

Ultrasonic assessment has high sensitivity for pregnant women with previous cesarean section occurring uterine dehiscence and rupture

A STARD-compliant article

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Abstract

To investigate the diagnostic performance of ultrasound (US) for pregnant women with previous caesarean section (CS) occurring lower uterine segment (LUS) dehiscence and rupture.

107 pregnant women with previous CS and LUS thickness of 1.0 mm or less were recruited, the LUS and myometrium was measured, and US findings suggestive of uterine rupture were compared with findings at laparotomy. The included pregnant women were assigned into 2 groups, including 64 pregnant women had vaginal delivery at full-term and 43 pregnant women underwent repeat CS at preterm.

US findings suggestive of uterine rupture and dehiscence occurred in 18 women and 89 women, respectively; ten of them developed uterine rupture, and the incidence of uterine rupture was 9.34% (10/107). The sensitivity, specificity, accuracy, positive, and negative predictive values of US for the evaluation of LUS dehiscence and rupture were 100.0%, 91.8%, 92.5%, 55.6%, and 100.0%, respectively. There was no severe maternal obstetric complication, 1 fetus died, and the other fetuses were born with a 5-minute Apgar score of 7 to 10.

US has high sensitivity and specificity for pregnant women with previous CS occurring LUS dehiscence and rupture.

Abbreviations: CS = caesarean section, LUS = lower uterine segment, NPV = negative predictive value, PPV = positive predictive value, US = ultrasound.

Keywords: caesarean section, dehiscence, gestation, rupture, ultrasound, uterus

1. Introduction

Concern for uterine rupture has led to the decline in vaginal births after caesarean. The rate of caesarean section (CS) varies considerably from country to country: from 13% in northern Europe to 32% in the United States, 42% in China and 48% in Brazil by the year 2011, and majority of them are much higher than the World Health Organization's recommended proportion

for CS of 15%.^[1-3] This variation is attributable to a combination of factors, including the increased safety of the procedure, medical training, clinical environment, patient choice and the risk of litigation.^[1-5] According to guidelines and recommendations, vaginal birth after 1 CS is believed to be safe for most women. In a report of pregnant women with previous CS, 67% (778/1161) of them delivered vaginally, incidence of uterine rupture after trial of labor were 1.3% (15/1161).^[6] Other reports of the overall scar rupture rate were 0.29% (6/2075) and 0.9%.^[4,5] However, in actual situation, the optimal management of birth after a history of a CS is uncertain, and individual decisions together with the pregnant woman are being taken.^[6-9] Fearing rupture of uterus with CS scar and potential risk to the fetus, pregnant women with previous CS prefer planned repeat CS to vaginal delivery, as a result, both planned repeat CS and preterm CS increased.^[6,8-10]

Prenatal ultrasound (US) evaluation of the CS scar has become a common practice in China. The critical cut-off value of the lower uterine segment (LUS) thickness for the prediction of scar dehiscence and scar rupture of pregnant women with previous CS varied from 1.5 mm to 3.2 mm, basing on measurement of LUS myometrial thickness and full LUS thickness.^[10-15]

However, in clinical practice, some pregnant women with previous CS scar and LUS myometrial thickness less than 1.0 mm did not develop rupture. It's no doubt that when the LUS ruptures, the gestation must be ended, but whether it is urgent to consider birth when LUS dehiscence has been suggested by US evaluation has not been fully understood. We hypothesize that the US has very good performance in the evaluation of LUS dehiscence and rupture, and it is not urgent to consider birth

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when US reveals LUS dehiscence. The purpose of the present study was to investigate the diagnostic performance of US for pregnant women with previous CS occurring LUS dehiscence and rupture.

2. Materials and methods

2.1. Study population

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the World Medical Association Declaration of Helsinki (revised in 2000). The study was approved by our hospital Institutional Review Board, and patients informed consent was not necessary due to the retrospective study design.

This study used a retrospective case-control design, measurements of LUS thickness between pregnant women with previous CS of full-term birth and preterm birth were compared, pregnant women without previous CS and other abnormalities in uterus were selected as control, and performance of US in the evaluation of LUS dehiscence and rupture were calculated.

