Chapter 2

Fundal height measurements

Fundal height (FH) measurement is a measure of uterine size to estimate the gestational age,[1] assess uterine and fetal growth[2-6] and identify abnormal uterus, fetus and amniotic fluid volume during pregnancy.[7] It has been performed in a number of different ways which have been developed to increase accuracy over a long period of time since the eighteenth century until present.

Method of FH measurements

FH measurement can be categorized in three methods including abdominal landmarks method, calipers method and tape measure method.[8] However, the currently used method is the tape measure method. Other methods are not suitable to use, because the landmarks method is less accurate for monitoring and screening growth of the fetus[9, 10] and the calipers method is difficult to use. Therefore, this chapter describes only the tape measure method, while other methods are summarized in Table 2.1.[8]

Table 2.1 Methods, advantages and disadvantage of FH measurement

Method of FH measurement	Advantages	Disadvantage
Abdominal landmarks method • Measure by comparing the height of uterine fundus with anatomic landmarks on the maternal abdomen such as the pubic symphysis, umbilicus and the xiphoid process and uses the examiner's fingerbreadths as the measuring tool (Figure 2.1).	• Useful when a tape measure is unavailable. • Accurate to identify gross discrepancies between uterine size and date before 20 weeks of gestation.	• The biologic variability in the placement of anatomic landmarks on the maternal abdomen and the width of examiners' fingers varies considerably.
Calipers method • Measure the FH in centimeter by the calipers, placing one tip on the upper border of the pubic symphysis and the other tip at the top of the uterus. Both tips are placed in the abdominal midline (Figure 2.2). The number of centimeters should be approximately equal to weeks of gestation after about 22 to 24 weeks.	• The most accurate, reliable and valid, method of measuring FH after 22-24 weeks of gestation.	• Rarely used in clinical practice because of several problem such as less portable and awkward to use.

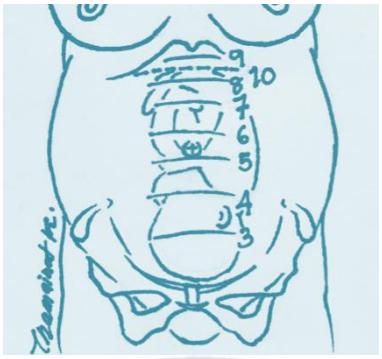

Figure 2.1 FH measurement by abdominal landmarks method

Figure 2.2 FH measurement by calipers method

Tape measure method

This method is the most frequently used to obtain an exact measurement because it's inexpensive, non-invasive, more portable, and easier to use.[3, 11, 12] However, it is accurate to use after 20-24 weeks of gestation.[3, 13] The method is performed using a non-stretch tape to measure FH in centimeters while the pregnant woman is in the supine position and extends her legs to allow the uterus to relax, and the urinary bladder should be empty. The tape measure can be used in many ways (Figure 2.3,[8] 2.4,[14] and 2.5[15]).

In northern Thailand, it can be measured by placing the tape measure on the abdominal midline and contacting the skin of the maternal abdomen for the entire length of the uterus. Then measuring from the top of the uterine fundus to the upper border of the symphysis pubis or reversed[15] (Figure 2.5), currently this method refers to symphysis-FH measurement or FH measurement.

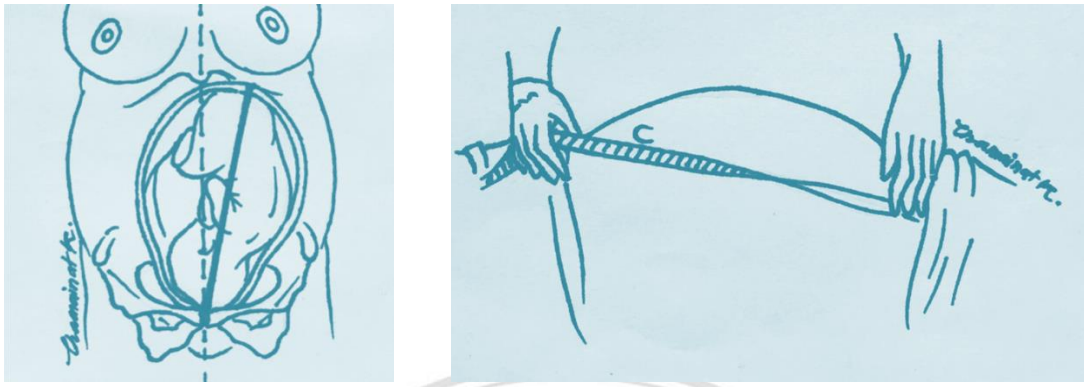

Figure 2.3 Tape measure is run along the longitudinal axis of the uterus from the top of fundus to the top of the pubic symphysis.

