Can Sonographic Evaluation of Lower Uterine Segment Predict Women at Risk of Uterine Rupture / Dehiscence?

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Abstract: *Introduction*: Ultrasonography has been used to examine the scarred uterus in women who have had previous caesarean sections in an attempt to assess the risk of rupture of the scar during subsequent labour. This study aims to evaluate the usefulness of sonographic measurement of the lower uterine segment before labour in predicting the risk of intrapartum uterine rupture.

Methods: This is a prospective cohort study. Eligible parturients were those with one previous caesarean section who meet the inclusion criteria and were booked for delivery at Irrua Specialist Teaching Hospital. 153 patients underwent transvaginal ultrasound examination at 35-37 weeks' gestation, and were allocated to four groups (≤2.5mm, 2.6-3.5mm, 3.6-4.5mm and ≥4.6mm) according to the thickness of the lower uterine segment. A systematic random sampling technique was used for patient selection. All labor was actively managed.

Inclusion criteria included women with 1 previous transverse lower uterine segment caesarean section scar presenting in spontaneous labor, singleton fetus with vertex presentation, non-recurrent indications for previous caesarean section e.g. malpresentation such as breech presentation, fetal distress and an estimated fetal weight (EFW) of less than or equal to 3.8 kg. The exclusion criteria included Women with a previous history of uterine rupture, women with fetal macrosomia, placenta previa, multiple gestation as well as abnormalities in amniotic fluid volumes such as polyhydramnious or oligohydramnious, women with co-existing medical conditions like hypertensive disease in pregnancy, uncontrolled diabetes mellitus in pregnancy, and women whose previous caesarean section was complicated by wound sepsis or wound breakdown.

Main Outcome Measure(s): The primary outcome in this study was the association between echographic measurements of the LUS and the risk of intrapartum uterine rupture. The secondary outcomes were trial of labor outcome (successful VBAC versus repeat Cesarean section), and determination of clinical (obstetric) factors that could serve as predictors for uterine rupture or dehiscence.

Results: The overall frequency of defective scar was 3.9% (2 ruptures, 4 dehiscences). The frequency of defects rose as the thickness of the lower uterine segment decreased: there were no defects among 49 women with measurements greater than 4.5 mm, 1 (1.4%) among 70 women with values of 3.6-4.5 mm, 2 (10%) among 20 women with values of 2.6-3.5 mm, and 3 (21.4%) among 14 women with values of 2.5 mm and below. With a cut-off value of 3.5 mm, the sensitivity of ultrasonographic measurement was 83.3%, the specificity was 80.3%, positive predictive value was 14.7%, and negative predictive value was 99.2% with an accuracy of 80.4%.

Conclusion: The results from this study showed that the risk of a defective scar is directly related to the degree of thinning of the lower uterine segment at around 37 weeks of pregnancy. The high negative predictive value of the study may encourage obstetricians to offer a trial of labour to patients with a thickness value of 3.5 mm or greater.

Keywords: Lower uterine segment, uterine rupture, dehiscence, VBAC.

1. INTRODUCTION

As the incidence of cesarean deliveries rises [1], the number of patients who face the decision between a vaginal delivery after caesarean section (VBAC) and repeat caesarean section delivery increases. The relative safety of the operative procedure had led to relaxation of indications, resorting to the procedure being conducted for relative indications and even 'caesarean on demand' by some women. This tendency needs to be controlled as it puts a great drain on health care resources, is costly and associated with serious risks to the mother and baby, all the recent advances notwithstanding. This rising caesarean section rate has created an expanding high risk obstetric sub-population “Women with scarred uterus” [2-7]. In Nigeria, it is apparent that previous caesarean section constitutes the highest indication for repeat caesarean section [8-10]. The reason for this is that two or more previous caesarean section is regarded as an absolute indication for repeat caesarean section in most centres in Nigeria [11].

Uterine rupture is a rare but serious complication of a trial of vaginal birth after caesarean delivery [12-14]. Therefore, vaginal birth after caesarean delivery should be proposed only to women who are likely to have a low risk of uterine rupture. Is it possible to identify these women? A number of clinical factors might be important as well as the integrity of the caesarean scar and the thickness of the lower uterine segment assessed by imaging techniques. A simple and easily available imaging technique to use for this purpose is ultrasound. Possibly, ultrasound assessment of the

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caesarean scar or of the whole lower uterine segment could be used alone or in combination with clinical factors to estimate the likelihood of uterine rupture or dehiscence occurring spontaneously or during a trial of labour.

Current evidence on our ability to predict uterine rupture or dehiscence using ultrasound or clinical variables is limited. We do not know for sure how common uterine rupture is after caesarean delivery. In retrospective studies, the rate of uterine rupture during a trial of labour after a previous lower segment caesarean delivery is around 1% [14-21]. These studies seem to have included only symptomatic uterine rupture. In prospective studies in which women with one previous lower segment scar, who had the thickness of their lower uterine segment measured with ultrasound were followed up with regard to pregnancy outcome, the rate of uterine rupture or dehiscence is on average 6.6% (range 1-46%) [22].

Whether a uterus with a dehisced caesarean scar (or with an extremely thin myometrium in the scar area) will proceed to rupture is likely to depend on the management of labour and on the timing of caesarean delivery. Uterine rupture before start of labour is extremely rare [24]. Vaknin *et al.* [24] reported uterine rupture to occur before start of labour in 7 of 120,636 (i.e. 1 in 17,234) pregnancies at 22 gestational weeks or over.

