Scientific Research Publishing

Open Journal of Obstetrics and Gynecology, 2023, 13, 1287-1306
https://www.scirp.org/journal/ojog
ISSN Online: 2160-8806
ISSN Print: 2160-8792

Ultrasound Evaluation of Caesarean Scar of Prelabour and Labour Caesarean Sections: A Cross Sectional Analytical Study

Nisansala Perera[1], Thiran Dias[2]

[1]Colombo North Teaching Hospital, Ragama, Sri Lanka
[2]Faculty of Medicine, University of Kelaniya, Kelaniya, Sri Lanka
Email: nishmfc@yahoo.com, thiran_dias@yahoo.com

How to cite this paper: Perera, N. and Dias, T. (2023) Ultrasound Evaluation of Caesarean Scar of Prelabour and Labour Caesarean Sections: A Cross Sectional Analytical Study. *Open Journal of Obstetrics and Gynecology*, **13**, 1287-1306.
https://doi.org/10.4236/ojog.2023.137109

Received: May 2, 2023
Accepted: July 28, 2023
Published: July 31, 2023

Abstract

Caesarean section is dramatically increased throughout the world in recent years. Rupture of the uterus is a devastating complication in trial of labour following previous Caesarean section. Evidence suggests that the size of the uterine scar and the residual myometrial thickness (RMT) are associated directly with the risk of uterine rupture and risk of dehiscence in subsequent deliveries. Impact of the prelabour and labour Cesarean section on the RMT has not been studied in detail. **Objectives:** To compare RMT, Caesarean scar defects and to evaluate the elasticity of the Caesarean scar between women who underwent prelabour and labour Caesarean sections. **Methods:** This was a Cross sectional analytical study. Women who underwent Caesarean section in their first pregnancy were recruited. Sample was stratified to prelabour and labour Caesarean section groups. Transvaginal ultrasound scan was performed six months following the Caesarean section. Dimensions of the uterus, uterine scar defect, RMT and elastosonography of the uterine scar were assessed. **Results:** A total of 240 postpartum women were analyzed. Uterine niche was detectable in 194 subjects. Prelabour CS group had demonstrated 91.7% (n = 110) scar defects (uterine niche) out of 120 cases and the rate among labour CS group was 70% (n = 84). There was a significant difference in the presence of uterine niche among 2 groups as Prelabour group was found to have more scar defects ($p < 0.01$). Mean RMT of prelabour CS and labour CS groups were 5.06 mm (SD 1.2) and 4.99 mm (SD 1.3) respectively and there was no significant difference ($t = 0.38$, $p = 0.71$). There was no significant difference between the dimensions of the uterine CS defects of the studied groups. Prelabour CS group had significantly higher Target strain [0.28 vs. 0.24 ($t = 2.12$, $p = 0.04$)] and significantly less strain ratio [1.45 vs. 1.55 ($t -2.42$, $p = 0.04$)] than labour CS group indicating a better scar in prelabour group. **Conclu-**

sion: There was no significant difference in RMT and uterine scar defects between prelabour and labour Caesarean section groups. But prelabour Caesarean section scars were less stiff than labour Caesarean section scars. Further studies are warranted to elaborate on the association.

Keywords

Caesarean Section Scar, Residual Myometrial Thickness, Labour

1. Introduction

Caesarean delivery is defined as an extraction of the infant, placenta, and membranes through an incision in the maternal abdominal and uterine wall [1]. There are two main types of Lower Segment Caesarean Sections (LSCS) based on method of planning; Prelabour and Labour. Prelabour LSCSs are usually based on pre-existing indications and planned over the course of antenatal care. Labour LSCS means an urgent decision to perform an LSCS because of some condition which makes the continuation of labour no longer safe for baby or mother.

In recent years, Caesarean section rate has dramatically increased in most countries. An average rate of 21.1%, with a range between 6.2% and 36% has been reported for developed countries [2]. In Norway, there was an increasing rate of Caesarean section, from 1.8% in 1967 to 17.1% in 2008 [3]. However, there is a relatively high rate of TOL (Trial of Labour) with vaginal births in 51% of mothers with previous Caesarean section. The observed trend was similar in many European Union countries. In the United States, the Caesarean section rate rose by 53% from 1996 to 2007, reaching 32%, the highest rate ever reported in the country. Situation was similar in many other western countries. Rates for all age groups increased modestly from 1996 to 2000, then rose more than 33% from 2000 to 2007. Women under age 25 experienced the greatest increases in Caesarean deliveries from 2000 to 2007 (57%). Rates of Caesarean delivery typically rise with increasing maternal age. As in 1996 and 2000, the rate for mothers aged 40 - 54 years in 2007 was more than twice the rate for mothers under age 20 (48% and 23%, respectively) [4]. In Sri Lanka Caesarean section rate has dramatically increased from 25.8% in 1998 to 31.1% in 2013 [5].

Uterine dehiscence and rupture of the uterine scar is a devastating complication in a trial of labour following Caesarean section [6] and its incidence has increased with the increase in Caesarean section rate. It results in severe maternal and perinatal morbidity and mortality and is one of the most common clinical causes of medical litigation in the developed world [7]. For women with one prior Caesarean delivery, the risk of uterine rupture is higher among those whose labour is induced than among those with repeated Caesarean delivery without labour. Concern persists that a trial of labour may increase the risk of maternal complications as compared with elective Caesarean delivery. Such complications

include uterine rupture, which is uncommon but serious and may result in hysterectomy, urologic injury, a need for blood transfusion, maternal death, and perinatal complications, including neurologic impairment and death.

Studies have been carried out to evaluate the Caesarean uterine scar and evidence suggests that the uterine rupture and scar dehiscence in subsequent deliveries are directly associated with Residual myometrial thickness which is measured by ultrasonography.

Zirqi *et al.*, 2010 found that the percentage of uterine rupture was lowest for elective prelabour Caesarean section (0.7/1000), it was much higher when Caesarean section was an unplanned emergency section (7.1/1000). Ruptures were significantly higher after TOL compared with prelabour Caesarean section (6.7/1000 versus 2.0/1000; P = 0.000) [8].

Several authors including Rozenberg *et al.* suggest that, there were no scar complications (Uterine dehiscence and rupture of the uterine scar) among women who had RMT greater than 4.5 mm and there is a gradual increase in scar defects as it decreases from 4.5 mm to 1.6 mm [9].

In a study carried out by Naji *et al.* to assess the changes in dimensions of the Caesarean section scar during pregnancy, they showed that Caesarean section scar was visible in 89% cases and mean RMT was 5.2 mm in the first trimester. They had measured the RMT via trans-vaginal ultrasound scan during 11 - 13 weeks [10]. Bennich *et al.* in their study showed that the Caesarean section scar was visible in 96.9% cases after 5 months of the Caesarean section using Saline contrast sonohysterography [11]. Osser *et al.* concluded that more scars can be detected using Saline contrast sonohysterography than the unenhanced ultrasound examination [12].