Figure 2.4 Using the tape measure in the midline, contacting the skin, and not including the upper curve of the fundus

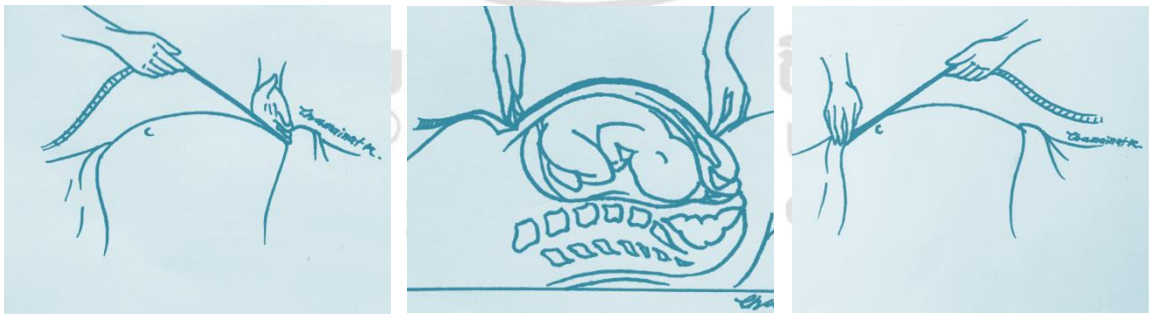

Figure 2.5 Using the tape measure on the abdominal midline, contacting the skin, and including the upper curve of the fundus, measuring from the top of the fundus to the pubic symphysis or reversed

However, a tape measurement can be less accurate when each time of antenatal visit there were 1. Different measurement techniques. 2. Different examiners who meet the pregnant woman in each antenatal visit. 3. The examiner who has already known GA. or 4. The

using of a marked measuring tape. This tendency increases with higher pregnant body mass index[3, 16, 17] and with less provider experience.[17]

Errors can be minimized or the method can increase accuracy by those methods described below.[2, 3]

1. Using the same practice protocols to measure FH in centimeters including an empty bladder before examining, using the same position of the pregnant woman during the measurement, blinded to gestational age, using unmarked measuring tape or blinded marked tape, using the same method of tape measure, and measuring while the uterus is relaxed.
2. Training providers how to measure using the method, where the exact upper border of the symphysis pubis and the top of uterus are, and continuing to monitor the practice and quality of measurement.
3. Supervising providers who have less experience.
4. Using the same examiner to measure the FH throughout pregnancy.

Factors influencing FH measurements

Many factors that affect FH measurements are shown in Figure 2.6. However, the factors contributing differences in FH growth curve are maternal and fetal characteristics, race and ethnicity, socioeconomic status, and routine practices in antenatal care clinics.

1. Maternal age

The effects of maternal age on FH differed between each study. Some indicated that maternal age had no effect on FH.[18] One study in North Carolina, USA noticed that birth weight will increase following maternal age[19] while another study found that it might be only an effect modifier that occurs together with other factors such as parity[20, 21] and BMI.[21, 22] This was because pregnant women who are multiparous are getting older, and increased weight leads to increased BMI. They affect fetal weight gain and FH centimeter measurement.

2. Parity

The effects of parity, birth order, on FH differed in each study. One study in Mozambique found that FH growth curve derived from nulliparous and multiparous did not differ.[23] One study in the UK manifested that parity is an independent predictor of FH and multiparous women revealed an FH of 1 cm exceeding the average[18] and in some studies noticed that birth weight will increase subsequently following the order of pregnancy.[19, 24] This might due to the latest pregnancy, as the mother usually has constant weight after delivering the previous pregnancy leading to accumulated adipose tissue in the body causing the prepregnancy BMI to increase. Therefore, parity is related to BMI and obesity.[20, 21, 25]

3. Maternal weight before pregnancy

Maternal weight before pregnancy is an important independent predictor of FH. It has been shown that a FH of 0.7 cm was higher for every 10 kg above the average maternal weight at booking[4, 18] and was directly proportional to fetal weight. Pregnant women who are slim or

thin will have a constitutionally small or genetically small fetus.[21] FH will also be small following the fetal size. For obese or fat pregnant women, fetus and FH are usually big. One study in Sweden showed that FH of the heaviest pregnant women, weighing ≥79 kg, was more than the lightest women, weighing ≤53 kg, about 2 cms throughout pregnancy. Moreover, mean birth weight of the infant of the heaviest women were more than the lightest women by 458 g.[26]

4. Maternal height

Some studies reported no effect of maternal height on FH[18] while some studies showed it as an independent predictor of FH which positively correlated with fetal weight.[24] It was shown that birth weight will increase about 10 g for 1 cm change of maternal height.[27] Mothers who had short stature showed slower fetal growth.[28]

5. Prepregnancy BMI

BMI is a measurement of the relative percentages of fat and muscle mass in the human body calculated by weight in kilograms divided by height in meters squared. Related studies have shown that prepregnancy BMI was an important factor influencing FH. Pregnant women who had more BMI exhibit higher FH than those who had normal and underweight BMI consequently[21, 23, 29] and the FH of 3 groups totally differed in the third trimester[21, 30] which might due to the causes listed below.