Jastrow *et al.* [22] in a systematic review published in 2010 attempted to establish whether the thickness of the lower uterine segment as measured by ultrasound at 35-40 gestational weeks predicted uterine rupture or dehiscence. The aim was to estimate the strength of the association between sonographic thickness of the lower uterine segment in women who had undergone caesarean delivery and uterine scar dehiscence or rupture, and to find the best cut-off value for the thickness of the lower uterine segment in predicting uterine dehiscence or rupture.

In a research done by Rozenberg *et al.* [23], full lower uterine segment thickness varied between 1.6 and 12.3 mm. Uterine rupture was diagnosed in 15 (2.3%) women and uterine dehiscence in 10 (1.6%) women (i.e. the rate of uterine defect was 3.9%). The thinner the full thickness of the lower uterine segment the higher the risk of uterine rupture or dehiscence. In groups of women with full lower uterine segment thickness of 1.6-2.5 mm, 2.6-3.5 mm, 3.6-4.5 mm, and over 4.5 mm, the frequency of any uterine defect (either dehiscence or rupture) was 16%, 10%, 2% and 0%, the frequency of uterine rupture was 10%, 7%, 0.6% and 0%, and that of uterine dehiscence was 6%, 4%, 1% and 0% respectively. The investigators suggested a cut-off of 3.5 mm to be optimal and suitable for clinical use and values for full lower uterine segment thickness 3.5 mm or less being taken to indicate a high risk of uterine rupture. The cut-off had a sensitivity of 88% and a specificity of 73%. This corresponds to a positive likelihood ratio of 3.3 and a negative likelihood ratio of 0.16, which means that this test had poor - or at most moderate [25] - ability to predict uterine dehiscence or rupture.

A wide range of ultrasound measurements of the lower uterine segment thickness at 35-40 weeks in women with one previous low transverse caesarean section have been published in various studies [23, 26-33]. From these various studies, it is shown that the sonographic full thickness of the lower uterine segment at 35-40 weeks in women delivered by caesarean section is on average 3-4 mm, with a range from 2-19 mm, and that sonographicmyometrial thickness ranges from 0-10 mm.

The reproducibility of ultrasound measurements of the thickness of the lower uterine segment using different examination techniques has been examined in five studies [28-30, 32, 33]. Most intra- and inter-observer differences were 1 mm or less [57, 60] but the limits of agreement (the limits within which 95% of future measurements are expected to fall) were wide (i.e. up to 4 mm for full lower uterine thickness and up to 1.5 mm for myometrial thickness) [32]. Despite the imprecision in the measurements, the intra- and inter-observer agreement on classifying the lower uterine segment as being thicker or thinner than a certain cut-off level was at least moderate in most studies. Clearly, if measurements of the thickness of the lower uterine segment are to be used clinically, ultrasound examiners would need to be properly trained and a meticulous measurement technique used.

Presently, there are various clinical models available to predict the success of VBAC following induction of labour. However, there are no currently used models or variables in clinical practice to predict the risk of uterine rupture/dehiscence in women being planned for VBAC.

3. STUDY JUSTIFICATION

A statistically significant association with uterine rupture during a trial of labour after caesarean delivery has been found in at least two studies for the following variables: inter-delivery interval (higher risk with short interval), birth weight (higher risk if 4000 g or over), induction of labour (higher risk), oxytocin dose (higher risk with higher doses), and previous vaginal delivery (lower risk). However, only few clinically useful risk estimation models that include clinical variables have been published with majority of these not used clinically. A thin lower uterine segment at 35-37 weeks, as measured by ultrasound in women with a caesarean section scar, increases the risk of uterine rupture or dehiscence. No cut-off for lower uterine segment thickness, however, can be suggested because of study heterogeneity, and because prospective validation is lacking. At term, large caesarean section scar defects in pregnant women seen at ultrasound examination increase the risk of uterine rupture or dehiscence but the strength of the association is unknown. Currently we lack a method that can provide a reliable estimate of the risk of uterine rupture or dehiscence during a trial of labour in women with caesarean section scar(s). The association between the increased cesarean section rate, previous cesarean sections and the increased likelihood of uterine rupture or dehiscence in future pregnancies makes imperative the need to have a method that can adequately predict the risk of uterine rupture/dehiscence.

This study, a prospective cohort study is therefore designed to add to and strengthen existing knowledge on the significance of sonographic measurement of the lower uterine segment in being able to predict cases of uterine rupture / dehiscence in women being planned for vaginal delivery following a prior caesarean delivery. It will help to adjust current intervention as well as modify care of patients, while also serving as a baseline for patients being managed for VBAC in Nigerian suburban Teaching hospital.

3.1. Aim and Objectives

3.1.1. Aim

To evaluate by ultrasonography, the lower uterine segment thickness of women with a previous cesarean delivery and determine a critical thicknessatwhich uterine defect (dehiscence/ rupture) is predictable.

3.1.2. Specific Objectives

1. Determine the thickness of the lower uterine segment of patients being planned for vaginal birth after caesarean section.
2. To determine critical thickness of the lower uterine segment at which uterine defect (dehiscence/ rupture) is predictable.
3. To determine clinical (obstetric) factors that could serve as predictors for uterine rupture or dehiscence.

Null hypothesis (H_O): Estimation of lower uterine segment thickness cannot predict the risk of uterine rupture/ dehiscence in women being planned for vaginal delivery after a previous caesarean section.