Studies have been carried out to assess the healing and remodeling of Caesarean uterine scar and authors including Dicel *et al.* have mentioned that healing of the uterine scar is a dynamic process and complete recovery needs at least 6 months [13].

Caesarean uterine scar can be identified as a small defect in most cases which is anechoic and in the anterior uterine wall (Uterine niche). RMT is measured from the top of the uterine niche to the serosal surface. RMT is measured from the delineation of the endometrium to the serosal surface at the level of the Caesarean section scar in women without a scar defect (**Figure 1**). Several studies have demonstrated the method of measurement of RMT [11] [12] [14] [15].

Studies have been carried out to assess the impact of uterine closure technique on the uterine scar defects and on the RMT. Studies suggest that there is no significant difference between unlocked single vs. double layer closure of uterine incision on scar dehiscence and rupture and on the effect on the RMT but single and locked suture technique is coupled with thinner RMT and risk of uterine rupture [14] [16]. Certain studies were done to assess the difference of outcome between single and double layered closure as well. Residual myometrial thickness was higher and defect length, but not its depth and width, was smaller after

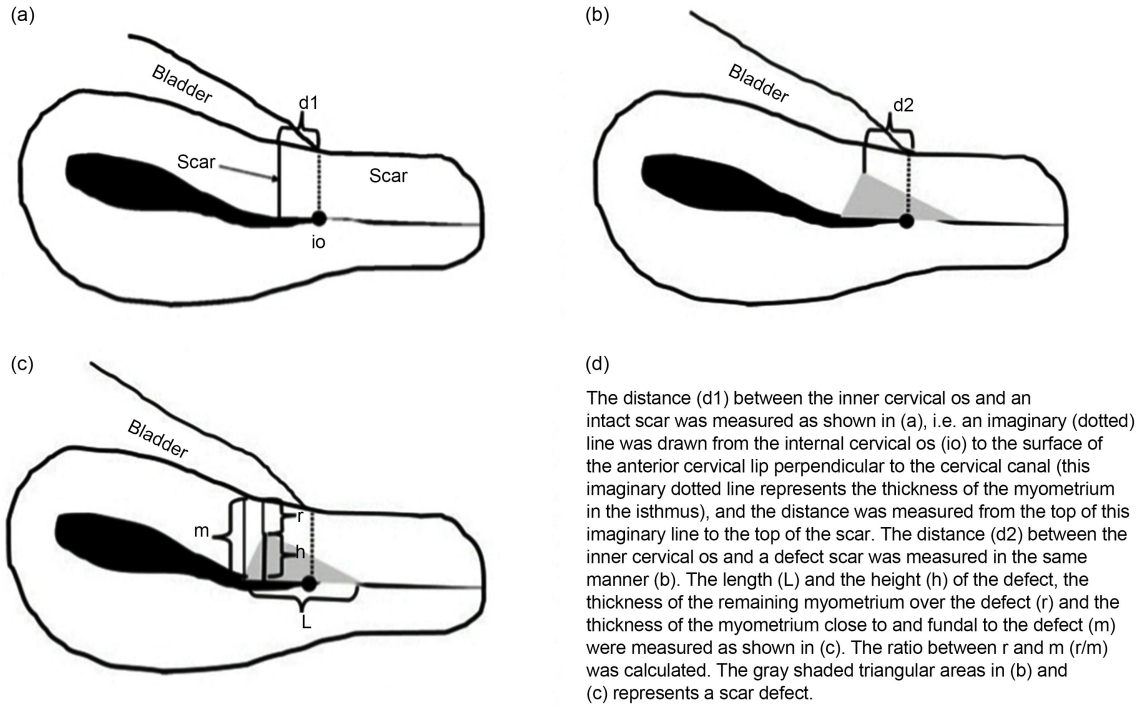

Figure 1. Measurement of Caesarean scar defect (Source: Vikhareva Osser *et al.*).

double layer compared with single layer closure which may indicate some limited benefit of double layer closure following first elective Caesarean section. [14]. In a separate study Osser *et al.*, 2009 also noted that RMT at the level of the isthmus of uterus reduces with the number of CSs and the frequency of large scar defects rises. Scars with defects are located lower in the uterus than intact scars [15]. But a metaanalysis had shown that no significant difference between single- vs. double-layer closure for uterine dehiscence (relative risk, 1.86; 95% CI, 0.44 - 7.90; P = 0.40) or uterine rupture (no case) [16].

Though studies have been carried out on the impact of suturing technique on the uterine scar and on the changes of the scar with pregnancy; evidence is lack on the impact of stage of the labour on the uterine scar and on the RMT.

As well as the scar thickness its texture and the elasticity will also affect the strength of the uterine scar. Elastography has been widely used to ascertain the texture of the tissues in many fields and also in assessing the elasticity of the uterine cervix in predicting the preterm labour. But there are no published data available on the elastography of the uterine scar [17].

Elastography is an ultrasound technique that measures stiffness of tissue. It is based on differences in the elasticity of various tissues, in both physiological and pathological conditions. To obtain an elastography image it is necessary to have a source of stress that provides deformation of the tissue. The main difference between the different types of elastography is the source of stress, which can be induced by (physical) compression, vibration or acoustic pulse waves.

As well as the scar thickness its texture and the elasticity will also affect the strength of the uterine scar. Elastography has been widely used to ascertain the

texture of the tissues in many fields in diagnosing breast cancer, thyroid nodules, and liver pathologies and also in assessing the elasticity of the uterine cervix in predicting the preterm labour [17]-[22]. But there are no published data available on the elastography of the uterine scar.

Strain elastography depends on the displacement of the tissue in response to successive repetition of empirical compression and decompression by hand. Displacement of a harder area or tissue is less than that of a soft area (**Figure 2**). Gradient values of the displacement of hard areas are also less than that of soft areas. Soft tissue has larger strain and hard tissue have a smaller strain due to the greater displacement of soft tissue in comparison with the displacement of hard tissue. During the scar maturation tissue consistency gradually converts from hard to soft. In accordance with colour cording which ranges from blue to red, large strain and hence soft tissue represented by blue colour and the small strain represent by red colour. So hard tissue appeared as red colour and soft tissue appeared as blue colour (**Figure 3**).

This study was done in such way where we examined postpartum women who underwent Caesarean section following 6 months of the surgery with transvaginal ultrasound scan to assess the RMT of the uterine scar as well as the elastography of the uterine scar to evaluate prelabour and labour Caesarean uterine scars.

The aim of this study was to determine the effect of prelabour and labour Caesarean section on the residual myometrial thickness (RMT) of the uterine scar as well as to characterize the elasticity of the uterine scar.