1. Abdominal subcutaneous fat thickness: overweight BMI women usually have thicker subcutaneous fat than other 2groups. One study among non-pregnant women divided subjects by group of BMI: <25, 25-29.9, 30-39.9, and ≥40 kg/m^2 and found that the thickness of subcutaneous fat was increased following BMI: 10.6, 17.6, 22.4 and 26.8 mm, respectively.[31] Moreover, among pregnant women BMI correlated with abdominal subcutaneous fat thickness.[32]

2. Fetal size: prepregnancy BMI may be considered as a surrogate for the nutritional status of the mother.[33] Therefore, an overweight BMI mother could affect change in metabolic hormones and providing more nutrient transportation to the fetus through the placenta resulting in a giant or excessive weight fetus. For underweight BMI, the opposite results occurred in which mothers tended to deliver small or underweight newborns.[34]

3. Hormonal changing in the third trimester: pregnant women who had overweight or obese prepregnancy BMI present low serum concentration levels of insulin-like growth factor binding protein-1 (IGFBP-1). This may continue to increase the bioavailability of insulin-like growth factor-I (IGF-I) which then regulates more nutrient transported to the placenta and initiated excessive fetal growth.[34] Hence, the fetus in the uterus will be larger than fetus in pregnant women who had normal or underweight prepregnancy BMI.

6. Gestational weight gain

The majority of studies found that maternal weight gain during pregnancy was related to infant birth weight.[35, 36] Pregnant women, who had weight gain more than normal baseline, tended to deliver giant or excessive birth weight newborns. For pregnant women having less weight gain than baseline, tended to deliver small or low birth weight newborns.[35, 37] Most of

the evaluation of weight gain during pregnant was based on the following the criteria of the Institute of Medicine (IOM).[38]

7. Socioeconomic status

Socioeconomic status is related to maternal and fetal nutrition and may affect the growth of the fetus and infant birth weight. Mothers who had low socioeconomic status, tended to deliver SGA fetuses and LBW newborns.[24, 39-41]

8. Race and ethnicity

Race and ethnicity influenced size and shape of the maternal pelvis, fetal size, and fetal weight.[41-44] These important factors can affect the FH growth curve such as most Caucasian pregnant women had large stature thus the fetus will also be large.[42, 45] The pelvis, which was large[43] may result in a cubic pattern FH growth curve. On the other hand, Southeast Asian pregnant women have small stature therefore their fetus will also be small.[42] The pelvis which was small may result in quadratic pattern FH growth curve.[21] Comparing between FH growth curves of Caucasian and Southeast Asian Hmong in the USA revealed that Southeast Asian Hmong had a slower rate of growth curve than Caucasian pregnant women because the Hmong ate less meat and consumed more rice and vegetables.[46]

9. Fetal weight and fetal size

Fetal weight and fetal size are directly proportional to FH. Size of the uterus is increasing following the development of the intrauterine cavity passenger such as fetus, placenta and amniotic fluid in which the fetus is the most important factor influencing the change of the uterus.[47] The previous study found differences correlation between fetal weight in grams and fundal height in centimeters in each setting, for example Xhosa pregnant women in South Africa: fetal weight = (FH - 21)/0.004,[48] Caucasian pregnant women in UK: In (fetal weight) = 10.69 - 100.25/FH,[49] multicenter subjects in France and Belgium: fetal weight = -199.93 + (108.59 x FH).[50] Therefore, at the same gestational age, pregnant women who have more fetal weight average, the FH in centimeters tended to be much more than those having lower fetal weight average.

10. Fetal sex

For pregnant women who are similar in characteristics at the same gestational age, the female fetus will systematically be smaller than the male fetus[51] and at full term pregnancy, the male infant's weight will be more than the female infant at approximately 183-184 g.[52, 53] In one study of Caucasian pregnant women with male infants, FH of 1 cm was exceeded an average.[18] Thus, male infants might affect increasing FH.