Alternate hypothesis: Estimation of lower uterine segment thickness can predict the risk of uterine rupture/ dehiscence in women being planned for vaginal delivery after a previous caesarean delivery.

4. METHODS

4.1. Study Area

The study was conducted at the Obstetrics and Gynaecology department of Irrua Specialist Teaching Hospital (ISTH), Irrua, Edo state, Nigeria. The department has 82 obstetric beds and 68 gynaecologic beds and undertakes an average of 1800 deliveries annually.

4.2. Study Design

A prospective cohort design.

4.3. Study Population

The study group consisted of pregnant women with one previous low transverse cesarean delivery. Those who satisfied the inclusion criteria for trial of vaginal birth after caesarean section were recruited into this study after obtaining informed consent from them.

4.4. Selection Criteria

4.4.1. Inclusion Criteria

1. Women with one previous transverse lower uterine segment caesarean section scar presenting in spontaneous labor.
2. Singleton fetus with vertex presentation.
3. Non-recurrent indications for previous caesarean section e.g. malpresentation (such as breech presentation), fetal distress.
4. Estimated fetal weight (EFW) of less than or equal to 3.8 kg.

4.4.2. Exclusion Criteria

1. Women with a previous history of uterine rupture.

2. Women with fetal macrosomia, placenta previa, multiple gestation as well as abnormalities in amniotic fluid volumes such as polyhydramnious or oligohydramnious.

3. Women with co-existing medical conditions like hypertensive disease in pregnancy, uncontrolled diabetes mellitus in pregnancy.

4. Women whose previous caesarean section was complicated by wound sepsis or wound breakdown.

4.5. Sample Size Determination

The sample size of 153 was calculated using the statistical formula by D.W Taylor, based on the WHO caesarean section rate of 10% [34] and a confidence level of 95%.

4.6. Sampling Technique / Patient Selection

A systematic random sampling technique was used. Pregnant women with one previous caesarean delivery attending the antenatal clinic of ISTH were counselled about the study and those that met the inclusion criteria were randomized using systematic random sampling technique and thereafter consented.

The study population was identified and an appropriate sample size of 153 calculated. The sampling interval/fraction was calculated and used as a guide in selecting the first subject using a random number table. A sampling register was opened and numbers assigned to cases after randomization.

Those admitted in spontaneous labor, to the labour ward of ISTH who satisfy the inclusion criteria for trial of vaginal birth after caesarean section were recruited until the calculated sample size was completed. All patients enrolled had a transvaginal ultrasound done to assess the thickness of the lower uterine segment between 35-37 weeks gestational age.

4.7. Measurement Methodology

The study was explained by the researcher (and/or research assistant) to all pregnant women with 1 previous transverse lower segment caesarean delivery who were attending the antenatal clinic who met the inclusion criteria.

For patients who participated in the study with no obstetric contra-indications, the sonographic examination included, in addition to the evaluation of the full thickness of the lower uterine segment (and scar thickness where identifiable), identification of fetal presentation and exclusion of unexpected abnormal amniotic fluid volume and placenta previa.

During the transvaginal scanning (TVS) examination, the lower uterine segment was examined longitudinally and transversely to identify any areas of obvious dehiscence or rupture. The full thickness of the lower uterine segment was defined as the shortest distance between the urinary bladder wall-myometrium interface and the myometrium/chorioamniotic membrane-amniotic fluid interface. The myometrial layer was defined as the smallest hypoechoic portion of the lower uterine segment overlying the amniotic cavity at the level of the uterine scar. Any balloon effect, as described by Michaels *et al.* [35] consisting of any abnormal bulging of the outer layer associated with fetal movement or changes in amniotic fluid pressure against the urinary bladder base, was noted. If the lower uterine segment appears intact, an attempt was made to identify the previous uterine scar, and the appearance noted. The thinnest zone of the lower segment was identified visually at the mid-sagittal plane along the cervical canal. This area was magnified to the extent that any slight movement of the caliper would produce a change in measurement by only 0.1 mm. The measurement of the full thickness of the LUS was taken with the cursors at the urinary bladder wall-myometrium interface and the myometrium/ chorioamniotic membrane-amniotic fluid interface. The measurement was repeated three times and a mean obtained and taken as the lower uterine segment thickness for this study. All assessments were performed using a Voluson E8 ultrasound machine and a four dimensional 5-9-MHz transvaginal probe. The full thickness of the LUS thickness measured was divided into 4 groups: ≤2.5mm, 2.6-3.5mm, 3.6-4.5mm and ≥4.6mm. This LUS thickness interval was chosen because the axial resolution of the vaginal probe was set at 0-5 mm. The study was a double-blinded study, i.e., the sonographic findings were neither conveyed to the treating obstetricians nor to the patients and decisions for repeat Caesarean Section were performed because of obstetric indications only.

Antenatal examinations noted amongst others, factors that were favourable or otherwise for a trial of VBAC. Circumstances surrounding previous deliveries were also noted

All participants were admitted into the labor ward in spontaneous labour. Patients induced were excluded from the study, however augmentation of labour (AOL) was allowed if indicated. AOL was done cautiously using 2.5 IU oxytocin in 500mls of ringers lactate starting at 2mIU/ml and this was doubled every 45 minutes to a maximum 32miu/ml or until the patient achieved 3 uterine contractions in 10 minutes, whichever comes first. At least 3 unit of blood was typed and cross matched. Intravenous line with a 16-18 gauge canula was established and maintained. The anaesthetist, theatre staff and neonatologist were informed for the possibility of a caesarean section. Continuous electronic monitoring of fetal cardiac activity, uterine contractions as well as maternal vital signs were vigilantly monitored throughout the trial. Any adverse maternal or fetal complication post delivery was also noted.