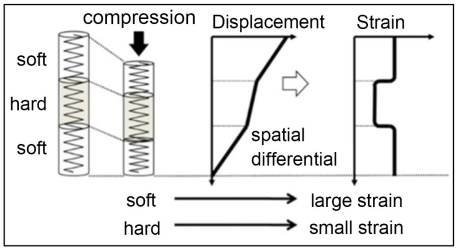

Figure 2. Displacement of tissue in strain elastography (Source: Hyunjung Kim *et al.*).

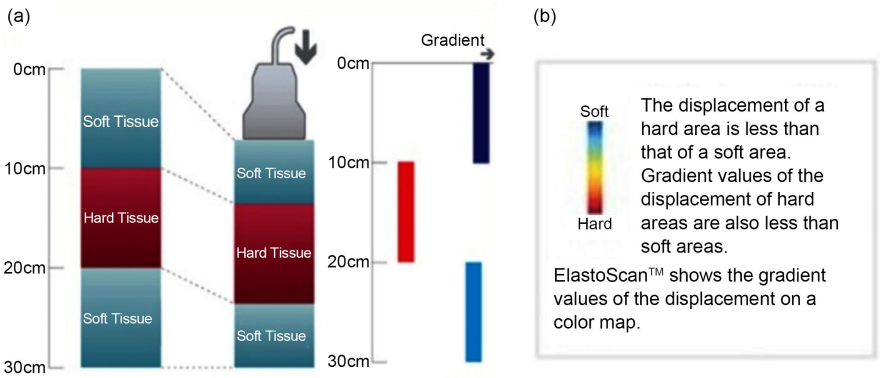

Figure 3. Colour cording of strain elastography (Source: Hyunjung Kim *et al.*).

2. Objectives of the Study

2.1. General Objectives

• To evaluate the Caesarean uterine scar characteristics of prelabour and labour Caesarean sections.

2.2. Specific Objectives

• To compare the residual myometrial thickness (RMT) of uterine scar following Caesarean section (CS) between women who have CS prior to labour and during labour.

• To compare the rate of Caesarean section scar defects (presence of uterine niche) following Caesarean section between women who have CS prior to labour and during labour.

• To evaluate the consistency of the uterine scar after Caesarean section using the elastosonography between women who have CS prior to labour and during labour.

• To determine the difference in RMT according to the stage of labour.

• To ascertain length of internal os to the scar.

3. Materials and Methods

3.1. Study Design

We have conducted a cross sectional analytical study.

3.2. Study Setting

Study was conducted at Professorial Obstetric unit, Colombo North Teaching Hospital, Sri Lanka. It is a tertiary level hospital in central part of Western province in Sri Lanka. The unit in CNTH with around 4200 deliveries per year with Caesarean section rate of 35.4%. It is also a training center for medical undergraduates, medical postgraduates, nursing students and para medical students. There is a population more than 1,000,000 in the draining area to the hospital.

3.3. Study Period

Study was conducted from December 2016 to December 2017.

3.4. Study Population

All the women who had Caesarean section in their first pregnancy at Professorial obstetrics unit, CNTH during the study period were considered as the study population. Study sample consisted of 2 main groups:

1) Women underwent prelabour Caesarean section;

2) Women underwent Caesarean section during labour.

Labour is a clinical diagnosis. Onset of regular, painful uterine contractions resulting in progressive cervical effacement and dilatation has defined as the onset of labour. Women underwent Caesarean section prior to the clinical diagno-

sis of labour were categorized as prelabour Caesarean section and women underwent Caesarean section following the clinical diagnosis of labour were categorized as labour Caesarean sections.

3.5. Inclusion Criteria

1) Underwent Caesarean section following singleton pregnancy at completion of 38 weeks.

2) Between 18 to 35 years of age.

3.6. Exclusion Criteria

1) Previous uterine surgeries including myomectomy.

2) Uterine infections following Caesarean section.

3) Multiple pregnancies in index pregnancy.

4) Medical diseases including systemic lupus erythematosus (SLE), rheumatoid arthritis (RA) and insulin-dependent diabetes mellitus.

3.7. Sample Size Calculation

The sample size calculation was done using the WinPepi computer software to demonstrate a difference in means with a study power of 80% at a significance level of 5%.

Data from the study by Bennich *et al.*, who studied the difference in thickness of the scar between single layer and double layer suturing, were used. The SDs for the two groups was 2.2 and 2.9 mm respectively. Since the difference in incidence of complications (scar rupture) is higher between prelabour and labour CS than with single layer and double layer as shown by Al-Zirqi *et al.*, it was assumed a greater difference would be seen in our study than with the study by Bennich *et al.*

In order to demonstrate a minimum difference of 1mm between the groups a sample size of 106 in each group was calculated. As described by Naji *et al.* the measurements could be obtained only in about 89% of subjects. Therefore, a total of 120 each were recruited.

3.8. Sampling Technique

Consecutive mothers who had Caesarian sections for her first pregnancy at Professorial obstetrics unit, CNTH and also who met eligibility criteria were taken till required sample size is reached. Subjects were being selected by going through the pregnancy records. As determined in the sample size calculation, 120 subjects from each group were selected.

A data sheet was developed to assess the selected variables related to risk conditions, significant obstetric/medical morbidities in the index pregnancy and information on arrival of mother to labour room were also are included.

Information pertaining to all the variables was extracted from relevant medical records. Analysis was done by using "Statistical Package for Social Sciences"

(SPSS). After data entry range checks were done and random checks were done to check the accuracy with original data sheets. Relevant descriptive statistics were calculated and significant tests were performed.

3.9. Data Collection

Transvaginal ultrasound scan was performed following sixth month of the post-partum period using "Alpinion EC-15 V4.0" ultrasound scanner. Ultrasound scan was done in accordance with the method as described in Vikhareva Osser *et al.* Ultrasound scan was done by an investigator who is experienced in the technique and who is blind to the category of the women. Ultrasound scan has been done in B mode with empty bladder. During this procedure, clear view of the uterus in mid sagittal plane with adequate magnified view was obtained.

Caesarean uterine scar can be identified as an anechoic triangular defect in the anterior uterine wall (Uterine niche). RMT was measured from the top of the uterine niche to the serosal surface. RMT is measured from the delineation of the endometrium to the serosal surface at the level of the Caesarean section scar in women without a scar defect (**Figure 1**).

Along with these measurements anterior wall thickness of the uterus was measured, and the length of the uterine niche as well as the depth of the uterine niche was measured. Dimensions of the uterus were also measured. Length, height and width of the uterus were measured. The distance from the internal os to the uterine scar as well as distance from internal os to the external os was measured.

Elastosonography of the lower uterine segment was performed with transvaginal probe half-empty bladder. The box of elastography was positioned and activated at the level of the uterine isthmus Caesarean scar using strain elastography. A color map is created, from red (hardest tissue) to blue (softest tissue). Strain of the target tissue was measured along with the strain of the normal myometrium as the reference strain using region of interest (ROI) Strain ratio was measured using the target stain and reference strain.