11. Fetal engagement

Among nulliparous women, the presentation of the fetus will engage approximately 2-4 weeks before delivery[7] so the growth rate of FH may diminish in this period while multiparous women are reversed because the fetal presentation will engage during the labor stage.[7]

12. Gestational age

Gestational age is the most influential factor concerningFH.[21, 54-56] Therefore, accurate dating is very important for evaluating FH. Gestational age, calculated by first day of the last menstrual period, tends to overestimate ultrasound dating approximately 2-3 days, and may be due to delayed ovulation more than early ovulation.[57, 58] Thus, the FH growth curve based on menstrual dating can cause artificial flattening of the growth curve at term whereas, ultrasound dating of the FH growth curve demonstrated no such flattening at term.[18, 29]

13. FH measurements

The accuracy of FH measurement is vital due to subjective methods can be less accurate both intra- and interpersonally. One related study found an intrapersonal error around ±1-2 cm and interpersonal error about ±2-4 cm.[16, 17] Furthermore, it has been shown that healthcare providers, who had at least two years of experience with obstetric and antenatal care, were able to minimize measurement error and bias.[17]

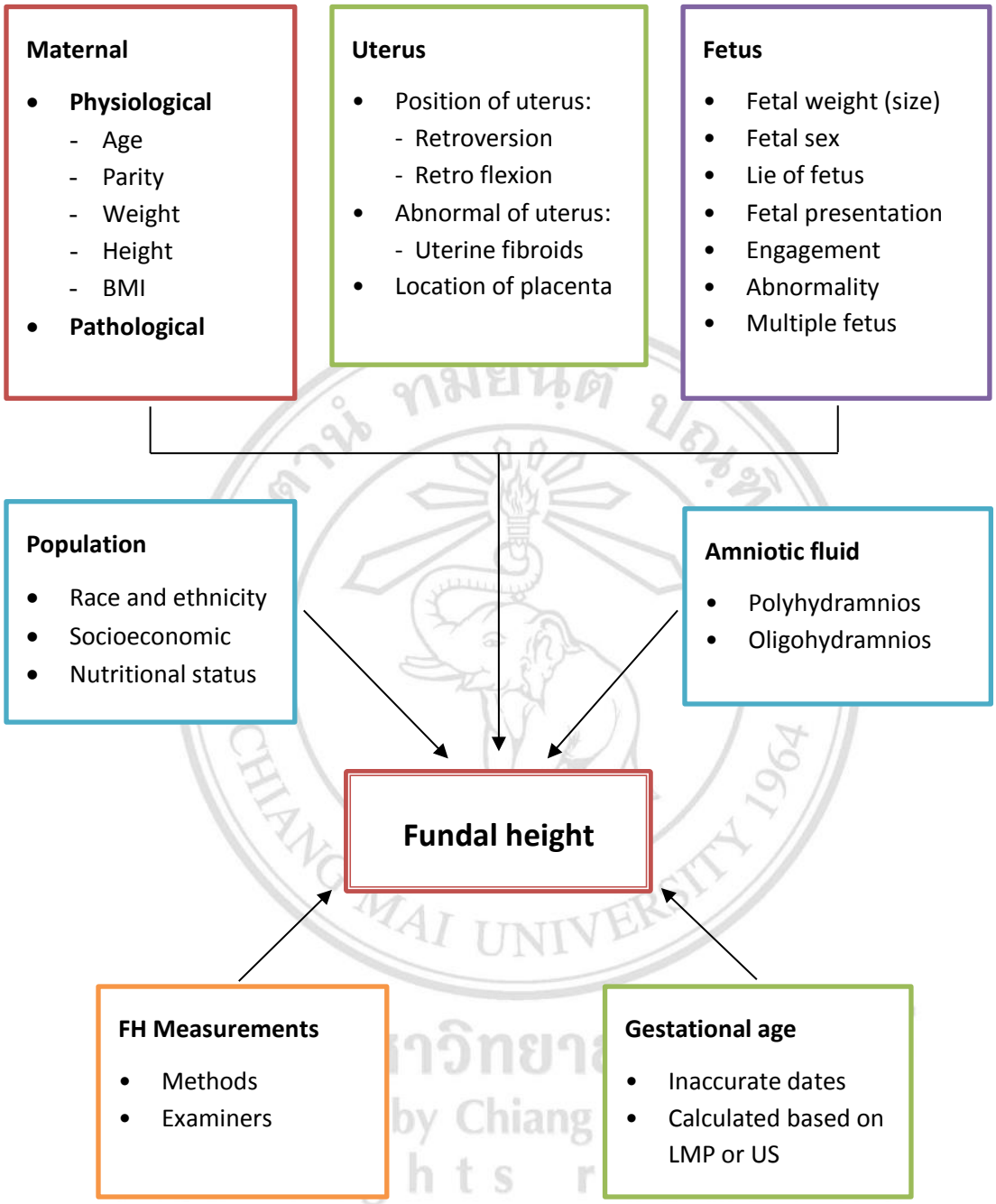

Figure 2.6 Factors influencing fundal height measurements during pregnancy

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