For those patients that had repeat cesarean deliveries, the Obstetrician who performs the surgery were asked to comment on the appearance of the lower uterine segment under the following categories (Qureshi *et al.* [36]):

(1) Grade I: indicates that the LUS was well developed.

(2) Grade II: indicates that the lower segment was thin without visible content.

(3) Grade III: was assigned when the lower segment was translucent with visible content.

(4) Grade IV: was assigned when well circumscribed defects, either dehiscence (represented by sub-peritoneal separation of the uterine scar, with the chorioamniotic membrane visible through the peritoneum of the lower uterine segment) or rupture (represented by complete separation of the uterine scar of any length, resulting in communication between the uterine and peritoneal cavities) were present.

All findings were properly documented and later transferred into spread sheets designed for the study.

4.8. Outcome Measures

The patients' labor and delivery outcomes were reviewed after delivery. The primary outcome measure in the study was:

1. LUS thickness estimation at 35-37 weeks (divided into 4 groups: ≤2.5mm, 2.6-3.5mm, 3.6-4.5mm and ≥4.6mm) and the risk of uterine rupture / dehiscence.

The secondary outcome measures were:

1. LUS thickness estimation at 35-37 weeks and outcome of delivery (Successful VBAC or repeat caesarean section).

2. Determination of clinical (obstetric) factors that could serve as predictors for uterine rupture or dehiscence.

4.9. Data Analysis / Statistical Method

Data obtained from the study was cleaned by the researcher and entered into the Statistical Package for Scientific Solutions (SPSS) version 16.0 software. The Socio-demographic variables (such as age in years, parity, educational level etc) of the study respondents were analyzed using descriptive statistics such as means and standard deviation if numerical and percentages if categorical. The primary outcomes (association between sonographic measurements of the LUS and the occurrence of uterine defect) were presented as proportions. The measures of effect were estimated using relative risks. Test of associations between obstetric profile and other determinants of primary outcome was done using the chi-squared test and the Fisher's exact test (where the proportion of expected frequencies <5 is more than 20%). A multivariate logistic regression analysis was used to identify statistically significant predictors of the chance of occurrence of uterine dehiscence/ rupture as well as successful VBAC.

4.10. Ethical Considerations

Approval for the study was obtained from the ethical committee of the Irrua Specialist Teaching Hospital.

4.11. Limitations of the Study

1. This is a tertiary hospital based study. The result may not reflect the findings in the generality of different categories of health facilities in the country.

2. The result would be more representative and epidemiologically significant if the study is multi -centred and sample size much larger.

5. RESULTS

A total of one hundred and fifty (153) pregnant women were recruited during the seven month study period (September 2013-March 2014). During this period, 948 patients gave birth in our department. 208 (22%) had a scarred uterus and 153 of these (73.55%) were included in the study. The remaining 55 patients were not included, either because they did not meet the criteria or have had more than one previous caesarean section.

The age range of participants was between 19-38 years with a mean of 26.5 (± 3.96) years, while the parity ranged between 1 and 4 with a mean of 1.3 (± 0.68). The gestational age at delivery ranged between 37.4-40.6 weeks with a mean of 39.4 (± 0.71) weeks. Eighty three (54.2%) women had tertiary level of education while 129 (84.3%) were employed. Forty (26%) patients received oxytocin augmentation of labour. The mean birth weight of the infants was 3211 (± 373) grams with a range of 2350-4100 g.

Of the 153 patients, 103 (67.3%) had a successful vaginally delivery and 50 (32.7%) had an emergency caesarean section (Figure **1**). There were 6 cases of uterine defects, 2 (1.3%) were uterine ruptures while the remaining 4 (2.6%) cases were uterine dehiscences. The overall frequency of lower uterine segment defects was therefore 3.92%. There was no adverse maternal or perinatal outcome.

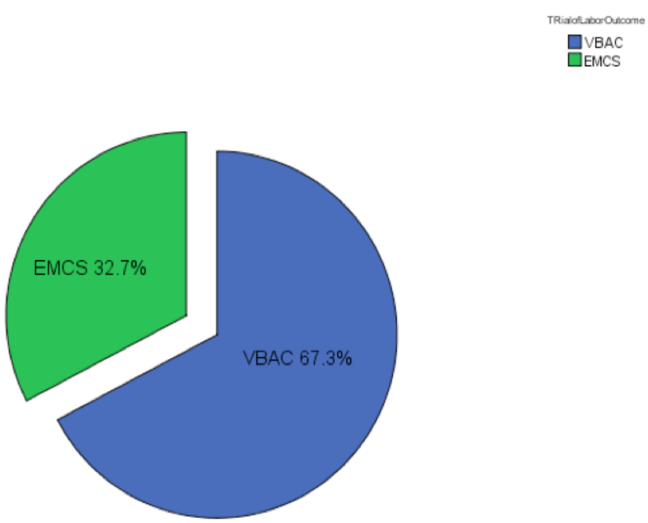

Figure 1: Trial of labor outcome.