The study was conducted at a tertiary hospital, between December 2016 and December 2019. Clinical and demographic

characteristics, gravidity, parity, special history, maternal obstetric complications, fetal complications, and US evaluations of pregnant women with previous CS who were monitored and given a birth were collected. Information on gestational age, gestational outcomes, spontaneous vaginal birth, primary CS, neonatal birth weight and outcome was derived from the prenatal records, the birth records, and the mother and infant's chart available in the database. The inclusions were: singleton pregnant women with only 1 previous CS, low transverse uterine incision, no previous additional intervention to the uterus, no congenital uterus or pelvic deformity. The exclusions were: 2 and more previous CS, multiple pregnancies, macrosomic fetus, placenta previa, polyhydramnios, severe maternal diseases, etc. 832 pregnant women with and without previous CS were considered, among them the LUS thickness of 1.0 mm or less of Han ethnicity were included, and the LUS thickness greater than 1.0 mm, uterine scar arising from other causes, 2 and more gravidity history, and normal uterus were excluded. As shown in Figure 1. The included pregnant women with previous CS were assigned to 2 groups after birth according to the birth term (full-term and preterm). 30 consecutive pregnant women without previous CS and other abnormalities in uterus who had vaginal birth were selected as control (28.65 ± 3.12 years old; age range of 22–35 years), and the LUS thickness was measured at term.

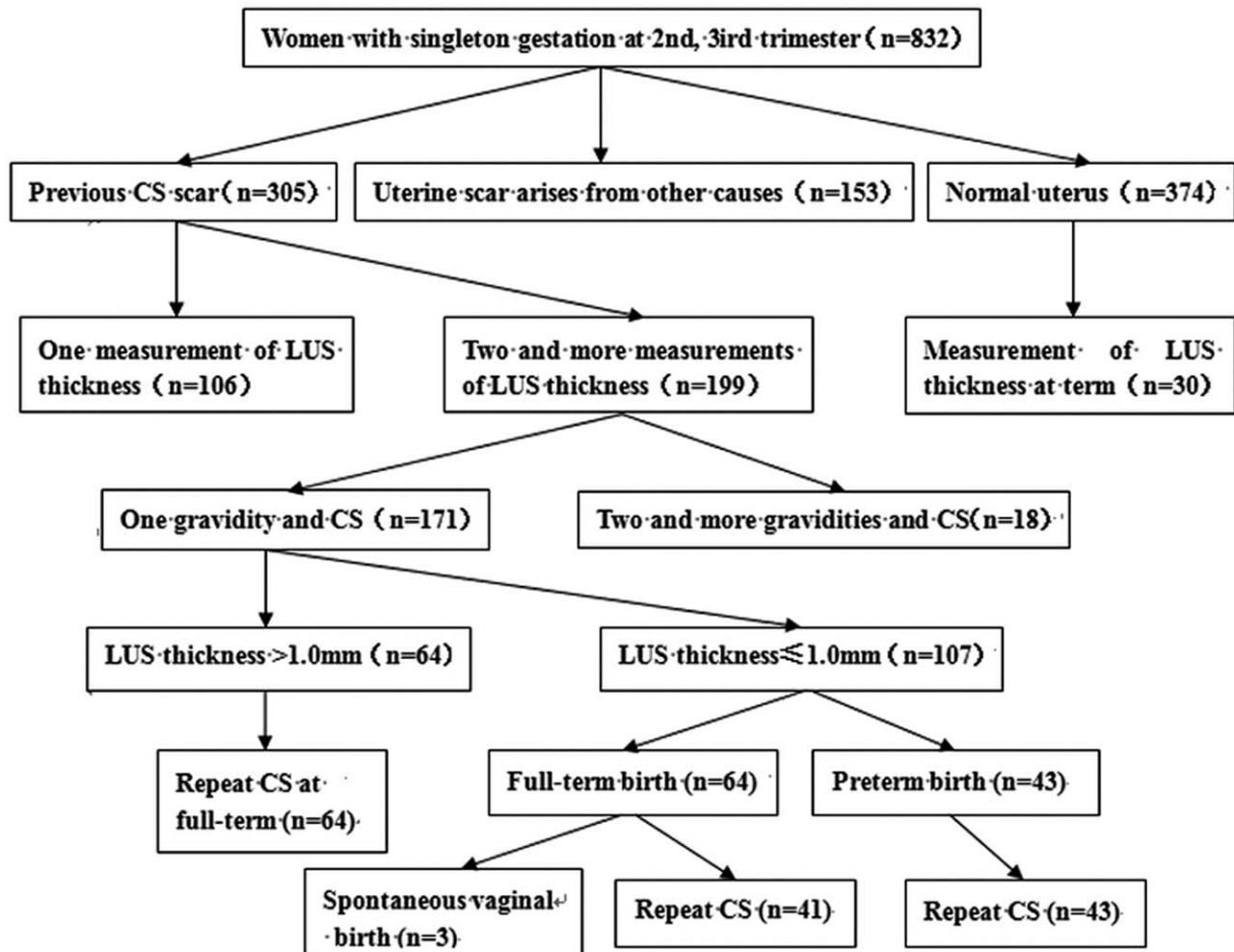


Figure 1. Flow chart of sample enrollment and outcome.

