLH} = 360 pg/mL$, $V_{2,LH} = 91000\ IU/day$, $\beta = 0.1566$, $LH[0] = 40$, $MP_{LH}[0] = 12$, $FSH[0] = 20$, $MeP_{FSH}[0] = 11$, $MeM[0] = 1$, $MeSe[0] = 5$, $MeP[0] = 1$, $MeS_1[0] = 1$, $MeS_2[0] = 1$, $MeC_1[0] = 1$, $MeC_2[0] = 1$, $MeC_3[0] = 1$, $MeC_4[0] = 1$.

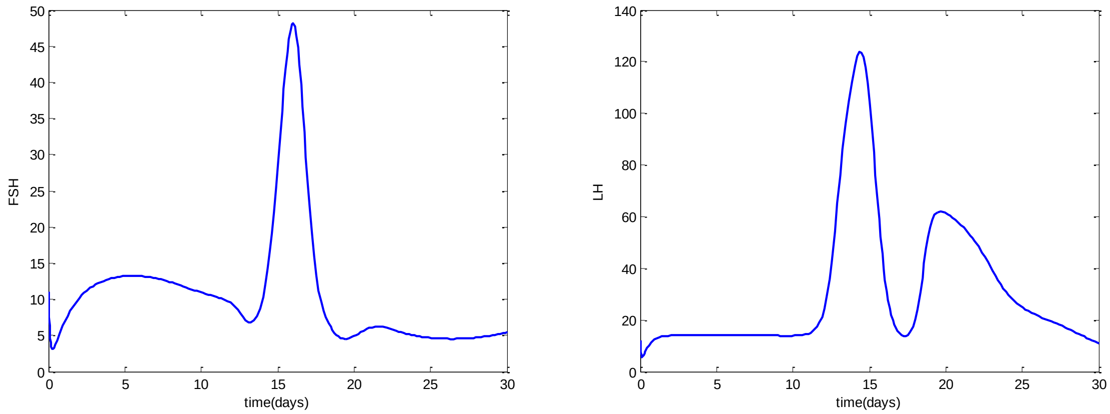

Fig. 3: is blood sugar 100-120 mg/dl(start at risk as diabetes), found that the LH hormone is highest at day 14 and FSH hormone is highest at day 17.The values of parameters are $K_{aLH,p} = 31.22$ ng/mL , $k_{LH} = 2.49$ day^{-1}, $V_{1,LH} = 1263.4$ IU/day , $cl_{LH,p} = 0.07$ mL/ng , $cl_{LH,E} = 0.0049$ mL/pg , $A_{LH} = 14$ day^{-1} , $A_{FSH} = 8.21$ day^{-1} , $V_{FSH} = 5700$ IU/day , $K_{aFSH,Ac} = 641$ IU/mL , $k_{FSH} = 7.29$ day^{-1}, $cl_{FSH,p} = 644$mL/ng, $\gamma = 0.0202$, $\alpha = 0.7736$, $cl_{FSH,E} = 0.16$ mL/pg , $K_{nLH} = 360$pg/mL , $V_{2,LH} = 91000$ IU/day, $\beta = 0.1566$, $LH[0] = 40$, $MP_{LH}[0] = 12$, $FSH[0] = 20$, $MeP_{FSH}[0] = 11$, $MeM[0] = 1$, $MeSe[0] = 5$, $MeP[0] = 1$, $MeS_1[0] = 1$, $MeS_2[0] = 1$, $MeC_1[0] = 1$, $MeC_2[0] = 1$, $MeC_3[0] = 1$, $MeC_4[0] = 1$.