Table **1** shows the comparison of Obstetric profiles between groups with and without uterine defects (Rupture/ dehiscence). Patients with defective scars did not differ significantly from those whose scars were intact as regards maternal age, parity, gestational age at sonographic measurement of LUS, gestational age at delivery and birth weight. Also there was no statistically significant difference in the use of oxytocin for augmentation of labor in both groups, incidence of Apgar score less than 7 at five minutes or whether the previous cesarean section was an elective or emergency procedure. However all cases of uterine defect occurred in patients whose previous delivery were emergency cesarean delivery.

Table 1: Distribution of Obstetric Characteristics

Obstetric Parameters	Frequency (153)	Percentage (%)
Inter pregnancy interval		
< 18 months	38	24.8
18-24 months	79	51.6
> 24 months	36	23.5
Stages of labor of primary CS		
Elective	35	22.9
1^{st} stage	107	66.9
2^{nd} stage	11	7.2
Gestational age at LUS		
35^{0-6} weeks	22	14.4
36^{0-6} weeks	89	58.2
37^{0-6} weeks	42	27.5
LUS Thickness		
≤ 2.5mm	14	9.1
2.6-3.5mm	20	13.1
3.5-4.6mm	70	45.8
≥ 4.6mm	49	32.0
Gestational age at delivery		
37+	3	2
38+	33	21.6
39+	76	49.7
40+	41	26.8
Bishop score at admission		
Unfavourable	51	33.3
Favourable	102	66.7
AOL		
No	113	73.9
Yes	40	26.1
Fetal weight (kg)		
2-2.9	53	34.6
3-3.9	100	65.4
APGAR score at 5minutes		
< 7	4	2.6
≥ 7	149	97.4

CS: Caesarean section; LUS: Lower uterine segment; AOL: Augmentation of labor

The thickness of the lower uterine segment, measured by ultrasound among these women ranged from 1.6 to 6.6 mm (mean 3.53 ± 0.97 mm). The mean thickness of the lower uterine segment among the 6 patients who had a defect of the lower segment was 2.51 ± 0.51mm (range 1.9-3.1mm). Statistically

Table 2: Comparison of Obstetric Profiles between Groups with and without Uterine Defects (Rupture/Dehiscence)

Obstetric Profile (mean)	Uterine Defect (+) (n=6)	Uterine defect (-) (n=147)	Significance p < 0.05
Age (26.5 ± 3.96)	28.3 ± 4.8	26.4 ± 3.8	0.26
Parity (1.3 ± 0.68)	1 ± 0	1.3 ± 0.69	0.27
Gestational weeks at measurement (36.1 ± 0.43)	36.6 ± 0.77	36.4 ± 0.59	0.49
Inter-pregnancy interval (months) (19.9 ± 1.31)	15.5 ± 1.04	21.7 ± 4.08	0.03*
Gestational weeks at delivery (39.4 ± 0.71)	39.05 ± 0.43	39.3 ± 0.72	0.12
LUS thickness measurement (mm) (3.53 ± 0.97)	2.51 ± 0.51	3.57 ± 0.96	0.02*
Bishop score at admission (6.11 ± 1.14)	3.3 ± 0.82	6.78 ± 2.2	0.000*
Neonatal birth weight (g) (3211 ± 373)	3320 ± 510	3210 ± 360	0.48
APGAR score at 5 mins (7.91 ± 0.33)	7.67 ± 0.52	8.12 ± 0.92	0.08
Augmentation of labor (AOL)	2	38	0.65
Previous CS type Elective Emergency	0 6	35 112	0.33
Trial of labor VBAC Emergency CS	0 6	103 44	0.001*

CS: Caesarean section; LUS: Lower uterine segment; AOL: Augmentation of labor; VBAC: Vaginal Birth after Caesarean Section

significant obstetric (clinical) parameters predictive of uterine defect in this study included the bishop score at admission (p = 0.000), inter-pregnancy interval of <18 months (p=0.03) and the thickness of the lower uterine segment (p=0.02).

Of the 50 patients that had emergency cesarean delivery, 4 (8%) cases were due to fetal distress of which 75% (3/4) of these were in the group with uterine defect (2 cases of rupture and 1 of dehiscence) and 25% (1/4) in the group without uterine defect. Other indications for emergency cesarean section included intrapartum hemorrhage 6(12%), cephalo-pelvic disproportion 23(46%), cord prolapse following spontaneous rupture of membrane in the labor room 1(2%), and failure to achieve active phase parameters after 8 hours in labour 16(32%).

For the purposes of analysis, four categories of uterine lower segment thickness were defined, as measured ultra-sonographically: ≤2.5mm, 2.6-3.5mm, 3.6-4.5 mm and ≥4.6mm.

None of the 49 women with lower-uterine-segment thicknesses of 4.5 mm or more had dehiscence or rupture**.** The proportion of defects rose as the thickness of the LUS decreased. In the 3.6-4.5 mm group there were 70 patients and only one had uterine defect (dehiscences) while in the 2.6-3.5 mm group there were 20 patients of which 2 (10.0%) had uterine defects (both were dehiscences). Three (21.4%) of 14 patients with thicknesses of ≤2.5 mm had uterine defects (one dehiscence, two ruptures) (Tables **3** and **5**). The differences between the 4 groups in the development of uterine defects was statistically significant (p=0.024). There was also statistical significance when the LUS thickness was re-grouped into two (≤3.5mm and >3.5mm) with p=0.01. However, in the two groups with the thinnest uteruses, there was no statistical significance with the occurrence of a uterine defect. Grade I and II accounted for 88% (44/50) while grade III and IV accounted 12% (6/50) of the lower uterine segment grading at cesarean section by the surgeons.