Data were recorded by using a data collection sheet which includes details of the women, details of the pregnancy and details of ultrasound scan.

3.10. Outcome Measures

1) Residual myometrial thickness (RMT) of prelabour Caesarean sections.

2) Residual myometrial thickness (RMT) of Caesarean sections which performed during labour.

3) Whether there is a statistically significant difference between RMT of prelabour and labour Caesarean sections.

4) Strain of the uterine scar of prelabour Caesarean section along with reference strain and strain ratio using elastography.

5) Strain of the uterine scar of Caesarean sections which performed during labour, along with reference strain and strain ratio using elastography.

6) To determine the length from internal os to the uterine scar as well as length

from internal os to the external os.

3.11. Data Analysis

Analysis was done by using "Statistical Package for Social Sciences" (SPSS). After data entry range checks were done and random checks were done to check the accuracy with original data sheets. Relevant descriptive statistics were calculated and significant testing was performed by applying chi square test and t test.

3.12. Ethical Issues

There were several aspects of ethical considerations of this study. Ethical clearance was obtained from the ethical review committee of Faculty of Medicine, University of Kelaniya, Sri lanka.

Informed consent was obtained following detail explanation on the study and its pros and cons.

Confidentiality was maintained in view of data collection and data handling.

Beneficence—Index cases were benefitted by the measurement of RMT and elastography and with assessment of the risk of complications of uterine scar which will aid the management of future pregnancy.

Non maleficence—There was no associated harm to the woman with the investigations using ultrasound.

Justice—There are lack of studies on the RMT and elastography of the prelabour and labour Caesarean sections. More studies have to be carried out on the intended topic.

Administrative issues—Permission was obtained from hospital director before the study and minimal disruption to the routine patient care was assured.

4. Results

A total number 240 mothers were taken for analysis. Study population had mean age of 29.0 (SD 3.6) years. Among total population equal halves consisted of labour (n = 120, 50.0%) and prelabour (n = 120, 50.0%) Caesarean sections. Maternal disease and fetal issues were noted as the commonest indication (n = 142, 59.5%) while labour complications ranked as second (n = 67, 27.8%). Among labour complications failed induction was the top cause among prelabour group while failure to progress was noted as the commonest indication among labour group. Only 12.7% (n = 31) had the indication of breech or transverse lie. Out of the mother who reported breech or transverse lie as the indication majority were belong to prelabour group (n = 28, 90.3%). Results are presented in **Figure 4**.

Distribution of gestational age at the time of delivery is presented in **Figure 5**.

Majority of deliveries were occurred at 38^{th} week of POA (n = 117, 48.1%) while second highest was 40 weeks (n = 77, 32%).

Mean BMI of the study population was 23.2 (SD 3.8). When BMI is categorized majority (n = 161, 67.1%) was belong to normal range (18.5 - 24.9) while only 22 (9.2%) was in obese category. Results are shown in **Figure 6**.

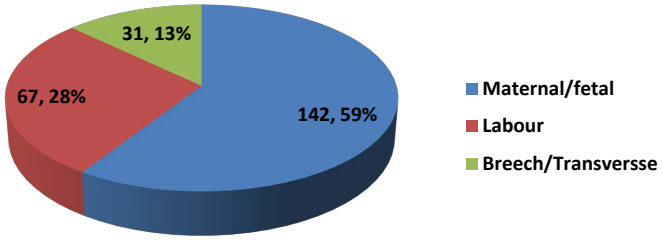

Figure 4. Distribution of indications for Caesarean section.

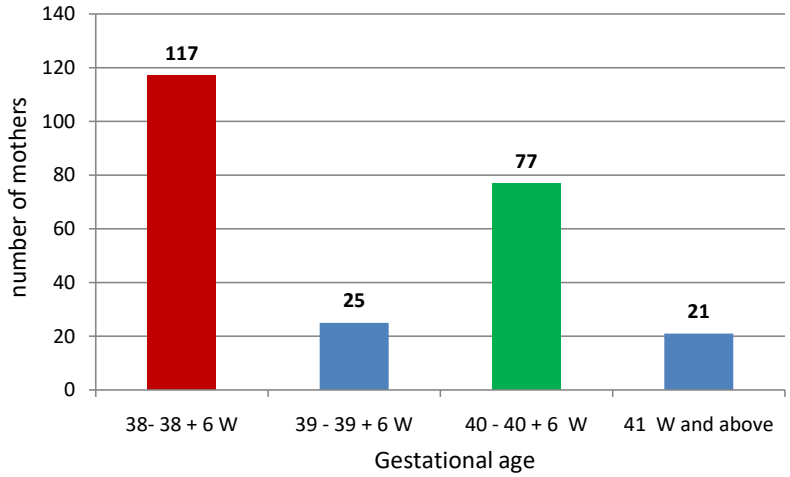

Figure 5. Distribution of gestational age at the time of delivery.

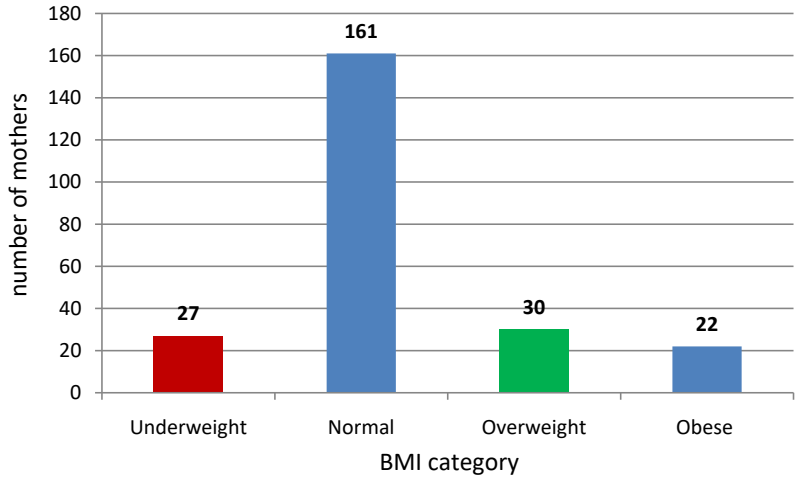

Figure 6. Distribution of BMI levels.

Comparison of prelabour CS and labour CS groups was done in relation to several characteristics.

As shown in Table 1, in comparison both groups are close to each other in relation to age. Among labour group BMI was significantly higher ($p = 0.02$). Prelabour CSs were done at slightly earlier than labour CSs ($p < 0.001$). There is a significant difference in the distribution of indications ($p < 0.001$). It was obvious that breech or transverse lie stood as an indication for prelabour CSs but it

was very few among labour CS's. Uterine length and width were not shown major difference. But uterine height of prelabour group was significantly higher than labour group (p = 0.002). That means both groups are comparable.