2.2. Instruments and evaluation protocols

The US examination was performed by 3 sonologists with 4 to 20 years of experience in US in obstetrics and gynecology. Voluson expert 730 (GE Healthcare, Piscataway, NJ), Logiq E9 (GE Healthcare, Wauwatosa, WI),

Voluson E8 (GE Healthcare, Zipf, Austria) US systems were used. All examinations were completed with a curvilinear transducer with a frequency of 2.5 MHz to 6 MHz. The LUS and CS scar of all pregnant women were evaluated using US, the LUS thickness was measured, and the CS scar was scrutinized for echogenic texture integrity.

All sonologists had trained for the measurements of LUS thickness during the routine quality control, 4 years prior to this study. The inter-performer and intra-performer reliability of the measurement had been evaluated based on the measurement of LUS thickness of 30 third trimester pregnant women with previous CS at that time. The inter-performer and intra-performer agreement values were 0.79 and 0.83, respectively. Inter-performer and intra-performer ICC values are grouped as follows: ICC values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability.^[16]

The LUS and CS scar was evaluated by 2D US after the urinary bladder being moderately distended. To trace the thinnest zone of the LUS, the shortest distance between urinary bladder and chorioamniotic membrane, the uterine lower segment was examined longitudinally and transversely, with the acoustic beam directing perpendicularly to the LUS plane. After the thinnest zone had been identified, acted the “zoom” button to magnify the thinnest zone enabling each slight movement of the calipers would produce only a 0.1 mm change in the measurement. The calipers had to be placed at the inner edge merged with

the limit line of the thickness that was measured, and the line of measurement had to be exactly perpendicular to the measured uterine wall. The measurement was repeated 3 times, with the lowest value being saved. The thickness measurement of the LUS myometrium and scar was to position 1 cursor at the uterovesical interface and the other at the uterus-decidua-amniotic interface so that it included only the hypoechogenic layer, as the method used by Cheung (Fig. 2).^[11] If there was no amniotic fluid, uterine wall-fetal head interface was taken.

The LUS with CS scar dehiscence is defined as a subperitoneal separation of the uterine scar, with the chorioamniotic membrane visible through the peritoneum (no communication between the uterine and peritoneal cavities).^[3,12] The US findings suggestive of dehiscence were based on the cut-off value of dehiscence by Cheung that LUS myometrial thickness less than 1.5 mm.^[11]

The LUS with CS scar rupture is defined as that the discontinuity of the uterine musculature, a full-thickness separation of the scar and the overlying serosa that resulting in communication between the uterine and peritoneal cavities.^[11] The US findings suggestive of scar rupture were based on that disappearance of LUS myometrial thickness, wedge defect appearance of LUS arising from marked asymmetry of the LUS myometrial thickness, or chorioamniotic membrane bulging out, or visible abnormal movement of the membrane.^[11,15]

2.3. Statistical analysis

Maternal age, body mass index (BMI), monitor time, interval time between present gestation and primary CS, gestational ages, and measurements of the CS scar and LUS thickness among different groups were analyzed using Mann-Whitney *U* test. US findings suggestive of uterine rupture were analyzed; the sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