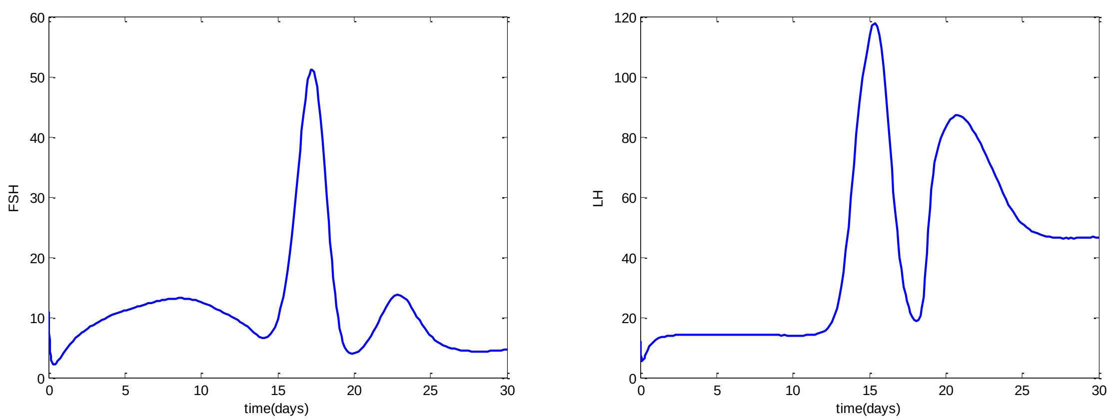

Fig. 4: is blood sugar 140-180 mg/dl(start at risk as diabetes), found that the LH hormone is highest at day 14 and FSH hormone is highest at day 17.The values of parameters are $K_{aLH,p} = 31.22$ ng/mL , $k_{LH} = 2.49$ day^{-1}, $V_{1,LH} = 1263.4$ IU/day , $cl_{LH,p} = 0.07$ mL/ng , $cl_{LH,E} = 0.0049$ mL/pg , $A_{LH} = 14$ day^{-1} , $A_{FSH} = 8.21$ day^{-1} , $V_{FSH} = 5700$ IU/day , $K_{aFSH,Ac} = 641$ IU/mL , $k_{FSH} = 7.29$ day^{-1}, $cl_{FSH,p} = 644$mL/ng, $\gamma = 0.0202$, $\alpha = 0.7736$, $cl_{FSH,E} = 0.16$ mL/pg , $K_{nLH} = 360$pg/mL , $V_{2,LH} = 91000$ IU/day, $\beta = 0.1566$, $LH[0] = 40$, $MP_{LH}[0] = 12$, $FSH[0] = 20$, $MeP_{FSH}[0] = 11$, $MeM[0] = 1$, $MeSe[0] = 5$, $MeP[0] = 1$, $MeS_1[0] = 1$, $MeS_2[0] = 1$, $MeC_1[0] = 1$, $MeC_2[0] = 1$, $MeC_3[0] = 1$, $MeC_4[0] = 1$.

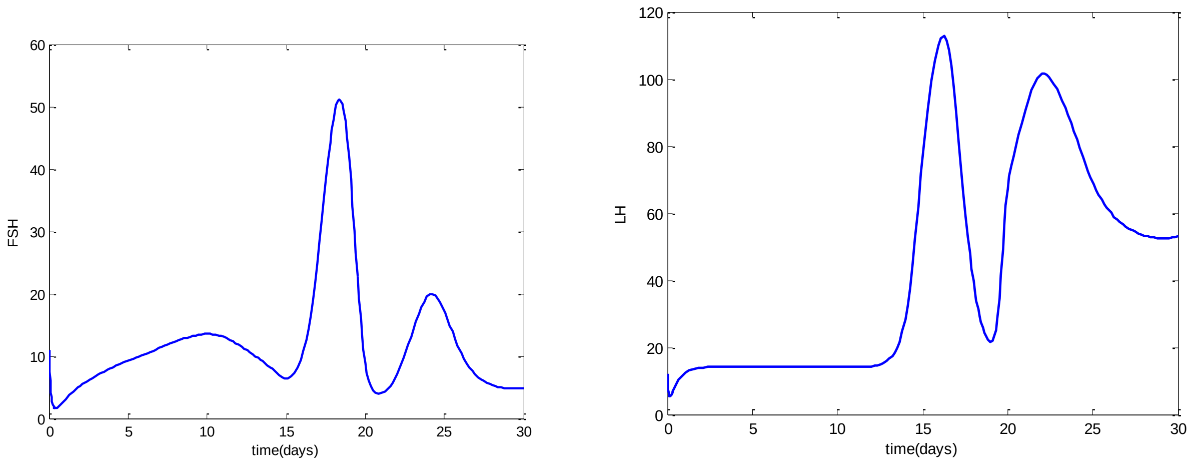

Fig. 5: is blood sugar 180 mg/dl up(diabetes), found that the LH hormone is highest at day 14 and FSH hormone is highest at day 19.The values of parameters are $K_{aLH,p} = 31.22$ ng/mL , $k_{LH} = 2.49$ day^{-1}, $V_{1,LH} = 1263.4$ IU/day , $cl_{LH,p} = 0.07$ mL/ng , $cl_{LH,E} = 0.0049$ mL/pg , $A_{LH} = 14$ day^{-1} , $A_{FSH} = 8.21$ day^{-1} , $V_{FSH} = 5700$ IU/day , $K_{aFSH,Ac} = 641$ IU/mL , $k_{FSH} = 7.29$ day^{-1}, $cl_{FSH,p} = 644$mL/ng, $\gamma = 0.0202$, $\alpha = 0.7736$, $cl_{FSH,E} = 0.16$ mL/pg , $K_{nLH} = 360$pg/mL , $V_{2,LH} = 91000$ IU/day, $\beta = 0.1566$, $LH[0] = 40$, $MP_{LH}[0] = 12$, $FSH[0] = 20$, $MeP_{FSH}[0] = 11$, $MeM[0] = 1$, $MeSe[0] = 5$, $MeP[0] = 1$, $MeS_1[0] = 1$, $MeS_2[0] = 1$, $MeC_1[0] = 1, MeC_2[0] = 1, MeC_3[0] = 1, MeC_4[0] = 1$.

4. Discussion and Conclusion

A considerable problem with menstrual cycle is studied to find the menstrual abnormalities that are caused by an imbalance of the hormones that cause the most common. The cause of hormonal imbalance is the cause of diabetes. From that of a normal sugar levels. (Not diabetic means) the amount of sugar in the blood 80-100 mg / dl. Relationship or hormones LH and FSH in equilibrium. Susceptible to diabetes or group with the amount of sugar in the blood 100-180 mg/dl was found in this group, the hormone LH and FSH. Incipient imbalance and in patients with diabetes is the amount of sugar in the blood of 180 mg/dl or more, making the amount of LH and FSH hormone imbalance. As a result, the irregular menstruation occurs. The quantity of sugar levels in the blood is associated with the hormones. We can conclude that diabetes are effect to disorders of hormones .

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