Uterine niche was detectable only in 194 subjects. Therefore, only that group was taken for following analysis as described in Table 2, with regard to RMT as proportion of anterior wall and CS scar defect dimensions. RMT, length from CS scar to internal os and length from internal os to external os were analyzed irrespective of the presence of uterine niche.

Prelabour CS group had demonstrated 91.7% (n = 110) scar defects (uterine niche) out of 120 cases and labour CS group demonstrated 70% (n = 84) scar defects out of 120 cases. There was a significant difference in the presence of uterine niche among 2 groups as prelabour group was found to have more scar defects (p < 0.01). But Among 2 groups none of the other parameter showed a significant difference.

According to Table 3, among prelabour group 46 had RMT between 4.0 - 4.9 mm (38.3%). while among labour group largest category was more than 6.0 mm group (n = 35, 24.8%). Labour CS consisted of 11 cases of RMT less than 3 mm. The reported lowest value was 22 mm. Neither group had RMT value less than 2 mm.

Table 4 described the elastrography characteristics of the uterine scar. Target strain among prelabour group was significantly higher (p = 0.04) while strain ratio among labour group was significantly larger (p = 0.04). But reference strain was not significantly different.

Table 1. Characteristics of the study population according to the prelabour and labour CS.

Characteristic	Prelabour CS (SD)	Labour CS (SD)	Significance
Patients (n)	120	120	
Maternal age (years)	29.3 (3.9)	28.7 (3.2)	t = 1.36, p = 0.18
BMI (kg/m^2)	22.7 (3.8)	23.8 (3.8)	t = −2.26, p = 0.02
GA at CS (weeks)	38.5 (0.9)	39.5 (1.0)	t = −8.4, p = 0.001
Indication for CS			
Breech or transverse lie	28 (23.3%)	3 (2.5%)	X^2 = 44.2, p < 0.001
Maternal diseases/fetal issues	78 (65.0%)	64 (53.3%)	
Labour complications	14 (11.7%)	53 (44.2%)	
Uterine dimensions (cm)			
Length	7.0 (0.7)	6.9 (0.7)	t = 1.07, p = 0.29
Height	3.5 (0.5)	3.3 (0.5)	t = 3.12, p = 0.002
Width	4.5 (0.5)	4.4 (0.4)	t = 1.96, p = 0.06

Table 2. Findings of transvaginal ultrasound examination preformed during sixth month of the postpartum period in women underwent prelabour and labour CS.

Ultrasound finding	Per-labour CS (SD)	Labour CS (SD)	Significance
Presence of niche	110	84	$X^2 = 18.2$. $p < 0.01$
RMT (mm)	5.06 (1.2)	4.99 (1.3)	t = 0.38, p = 0.71
RMT as proportion of anterior wall	0.60 (0.06)	0.60 (0.08)	t = 0.17, p = 0.87
CS scar defect dimensions (mm)			
Defect length	4.35 (1.21)	4.58 (1.18)	t = −1.36, p = 0.18
Defect depth	3.24 (0.74)	3.36 (1.02)	t = −0.97, p = 0.34
Length from internal os (cm)			
To CS scar	0.85 (0.22)	0.89 (0.24)	t = −1.09, p = 0.28
To external os	3.24 (0.39)	3.21 (0.24)	t = 0.56, p = 0.57

Table 3. Residual myometrial thickness (RMT) measured at 11 - 13 weeks of GA in women underwent prelabour and labour CS.

RMT	Prelabour CS	Labour CS
<3 mm	0	11
3 ≤ RMT < 4 mm	18	18
4 ≤ RMT < 5 mm	46	26
5 ≤ RMT < 6 mm	33	30
≥6 mm	23	35

Table 4. Elastography characteristics of the uterine scar of prelabour and labour CS.

Characteristic	**Prelabour CS (SD)**	**Labour CS (SD)**	Significance
Target strain	0.28 (0.15)	0.24 (0.14)	t = 2.12, p = 0.04
Reference strain	0.40 (0.20)	0.39 (0.28)	t = 0.23, p = 0.82
Strain ratio	1.45 (0.34)	1.55 (0.33)	t = −2.42, p = 0.02

5. Discussion

This study was designed and conducted with the objectives of comparing the residual myometrial thickness (RMT) of uterine scar following Caesarean section (CS) between women who have CS prior to labour and during labour, to compare the rate of Caesarean section scar defects following Caesarean section between women who have CS prior to labour and during labour and to evaluate the consistency of the uterine scar after Caesarean section using elastography between the above mentioned two groups.

Study was carried out in Colombo North Teaching Hospital, Ragama, which is the largest hospital in Gampaha district and which is tertiary level hospital. This hospital is catering a population around 1 million people and generate generalizable information.

Sample size was calculated following a standard formula and minimum adequate number to draw a valid conclusion was ensured. In order to demonstrate a minimum difference of 1mm between the groups a sample size of 106 in each group was calculated. Sample was consisted of pregnant women between 18 to 35 years to exclude the pregnancies with advance maternal age and with teenage pregnancies. Most of the prelabour elective Caesarean sections take place after completion of 38 weeks, hence completion of 38 weeks taken as an inclusion criterion to bring a uniformity of the sample.

Performing all Ultrasound scans by the same investigator had eliminated the inter-observer bias. But instrument bias could be occurred. Using the same Ultrasound machine, proper maintenance of machine during the study period and using a standard technique were utilize to minimize the bias. Assessments were done by an investigator who is experienced in the technique and who is blind to the category of the women. During this procedure, clear view of the uterus in mid sagittal plane with adequate magnified view was obtained. Selection bias was minimized by following a strict inclusion and exclusion criteria. Though some measurements were observer dependent, standard protocols were used.

Maternal disease and fetal issues were noted as the commonest indication (n = 142, 59.5%) while labour complications ranked as second (n = 67, 27.8%). Maternal disease included Gestational Diabetes, Gestational hypertension. Fetal issues included small for gestational age fetus and fetal anomalies in case of prelabour CS and fetal distress in labour CS. Labour complications included failed inductions in case of prelabour CS and failure to progress in labour in labour CS. This is the normal trend seen elsewhere in the world. Dumont *et al.*, 2001 also noted that abruptio placentae, eclampsia, placenta praevia were among top causes for Caesarean sections in Africa [1]. On the other hand, Geidam *et al.*, 2009 had found that failed induction of labour had accounted only for 5.5% of Caesarean sections [4]. These results show that our results are not different from global trends of Caesarean section indications. Out of the mother who reported breech or transverse lie as the indication majority were belong to prelabour group (n = 28, 90.3%). In other words, only 3 mothers went into labour and then had emergency CS's. This shows high tendency of planned CSs for breech or transvers lie situations. In a multicenter study conducted in UK it was noted that only 49.9% of breech cases underwent pre-determined CSs [23]. But authors also reported that equally higher rates of failed trial of scar cases a 43.4% went into labour CSs among the study population.