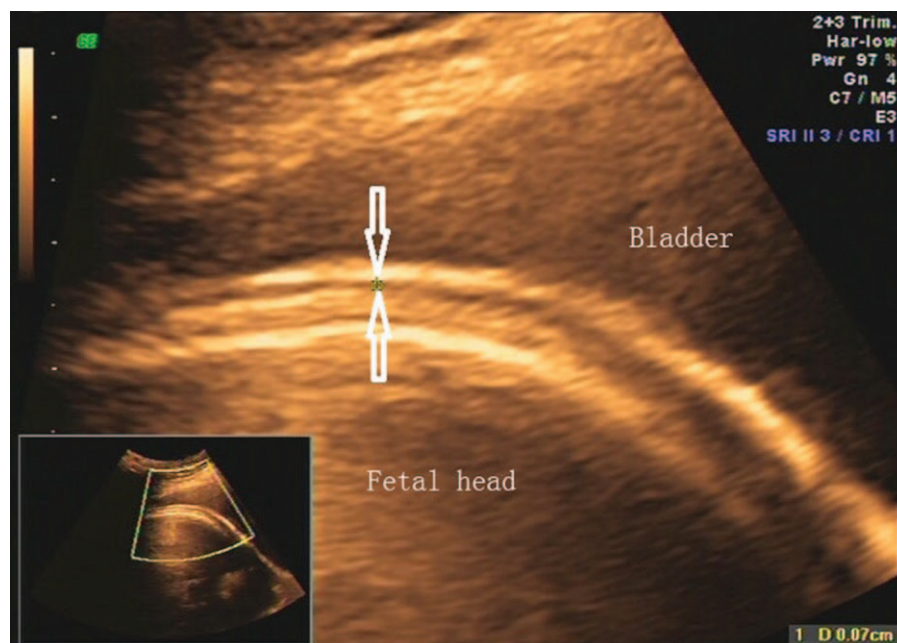


Figure 2. 34-yr-old pregnant woman with previous CS, and gestational age of 38 weeks. The hypoechogenic zone (arrows and cursors) is the LUS myometrial thickness, which is measured by positioning 1 cursor at the uterovesical interface and the other at the uterus-decidua-amniotic interface. CS = caesarean section, LUS = lower uterine segment.

Statistical analyses were performed using SPSS 20 (SPSS, IBM, Armonk, NY), and a $P < .05$ was set a priori (2-tailed).

3. Results

One hundred 7 pregnant women with previous CS and the LUS thickness of 1.0 mm or less were included, and 725 women were excluded. The 107 pregnant women with previous CS in 2 groups were: 64 women (34.69 ± 4.23 years old; age range of 23–45 years) gave birth at full-term, including 3 women of spontaneous vaginal birth and 61 women of repeat CS birth; and 43 women (35.37 ± 4.41 years old; age range of 27–42 years) had repeat CS birth at preterm. Comparison of demographic characteristics and measurements of LUS thickness between 2 groups of full-term birth and preterm birth was shown in Table 1. Between the full-term birth and preterm birth group, interval time between present gestation and primary CS had no significant difference ($P = .49$); gestational age had significant differences both at first and last measurement ($P < .001$); measurements of LUS thickness had no significant difference between the first time and last time ($P = .34$ and $.10$). Thickness of LUS of 30 pregnant women without previous CS and other abnormalities in uterus who had vaginal birth in control group was 0.59 ± 0.12 mm, compared with the thickness of last measurement of pregnant women with previous CS at group of full-term birth, there was no significant difference ($P = .50$). Of the 107 pregnant women with previous CS and the LUS thickness of 1.0 mm or less, 18 women (16.8%) and 89 women (83.2%) were suggestive of LUS rupture and dehiscence during the monitor period according to the US findings, respectively. Confirmed by laparotomy, 10 women developed uterine rupture, 94 (87.9%, 94/107) women had dehiscence. Three (3/107, 2.8%) women had spontaneous vaginal birth, and the clinical features and follow-up US of the uterus indicated their uteruses did not occur rupture. The incidence of LUS rupture was 9.34% (10/107). The sensitivity, specificity, accuracy, PPV, and NPV of US for the evaluation of LUS dehiscence and rupture were 100% (95% confidential interval, 95% CI: 94.6%-100%), 91.8% (95% CI: 88.3%-95.6%), 92.5%

Table 2

Ultrasound findings suggestive of uterine rupture of 107 pregnant women with previous caesarean section and outcomes confirmed by virginal birth and laparotomy.

	Full-term birth	Preterm birth
US findings suggestive of uterine rupture (n=18)	5	13
US findings suggestive of no uterine rupture (n=96)	56	30
LUS incomplete rupture confirmed by surgery (n=10)	2	8
LUS dehiscence confirmed by surgery (n=94)	59	35
Spontaneous vaginal birth (n=3)	3	0
Total (n=107)	64	43

US=ultrasound, LUS=lower uterine segment.