Table 3: Association between LUS Thickness and Uterine Defect (p=0.024)

		Uterine defect		
		Rupture/ dehiscence (+)	Rupture/ dehiscence (-)	Total
LUS	≤2.5	3	11	14
	2.6-3.5	2	18	20
	3.6-4.5	1	69	70
	≥4.6	0	49	49
Total		6	147	153
		3.92%	96.08%	100.0%

LUS: Lower uterine segment

Table 4: Association between LUS Thickness and Trial of Labour Outcome (p=0.03)

			Trial of Labor Outcome		Total
			VBAC	EMCS	
LUS	≤2.5mm		3	11	14
		%	21.4%	78.6%	100%
	2.6-3.5mm		8	12	20
		%	40%	60%	100%
	3.6-4.5mm		53	17	70
		%	75.7%	24.3%	100%
	≥4.6mm		39	10	49
		%	79.6%	20.4%	100%
Total			103	50	153
			67.3%	32.7%	100.0%

VBAC: Vaginal Birth after Caesarean section; EMCS: Emergency caesarean section

Table 5: Distribution of Patients according to LUS Grade at CS (p<0.05)

		LUS Grade @ CS				Total
		Grade I	Grade II	Grade III	Grade IV	
LUS	<=2.5mm	7	1	1	2	11
	2.6-3.5mm	6	4	2	-	12
	3.6-4.5mm	16	-	1	-	17
	>=4.6mm	10	-	-	-	10
Total		39	5	4	2	50

Likewise, the proportion of women that achieved a successful vaginal delivery rose as the thickness of the LUS increased. Three (21.4%) of the patients with LUS ≤ 2.5mm achieved a successful vaginal delivery. This rose to 40%, 75.7% and 79.6% in those with LUS thickness of 2.6-3.5mm, 3.6-4.5mm and ≥ 4.6mm respectively (p=0.03), Table **4**.

Table **6** shows the inter-delivery interval from the last CS with the various grades of LUS at the opening of the abdomen during surgery. All reported cases of uterine defect in this study occurred in women whose inter-delivery interval was less than 18 months and this was statistically significant when compared to inter-delivery interval of greater than 18 months (p=0.03).

The ROC curve in Figure **2** defines the Sensitivity and Specificity for each measured LUS value (AUC 0.825, 95% CI 0.712-0.928) that best predicts the occurrence of uterine defect (dehiscence/ rupture) in this study. When the cut-off value was set at 3.5mm, the sensitivity was 83.3% and the specificity was 80.3%. The Positive Predictive Value (PPV) was 14.7% while the Negative Predictive Value (NPV) was 99.2% and accuracy was 80.4% (Table **7**).

Table 6: Interval Time from the Previous CS and Correlation with Grades III or IV of LUS at the Abdomen Opening during Surgery (p=0.03)

Inter delivery Interval	LUS Grade @ CS				Total
	Grade I	Grade II	Grade III	Grade IV	
<18 months	14	1	4	2	21
18-24 months	19	3	0	0	22
>24 months	6	1	0	0	7
Total	39	5	4	2	50
	78.0%	10.0%	8.0%	4.0%	100.0%

LUS: Lower uterine segment; CS: Caesarean section.

Table 7: Comparison of Indices of Test of Validity for each Cut-Off of LUS Thickness

Cutoff (mm)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
≤ 4.5	100	33.3	5.7	100	35.9
≤ 3.5	83.3	80.3	14.7	99.2	80.4
≤ 2.5	50	92.5	21.4	97.8	90.8

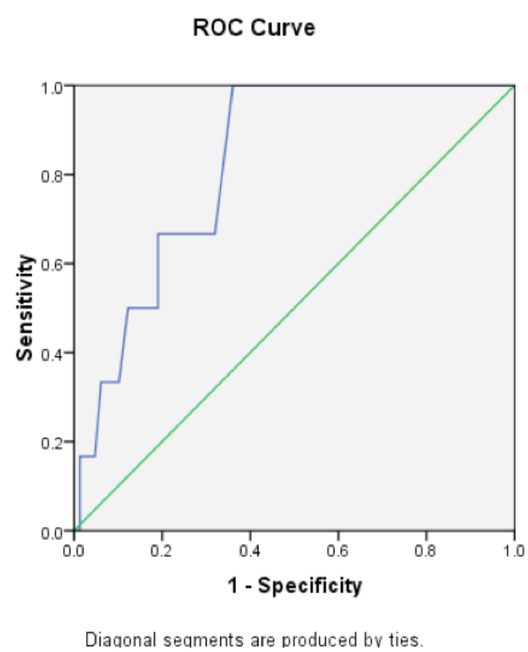

Figure 2: Prediction of uterine dehiscence by measurement of LUS thickness (AUC 0.825, 95% CI 0.712-0.928). LUS: Lower uterine segment; AUC: Area under curve; CI: Confidence interval.

6. DISCUSSION

Several factors are known to be linked to intrapartum uterine dehiscence. These factors include uterine anomalies, type of uterine closure during previous cesarean section, number of previous cesarean section, induction of labor, short inter-pregnancy interval time, postpartum fever during previous deliveries, being more than 30 years of age, and birth weight. Conversely, prior vaginal delivery seems to be a protective factor [37]. The Vaginal birth after cesarean section (VBAC) success rate of this study was 67.3%. This rate corresponds with present literature, in which the rate of successful Trial of labor (TOL) varies from 43% to 80%, and increases to almost 90% after a preceding vaginal birth [20].