Sebire *et al.*, 2001 also noted that compared to women with normal BMI, the obese women have more risk of delivery by emergency Caesarean section (1.30 (1.25 - 1.34), 1.83 (1.74 - 1.93) (odds ratio (99% confidence interval) for BMI 25 - 30 and BMI ≥ 30 respectively). Authors also pointed out that maternal obesity carries significant risks for the mother and fetus. The risk increases with the degree of obesity and persists after accounting for other confounding demographic factors. The basis of many of the complications is likely to be related to the al-

tered metabolic state associated with morbid obesity [24].

It was apparent that most of planned CSs were done during 38th week of POA. Out of all prelabour CSs 48.1% were occurred during 38th week. It is the standard practice that in many Obstetric units as, if there is a pre-determined indication labour is not let continue beyond 39th week. Out of all labour CSs 32.0% were done after completion of 40th week POA and 40 weeks plus 5 - 7 days is the out off point to induce labour is the standard practice.

Mean BMI of population was 23.2. In many recent studies done in Sri Lanka BMI among general population was noted to range between 23 - 25. Therefore, observed figures were compatible with population data.

When considering maternal age, no difference was noted. In prelabour group it was 29.3 (3.9) and in labour group it was 28.7 (3.2) (t 1.36, p = 0.18). Age of having first baby has being extended in Sri Lanka. Recent socio economic changes like preference of females for higher education, in reaching economic stability could having being influenced this trend. A significant association was detected between BMI. Higher BMI was associated with labour CS's. Among uterine dimensions both groups showed comparable uterine length and uterine width, only uterine height was shown an association with labour.

Presence of uterine niche after 6 months was significantly higher among prelabour group and this was contrary to the known believes. Prelabour Caesarean sections are known to give rise to a better uterine scar than in labour Caesarean sections. This is believed to link with the chance of uterine rupture. A meta-analysis found that uterine rupture may be twice as common after TOL than at elective repeat Caesarean section [25]. In a study done in Norway with a sample of 18794 Caesarean sections, a total of 94 uterine ruptures were identified (5.0/1000 mothers). Compared with elective prelabour Caesarean section, odds of rupture increased for emergency prelabour Caesarean section (OR: 8.63; 95% CI: 2.6 - 28.0), spontaneous labour (OR: 6.65; 95% CI: 2.4 - 18.6) and induced labour (OR: 12.60; 95% CI: 4.4 - 36.4). The odds were increased for maternal age of 40 years versus less than30 years (OR: 2.48; 95% CI: 1.1 - 5.5) [10].

Caesarean uterine scar can be identified as a small defect in most cases which is anechoic and which in the anterior uterine wall (Uterine niche). RMT is measured from the top of the uterine niche to the serosal surface. RMT is measured from the delineation of the endometrium to the serosal surface at the level of the Caesarean section scar in women without a scar defect. Several studies have demonstrated the method of measurement of RMT.

There is no doubt that the previous Caesarean section is the main risk factor for uterine rupture. But the difference of risk between prelabour and labour statuses had shown a contrary finding to the known literature result in our study. We expected that we could visualize more uterine scar defects (uterine niche) in the labour Caesarean section group rather than the labour Caesarean section. We have performed unenhanced ultrasound examination of the uterus. Bennich *et al.* in their study showed that the Caesarean section scar was visible in 96.9%

cases after 5 months of the Caesarean section using Saline contrast sonohysterography [11]. Osser *et al.* concluded that more scars can be detected using Saline contrast sonohysterography than the unenhanced ultrasound examination [12]. We could have detected more uterine scar defects if we use Saline contrast sonohysterography. On the other hand, a true difference can also exist in Sri Lankan population than west.

RMT also didn't show any significant difference among both groups. Mean RMT of prelabour CS and labour CS groups were 5.06 mm (SD 1.2) and 4.99 mm (SD 1.3) respectively and there was no significant difference ($t = 0.38$, $p = 0.71$). With regard to prelabour CS group most cases demonstrated (N = 46, 38.3%) RMT between 4 mm - 5 mm range and RMT ranged from 3.1 mm to 8.4 mm. Importantly this group did not show RMT less than 3 mm. With regard to labour CS group RMT ranges from 2.2 mm to 7.4 mm. 21.7%, 25% and 29.2% demonstrated RMT ($3 \leq RMT < 4$ mm), ($4 \leq RMT < 5$ mm) and ($5 \leq RMT < 6$ mm) respectively. 9.2% cases (n = 11) demonstrated RMT less than 3 mm. These findings are comparative to the results showed by Bennich *et al.*, which showed RMT of 5.7 ± 2.9 mm vs 5.7 ± 2.2 mm in their single and double layer uterine closure groups respectively at 5 months postpartum [11]. Rozenberg *et al.* suggest that, there were no scar complications (Uterine dehiscence and rupture of the uterine scar) among women who had RMT greater than 4.5 mm and there is a gradual increase in scar complications as it decreases from 4.5 mm to 1.6 mm [9]. In our study most of the cases showed RMT more than 4.5 mm both in prelabour CS and labour CS (5.0 mm and 5.1 mm respectively).

But our findings are contrary to known literature. Al-Zirqi *et al.* showed that percentage of uterine rupture was lowest for elective prelabour Caesarean section (0.7/1000), it was much higher when Caesarean section was an unplanned emergency section (7.1/1000) [8] Strength of the uterine scar is directly proportionate to the RMT. Since it is believed that prelabour Caesarean sections will give rise to a better uterine scar (scar strength) than in labour Caesarean sections, we have expected more difference between RMT between prelabour CS group and labour CS group.

RMT as proportion of the anterior wall was 0.60 (SD 0.06) in prelabour CS group and 0.60 (SD 0.08) labour CS group respectively. The work done by Bennich *et al.* also demonstrated comparable results. They found that RMT was only half the thickness of the non-scarred myometrium, and this finding was independent of the timing of the measurement (immediate postpartum: 56.8% ± 17.6% vs 58.2% ± 17.7%; 5 months: 48.1% ± 18.5% vs 48.9% ± 16.6%). Similarly, RMT as proportion to anterior wall also didn't show any association with type of CS. Since RMT didn't significantly different this can be an expected finding in this population. Strength of the uterine scar is directly proportionate to the RMT/Anterior wall thickness. Since it is believed that prelabour Caesarean sections will give rise to a better uterine scar (scar strength) than in labour Caesarean sections, we have expected more RMT/Anterior wall thickness in prelabour

CS group.