(95% CI: 86.6%-96.7%), 55.6% (95% CI: 52.8%-60.8%), and 100% (95% CI: 95.2%-100%), respectively, US findings suggestive of uterine rupture of 107 pregnant women with previous CS and outcomes confirmed by vaginal birth and laparotomy were listed in Table 2. Table 3 listed causes of preterm birth of pregnancy of women with previous CS. There was no severe maternal obstetric complication, 1 fetus died, and other neonates were born with a 5-minute Apgar score of 7 to 10. 30 pregnant women of control group underwent vaginal delivery, and maternities and neonates were all in good condition.

4. Discussion

In this study, the incidence of LUS rupture was 9.34% (10/107), which is much higher than the reports by Studsgaard et al that incidence of uterine rupture after trial of labor of previous CS were 1.3% (15/1161),^[6] by Sananès et al that the overall scar rupture rate of 0.29% (6/2075) and by Kiran et al that of 0.9% in a population of singleton pregnancies with a single prior CS,^[4,5] indicating that when the myometrial thickness of LUS with CS of 1.0 mm or less, the risk of LUS rupture increases markedly. US has high sensitivity, specificity, accuracy and NPV for pregnant women with previous CS occurring LUS dehiscence and rupture. The reasons that US has lower PPV for the evaluation of LUS dehiscence and rupture are that:

- (1) the simple thinner LUS thickness is not a reliable evidence for identifying rupture;^[17]
- (2) some women with thicker abdominal wall, which may impair the resolution of the beneath LUS;

Table 3

Causes of preterm birth of pregnancy of women with previous cesarean section.

	Number (n)	Percentile (%)	Cumulative percentile (%)
Cesarean section	18	41.9	41.9
Incomplete rupture	13	30.2	72.1
Severe eclampsia	5	11.6	83.7
Preterm rupture of membranes	2	4.7	88.4
Oligohydramnios	1	2.3	90.7
Fetal distress	1	2.3	93.0
Fetal demise	1	2.3	95.4
Preterm with cervical incompetence	1	2.3	97.7
Virginal bleeding	1	2.3	100.0
Total	43	100	

Table 1

Comparison of demographic characteristics and measurements of LUS thickness between 2 groups of full-term birth and preterm birth.

	Full-term birth (n=64)	Preterm birth (n=43)	P value
Maternal age (yr)	34.69 ± 4.23	35.37 ± 4.41	.54
Maternal body mass index (kg/m ²)	27.28 ± 2.82	26.26 ± 2.88	<.001
Monitor time (d)	34.59 ± 26.10	35.19 ± 21.04	.53
Interval time between present gestation and primary CS (yr)	8.33 ± 3.63	8.86 ± 4.00	.49
Gestational age at first measurement (wk)	32.04 ± 4.03	28.42 ± 5.62	<.001
Thickness of LUS at first measurement (mm)	0.73 ± 0.13	0.71 ± 0.20	.34
Gestational age at last measurement (wk)	36.44 ± 1.43	33.72 ± 2.51	<.001
Thickness of LUS at last measurement (mm)	0.55 ± 0.17	0.37 ± 0.28	.10

CS=cesarean section, LUS=lower uterine segment.

- (3) The dimensions of the LUS with CS change throughout pregnancy, the area of CS scar is expanded with the growth of the fetus, the wall of uterine corpus and scar become thin simultaneously.

However, the changes of LUS with CS are different from that of the normal uterine corpus that shows almost uniform thickness, the LUS with CS becoming large and thin is not synchronizing and evenly, which may cause asymmetric appearance, wedge-like defect appearance or other abnormal change of LUS, and therefore brings challenge to identify rupture at US evaluation.^[18] In our series, no chorioamniotic membrane bulging out and abnormal movement of the membrane were found in the LUS rupture at US scanning, as addressed by Kushtagi and Garepalli.^[15] The measurements of LUS thickness had no significant difference between the first time and last time ($P=.34$ and $.10$), suggesting that the capacity of fetal growth and myometrial thickness decreases is limited.

Our results are partially consistent with the previous study that uterine rupture after previous low segment transverse cesarean is rarely catastrophic, and pregnant women with previous transverse CS having trial of vaginal birth have low risk of uterine rupture.^[7] In our series, although 9.34% pregnant women with previous CS occurred LUS rupture in this study, there were no severe maternal and neonatal events. Three pregnant women with previous CS had spontaneous vaginal birth unexpectedly, and no uterine rupture occurred. These suggest that if a pregnant woman with previous CS and using tocolytics in preventing preterm labor, when US finds that the LUS thickness of 1.0 mm or less, and there is no other special symptom and sign, the thin LUS thickness is not a sufficient indication for timing of birth.