In this study, 29 patients had had a vaginal delivery before the last CS delivery. Among these patients, 21 (72.4%) had a successful VBAC while 8 (27.6%) had a cesarean delivery. All of these 8 patients were LUS grade I and II, which is consistent with the evidence that prior vaginal delivery seems to be a protective factor for uterine dehiscence. This sample of only 29 patients however was too limited to support this finding.

In the case of CS, poor healing of the uterine scars might affect the regeneration of the uterine isthmus, making the LUS thin and weak during subsequent pregnancies [77]. Recently, the American College of Obstetricians and Gynecologists (ACOG) Group, consistent with Gregory *et al.* [38] and George *et al.* [39], suggested that the absolute risk of uterine dehiscence is low and that most women with one prior low transverse CS should be offered the opportunity of labor [40].

In women with a previous LUS transverse incision, the incidence of uterine dehiscence or worse is 0.2%-1.5% compared with 0.2% in women with an intact uterus [41]. This risk increases to 4%-9% in women with a longitudinal or T-incision CS, which are now recognized as a contraindication in attempting a vaginal delivery after CS [28, 32]. Based on this evidence, patients were only considered eligible for this study if they had a documented transverse LUS incision during previous CS. However, four cases of uterine dehiscence and two cases of uterine rupture were observed, demonstrating that the type of incision is not sufficient to discriminate patients at risk of uterine dehiscence/rupture.

This study also establishes a relation between the anatomy revealed by the sonographic image and the functional status of the scarred lower uterine segment. It showed that the risk of uterine rupture or dehiscence from a defective scar is directly related to the degree of lower uterine segment thinning measured at or around 37 weeks, and in particular, that this risk increases significantly when the thickness is 3.5 mm or less. This relation, based on the thickness of the lower uterine segment rather than on the scar (rarely visible on the ultrasound), suggests that problems arise from an abnormality of the full structure of the scarred lower uterine segment. Two main processes might explain the mechanism. First, enlargement of the myometrium over the LUS might be impeded by the scar tissue and might occur in only the healthy part of the lower uterine segment, which is then excessively stretched. Alternatively, the inflammation that occurs when the scar is forming might affect the regeneration of the isthmus of the uterus which would become thinner. This thinning could lead to a thinner lower uterine segment during subsequent enlargement. Two findings support these observations. First, it has been noticed that lower uterine segments with several scars were more likely than single-scarred uteruses to measure 3.5 mm or less [23]. This observation may also explain why the rate of caesarean delivery increased as thickness decreased: normally, when a uterus has several scars delivery is by elective caesarean. Second, repeated ultrasound surveillance of the lower uterine segment has shown that enlargement occurs earlier in women who have previously had a caesarean delivery than in women who have not [41].

Lower uterine segment (LUS) defects may be present directly after previous CS, and the patient may present with isthmocele or a so-called niche before pregnancy. This could be an important source of bias for this type of study. To avoid this bias, none of the patients included in this study had any reported sonographic sign of uterine dehiscence in previous examinations (during the course of the pregnancy). Regarding the correlation between the type of previous LUS suture (single or double layer) and the risk of LUS grade III or IV at term, data from this study was not able to determine a relationship between these factors because all patients had a previous uterine double-layer suture.

One factor that did prove to be predictive of uterine dehiscence in this study was the interval time from the previous CS. Consistent with Bujold and co-wokers [28] and Shipp *et al.* [16], all cases of surgical LUS grade III or IV in this study occurred when the time from the last CS was less than 18 months and this was statistically significant when compared to inter-delivery interval of greater than 18 months (p=0.03).

The transvaginal approach is the preferred method to assess LUS status because it accurately defines LUS integrity. This approach enables better visualization of both the previous uterine scar and the contiguous uterine tissue. Compared with the transvaginal approach, more inter-observer variability in LUS measurements is reported with the transabdominal approach but the two approaches show good correlation in terms of positive predictive value (PPV) and negative predictive value (NPV) [31, 35]. The range of error during the sonographic measurement must be minimized because many factors can affect the LUS measurement (e.g., contractile state of the uterus, displacement of amniotic fluid, fetal movement and position, operator's pressure through the transducer during the examination, and fullness of the bladder) [36].

To minimize error, three LUS measurements were performed by the same sonographer to minimize bias related to inter- and intra-observer variability. The risk of a uterine scar defect has been shown to be inversely related to the LUS thickness. However, the sonographic LUS evaluation is not routinely performed in clinical practice because the best cut-off values and the best techniques have not been validated.

Cut-off values proposed in previous studies range from 2.0 to 3.5mm for the entire LUS thickness and from 1.4 to 2.0mm for the myometrial layer [31,44]. In an observational study, Rozenberg *et al.* [23] reported that the risk of uterine rupture is directly related to the degree of LUS thinning, with a 20-fold higher risk when the thickness of the LUS is ≤3.5 mm with a sensitivity of 88.0%, the specificity 73.2%, positive predictive value 11.8%, and negative predictive value 93.3%. Jastrow *et al.* [30] determined this cut-off value to have a sensitivity of 88%, a specificity of 73%, a PPV of 12%, and an NPV of 99%. No uterine dehiscence was observed when the entire LUS thickness was >4.5 mm [23].