There was no significant difference between the dimensions of the uterine scar defects of the studied groups. CS scar defect length was 4.35 mm (range 2.3 - 7.6) and 4.58 mm (range 2.4 - 6.9) in prelabour and labour CS groups respectively ($t = -1.36$, $p = 0.18$). CS scar defect depth was 3.24 mm (range 1.7 - 5.6) and 3.36 mm (range 1.6 - 4.9) in prelabour and labour CS groups respectively ($t = -0.97$, $p = 0.34$). Glavind *et al.* found CS scar defect length of 5.6 mm (3.9 - 6.8) and depth of 2.8 mm (2.0 - 4.0) following six month of the Caesarean section. But we have expected better uterine scar in prelabour CS group (scar with less in defect length and less in defect depth). As expected prelabour CS group have less CS scar defect length and depth than labour CS group. But the difference was not significant.

Caesarean scar was placed 8.6 mm (range 4.7 - 15.5) away from internal os in prelabour CS group and 8.9 mm (range 2.1 - 14.7) away from labour CS group. But the difference was statistically not significant.

Tissue elastography characterize the consistency of a tissue. Soft tissue has a large strain and hard tissue have small strain due to the difference in the relative displacement of the tissue in response to the pressure. Strain ratio is calculated by dividing the Reference strain by target strain (Strain ratio = Reference strain/ Target strain). Reference strain means strain in the normal tissue, in our case the strain of the normal myometrium; which should be similar in each group while target strain is identified as strain over the scar tissue, in our case the strain over the Caesarean scar tissue. Healthy scar is soft so have a large strain. Prelabour CS group had significantly higher target strain [0.28 vs. 0.24 ($t = 2.12$, $p = 0.04$)] than labour CS group indicating a better scar in prelabour group as expected. As described above Strain ratio indicate the stiffness of the scar. Better scar (healthy scar) is less stiff than weak scar (better scar has less Strain ratio than weak scar). As expected prelabour CS group has significantly less strain ratio [1.45 vs. 1.55 ($t = -2.42$, $p = 0.02$)] than labour CS group.

As strain ratio indicates the stiffness of the scar, results had shown that prelabour scars are less stiff or in other words healthier than labour scars. That indicates that prelabour CS scars are having less risk for uterine rupture in a subsequent pregnancy. This finding was clearly compatible with known literature as Zirqi *et al.*, 2010 also found that the percentage of uterine rupture was lowest for elective prelabour Caesarean section (0.7/1000), it was much higher when Caesarean section was an unplanned emergency section (7.1/1000) [8].

However, Buhimschi *et al.* showed that labour alters the viscoelastic properties of myometrium. Lower uterine segment myometrium is stiffest in women with dysfunctional labour compared with non labour control subjects. Labour and scarring also alter the pattern of collagen birefringence. Similar collagen cross-linking among the study groups may explain the reason that the breaking strength of the tissue is not altered by the state of labour and the reason that the rupture of the uterine scar is a rare event [26].

The remodeling of uterine connective tissue during labour can lead to the reorganization of the extracellular matrix that, in turn, may influence the biomechanical properties of the myometrial wall. We hypothesized that the stretching of the lower uterine segment in labouring women with dystocia changes the viscoelastic properties of the uterine wall.

6. Limitations

• Study was conducted in Colombo North Teaching Hospital (CNTH). Though it has a large draining area, generalizability of study findings has some degree of limitation.

• Though the ultrasound scans were performed by a single investigator due to machine factors instrumental bias could occur. Due to technical limitations frequent calibrations couldn't be done.

• Most of parameters were automatically calculated by the ultrasound machine. But there a variance could occur. In the measurements like RMT, scar dimensions and stiffness machine generate a range. Ascertainments of certain measurements were based on investigators observation and they could also be subjected to observer bias.

• We could not determine the difference in RMT according to the stage of labour due to retrospective nature of the study and technical difficulties in acquiring information from the clinical records.

7. Conclusions and Recommendations

7.1. Conclusions

• Maternal disease and fetal issues were noted as the commonest indication (n = 142, 59.5%) while labour complications ranked as second (n = 67, 27.8%). Among labour complications failed induction was the top cause among prelabour CS group while failure to progress was noted as the commonest indication among labour CS group.

• Though the strength of the uterine scar is directly proportionate to the RMT and RMT/Anterior wall thickness, there was no difference noted between prelabour and labour CS groups.

• Regarding scar dimensions, no significant difference was noted in depth and length in prelabour and labour CS groups.

• As strain ratio indicates the stiffness of the scar, results had shown that prelabour scars are less stiff or in other words healthier than labour scars. That indicates that prelabour CS scars are having less risk for uterine rupture in a subsequent pregnancy.

7.2. Recommendations

• We need to ensure judicial decision-making in determining elective CSs while taking every necessary measure to prevent unplanned (labour) CS's.

• Vigilance should be kept high in mothers who had previous CSs in planning

delivery. This has to be considered while taking history at beginning of pregnancy and continued antenatal care throughout the pregnancy.

• Further studies are warranted to further elaborate the associations between elasticity of the uterine scar and the type of Caesarean section.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Dumont, A., De Bernis, L., Bouvier-olle, M.H., Bréart, G. and the MOMA Study Group (2001) Caesarean Section Rate for Maternal Indication in Sub-Saharan Africa: A Systematic Review. *The Lancet*, **358**, 1328-1333. https://doi.org/10.1016/S0140-6736(01)06414-5

[2] Betrán, A.P., Merialdi, M., Lauer, J.A., Bing-Shun, W., Thomas, J., Van Look, P. and Wagner, M. (2007) Rates of Caesarean Section: Analysis of Global, Regional and National Estimates. *Paediatric and Perinatal Epidemiology*, **21**, 98-113. https://doi.org/10.1111/j.1365-3016.2007.00786.x

[3] Irgens, L.M. (2000) The Medical Birth Registry of Norway. Epidemiological Research and Surveillance throughout 30 Years. *Acta Obstetricia et Gynecologica Scandinavica*, **79**, 435-439.

[4] Geidam, A.D., Audu, B.M., Kawuwa, B.M. and Obed, J.Y. (2009) Rising Trend and Indications of Caesarean Section at the University of Maiduguri Teaching Hospital, Nigeria. *Annals of African Medicine*, **8**, 127-132. https://doi.org/10.4103/1596-3519.56242

[5] Family Health Bureau (2013) Annual Health Bulletin 2013. Ministry of Health, Colombo, Sri Lanka.

[6] Guise, J.M., McDonagh, M.S., Osterwei, L.P., Nygren, P., Chan, B.K.S. and Helfand, M. (2004) Systematic Review of the Incidence and Consequences of Uterine Rupture in Women with Previous Caesarean Section. *BMJ*, **329**, 19-25. https://doi.org/10.1136/bmj.329.7456.19

[7] Mavroforou, A., Koumantakis, E. and Michalodimitrakis, E. (2005) Physicians' Liability in Obstetric and Gynecology Practice. *Medicine and Law*, **24**, 1-9.