Several factors influence the LUS rupture risk of pregnancy with prior CS, including inter-pregnancy interval, number of previous CS, maternal age, wound infection after the CS, previous classical or inverted T incision and previous uterine rupture, type of prior hysterotomy closure, suture materials, fetal weight, uterine induction with oxytocin or prostaglandins, induction using mechanical methods, remarkable decrease of retropubic tissue thickness, and thin thickness of LUS with CS scar measured by US.^[4-9,14,19] All pregnant women with CS were monitored continuously to term by 4 to 7 weeks from the time of measurement of LUS thickness of 1.0 mm or less in this study, during the monitoring time, 9.34% (10/107) women developed LUS rupture. This suggests that if the gestation has not come to the term, it is still reasonable to monitor to the term, other than to undergo preterm CS birth. With reference to the previous study of critical cut-off value of dehiscence, LUS thickness of pregnant women with CS less than 1.0 mm should be dehiscence or rupture, and the results of this study supported it.^[11] Dehiscence may have occurred even before the previous proposal critical cut-off value; there are different studies with different criteria to predict the dehiscence and rupture.^[10-12] In our study, 9.34% pregnant women with previous CS and LUS myometrial thickness of 1.0 mm or less occurred LUS rupture. Uharček et al^[10] reported that full LUS thickness less than 2.5 mm is associated with a higher risk of uterine dehiscence, and Bujold et al^[12] reported that full LUS thickness of 2.3 mm is associated with a higher risk of complete uterine rupture. In their studies, the full LUS was measured; in our study, the LUS myometrium was measured. The LUS myometrium is far thinner than full LUS, so it is reasonable that there were some differences between our

conclusion and their conclusions. In our study, LUS rupture occurred before onset of labor, no 1 occurred during labor, no oxytocin and prostaglandins and augmentation of labor were used, the incidence of LUS rupture was much higher than other reports (0.29%-1.3%).^[4-6] The reasons may be that the variation of samples (Han ethnicity, elder maternal age, varied interval of CS, maternal nutrition and life style, etc).

In this study, the comparison of LUS thickness between normal uterus at term [0.59 ± 0.12 mm] and uterus with CS scar measured at last time [0.55 ± 0.17 mm] had no significant difference, which indicates that thickness change of LUS of pregnant woman with previous CS scar may not be the main cause of CS scar dehiscence and rupture. The uterine myometrium consisted by 3 layers of strong smooth muscle grows during pregnancy to accommodate the growing and enlarging fetus. Intact uterine myometrium is sound and strong enough to resist the force of labor contraction. After CS, the structure of the uterus changed, the CS scar and its adjacent myometrium with suture loses normal uterine structure of 3 layers, the suture margins usually do not get a better apposition, the scar fibers do not integrate with the normal uterine fibers during the process of wound healing, and the scar healing quality is not competent, which results in its ability to resist the tension and strain of fetal growing and labor compromised, and the uterus with CS scar is easy to occur scar dehiscence and / or rupture during vaginal birth. Detail changes of CS scar region have been studied by Pollio et al that the CS scar with dehiscence displayed a number of biochemical changes, including increased levels of collagen and decreased levels (or absence of) transforming growth factor.^[3] Lofrumento et al reported that uterine wound healing involves many cells, in the process a complex cascade of biochemical events mediated by proteins and peptides take place, both phenotype and genotype dependent.^[20]

There are 3 limitations of the study. First, the sample size was not large, which may affect partially the robustness of the conclusion. Second, the retrospective study design, which may not include all details relating to the study. Third, no planned vaginal delivery trial was done, so whether the US measurement of LUS myometrial thickness can predict safe vaginal delivery or not is unknown,

In conclusion, pregnant woman with previous CS and thin LUS myometrial thickness at third trimesters has higher risk of uterine rupture. US has high sensitivity and specificity for pregnant women with previous CS occurring LUS dehiscence and rupture. LUS rupture is usually not catastrophic if it is managed timely. If there is no other finding suggestive of LUS rupture by US, even the LUS myometrial thickness is of 1.0 mm or less, the gestation can sustain uneventful to term under closely monitoring.

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