Data on receiver operating curves obtained by Sen *et al.* [45] reports that 2.5 mm was the critical cut-off value for a safe LUS thickness. However, their study population was small, and no uterine rupture was reported. All of these studies indicate that a thickness less than 2.3-2.5 mm for the entire LUS is associated with uterine scar defects [27]. Gotoh *et al.* recorded intrapartum incomplete uterine rupture in 17 of 23 women (74%) with a LUS thickness of less than 2.0 mm [44].

In this study, 5 (83.3%) of the 6 cases of uterine defect with surgical LUS grade III or IV occurred when the full LUS thickness was 3.5 mm or less and only 1 (16.7%) in the group with LUS thickness between 3.6-4.5 mm. Based on these data, 3.5 mm was considered a good cut-off to identify women at risk of LUS grade III or IV with a sensitivity of 83.3%, specificity of 80.3%, PPV of 14.7%, NPV of 99.2% and an accuracy of 80.4%. In the study done by Salvatore *et al.* [45], using a cut-off of 3.0mm for full LUS thickness they achieved a sensitivity of 100%, a specificity of 85%, a PPV of 45%, and an NPV of 100% while Rozenberg *et al.* [23] using a cut-off of 3.5 mm achieved a sensitivity of 88%, a specificity of 73.2%, a PPV of 11.8%, and an NPV of 93.3%. The positive predictive value of the ultrasound measurement was weak in this study, suggesting that all thin lower uterine segments are not abnormal. The same finding was noted in the work done by Rozenberg *et al.* [23]. On the other hand, the ultrasonographic measurement had a good negative predictive value, confirming that a thick lower uterine segment is usually strong. In addition, since the negative prediction can be obtained at the beginning of the 9th month, the results of this examination can easily be included among the factors for selecting the type of delivery.

The role of myometrial thickness has been analyzed by Asakura *et al.* [41], who measured only the myometrial layer instead of the whole LUS thickness. In his study, the investigators concluded that an appropriate cut-off value for myometrial thickness is 1.6 mm. At values above this threshold, there is a low risk of complications due to labor. Measuring only the myometrial layer, which is more technically difficult, does not add anything to the PPV for uterine dehiscence in patients with a LUS thickness of more than 3.0 mm. Thus, its evaluation may be useful in estimating the risk of uterine dehiscence if the LUS thickness is near the cut-off value (3.5 ± 0.2 mm). In patients who had a LUS thickness over the proposed cut-off values, it is probable that the myometrial layer is thick enough to avoid dehiscence and therefore, measuring the myometrial thickness does not provide any additional information. This study evaluated only the full LUS thickness.

Ultrasonographic examination permits a better assessment of the potential risk of uterine rupture in patients who have previously had caesarean deliveries and could accordingly allow safer management of this important obstetric danger. A new strategy to try to reduce the risk of uterine rupture, integrating ultrasound examination of the lower uterine segment into the conclusive appraisal of the type of delivery for this category of women with a scarred uterus is advisable.

7. CONCLUSION AND RECOMMENDATION

7.1. Conclusion

Whether a scarred uterus will rupture or not is determined by a number of factors, not only by the strength of the scar but also by the strain on the scar. Clinical variables alone do not seem to be able to provide a precise estimate of the risk of uterine rupture during a trial of labour after caesarean.

This study showed that full LUS thickness of ≤3.5 mm at 35-37 weeks of gestation is associated with an increased risk of complete uterine rupture and uterine dehiscence during a Trial of Labor (TOL). Therefore, measurement of full LUS thickness near term could lead to a reduction of uterine rupture in women who contemplate VBAC. A cut-off value of 3.5 mm combined with inter-delivery interval of <18 months is related to a high risk of uterine rupture and should therefore preclude a TOL.

Sonographic evaluation of LUS represent a non-invasive, reproducible, tolerated, and safe technique for defining the risk of uterine dehiscence or worse in women with previous CS, especially in those who have undergone a CS more than 18 months before. This procedure has to be considered complementary to a complete and accurate obstetric profile risk.

No relationship exists however, between what we see and measure with ultrasound and the strength of the scar or of the lower uterine segment. Nonetheless, an association does seem to exist between a thin lower uterine segment thickness of ≤3.5mm measured at 35-37 gestational weeks and uterine rupture or dehiscence.

In particular, the utility of the sonographic definition of LUS status may be proposed when selecting the criteria of the guidelines for vaginal birth after CS because the benefits of vaginal delivery in terms of maternal and neonatal outcome and of early bonding and breastfeeding have already been established [44].

7.2. Recommendation

More studies are needed (large and well designed) before ultrasound assessment of the pregnant uterus can be introduced into clinical practice to help select women for a trial of labour after caesarean.

If sonographic thickness of the lower uterine segment at 35-37 weeks will be introduced into clinical practice, it is extremely important that exactly the same measurement technique is used as in the study where the recommended cut-off was established, and that those taking these measurements are appropriately trained and use a meticulous measurement technique.

Even though a recent systematic review has shown that presently no cut-off for the sonographic thickness of the lower uterine segment at 35-38 gestational weeks can be recommended for prediction of uterine rupture or dehiscence, a suggested cut-off of 3.5mm full LUS thickness seems to be the most reliable one. This cut-off of 3.5 mm is in keeping with the findings of this study as well as that by Rozenberg *et al.* [23] (large study, appropriate study design) and the one that should be prospectively validated in future studies.

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