[8] Al-Zirqi, I., Stray-Pedersen, B., Forsén, L. and Vangen, S. (2010) Uterine Rupture after Previous Caesarean Section. *BJOG: An International Journal of Obstetrics & Gynaecology*, **117**, 809-820. https://doi.org/10.1111/j.1471-0528.2010.02533.x

[9] Rozenberg, P., Goffinet, F., Phillippe, H.J. and Nisand, I. (1996) Ultrasonographic Measurement of Lower Uterine Segment to Assess Risk of Defects of Scarred Uterus. *The Lancet*, **347**, 281-284. https://doi.org/10.1016/S0140-6736(96)90464-X

[10] Naji, O., Daemen, A., Smith, A., Abdallah, Y., Saso, S., Stalder, C., Sayasneh, A., McIndoe, A., Ghaem-Maghami, S., Timmerman, D. and Bourne, T. (2013) Changes in Caesarean Section Scar Dimensions during Pregnancy: A Prospective Longitudinal Study. *Ultrasound in Obstetrics & Gynecology*, **41**, 556-562. https://doi.org/10.1002/uog.12334

[11] Bennich, G., Rudnicki, M., Wilken-Jensen, C., Lousen, T., Lassen, P.D. and Wojdemann, K. (2016) Impact of Adding a Second Layer to a Single Unlocked Closure of a Caesarean Uterine Incision: Randomized Controlled Trial. *Ultrasound in Obste-*

trics & Gynecology, **47**, 417-422. https://doi.org/10.1002/uog.15792

[12] Osser, O.V., Jokubkiene, L. and Valentin, L. (2010) Caesarean Section Scar Defects: Agreement between Transvaginal Sonographic Findings with and without Saline Contrast Enhancement. *Ultrasound in Obstetrics & Gynecology*, **35**, 75-83. https://doi.org/10.1002/uog.7496

[13] Dicle, O., Küçükler, C., Pirnar, T., Erata, Y. and Posaci, C. (1997) Magnetic Resonance Imaging Evaluation of Incision Healing after Caesarean Sections. *European Radiology*, **7**, 31-34. https://doi.org/10.1007/s003300050103

[14] Glavind, J., Madsen, L.D,. Uldbjerg, N. and Dueholm, M. (2013) Ultrasound Evaluation of Caesarean Scar after Single- and Double-Layer Uterotomy Closure: A Cohort Study. *Ultrasound in Obstetrics & Gynecology*, **42**, 207-212. https://doi.org/10.1002/uog.12376

[15] Vikhareva Osser, O., Jokubkiene, L. and Valentin, L. (2009) High Prevalence of Defects in Caesarean Section Scars at Transvaginal Ultrasound Examination. *Ultrasound in Obstetrics & Gynecology*, **34**, 90-97. https://doi.org/10.1002/uog.6395

[16] Roberge, S., Demers, S., Berghella, V., Chaillet, N., Moore, L. and Bujold, E. (2014) Impact of Single-vs Double-Layer Closure on Adverse Outcomes and Uterine Scar Defect: A Systematic Review and Metaanalysis. *American Journal of Obstetrics and Gynecology*, **211**, 453-460. https://doi.org/10.1016/j.ajog.2014.06.014

[17] Kim, H. and Hwang, H.S. (2017) Elastographic Measurement of the Cervix during Pregnancy: Current Status and Future Challenges. *Obstetrics & Gynecology Science*, **60**, 1-7. https://doi.org/10.5468/ogs.2017.60.1.1

[18] Nakashima, K., Shiina, T., Sakurai, M., Enokido, K., Endo, T., Tsunoda, H., *et al.* (2013) JSUM Ultrasound Elastography Practice Guidelines: Breast. *Journal of Medical Ultrasonics*, **40**, 359-391. https://doi.org/10.1007/s10396-013-0457-0

[19] Kudo, M., Shiina, T., Moriyasu, F., Iijima, H., Tateishi, R., Yada, N., *et al.* (2013) JSUM Ultrasound Elastography Practice Guidelines: Liver. *Journal of Medical Ultrasonics*, **40**, 325-357. https://doi.org/10.1007/s10396-013-0460-5

[20] Bamber, J., Cosgrove, D., Dietrich, C.F., *et al.* (2013) EFSUMB Guidelines and Recommendations on the Clinical Use of Ultrasound Elastography. Part 1: Basic Principles and Technology. *Ultraschall in der Medizin*, **34**, 169-184. https://doi.org/10.1055/s-0033-1335205

[21] Cosgrove, D., Piscaglia, F., Bamber, J., Bojunga, J., Correas, J.M., Gilja, O.H., *et al.* (2013) EFSUMB Guidelines and Recommendations on the Clinical Use of uLtrasound Elastography. Part 2: Clinical Applications. *Ultraschall in der Medizin*, **34**, 238-253. https://doi.org/10.1055/s-0033-1335375

[22] Barr, R.G., Nakashima, K., Amy, D., Cosgrove, D., Farrokh, A., Schafer, F., *et al.* (2015) WFUMB Guidelines and Recommendations for Clinical Use of Ultrasound Elastography: Part 2: Breast. *Ultrasound in Medicine and Biology*, **41**, 1148-1160. https://doi.org/10.1016/j.ultrasmedbio.2015.03.008

[23] Hannah, M.E., Hannah, W.J., Hewson, S.A., Hodnett, E.D., Saigal, S., Willan, A.R., *et al.* (2000) Planned Caesarean Section versus Planned Vaginal Birth for Breech Presentation at Term: A Randomised Multicentre Trial. *The Lancet*, **356**, 1375-1383. https://doi.org/10.1016/S0140-6736(00)02840-3

[24] Sebire, N.J., Jolly, M., Harris, J., Wadsworth, J., Joffe, M., Beard, R., *et al.* (2001) Maternal Obesity and Pregnancy Outcome: A Study of 287 213 Pregnancies in London. *International Journal of Obesity*, **25**, 1175-1182. https://doi.org/10.1038/sj.ijo.0801670

[25] Mozurkewich, E.L. and Hutton, E.K. (2000) Elective Repeat Caesarean Delivery

versus Trial of Labour: A Meta-Analysis of the Literature from 1989-1999. *American Journal of Obstetrics & Gynecology*, **183**, 1187-1197. https://doi.org/10.1067/mob.2000.108890

[26] Buhimschi, C.S., Buhimschi, I.A., Yu, C., Wang, H., Sharer, D.J., Diamond, M.P., *et al.* (2006) The Effect of Dystocia and Previous Caesarean Uterine Scar on the Tensile Properties of the Lower Uterine Segment. American Journal of Obstetrics and Gynecology, 194, 873-883. https://doi.org/10.1016/j.ajog.2005.09.004