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Preoperative sonographic prediction of intra-abdominal adhesions using sliding sign at repeat caesarean section at the University of Maiduguri Teaching Hospital, Nigeria: a prospective observational study

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ABSTRACT

Objective To determine if the presence or absence of sonographic sliding sign preoperatively is a good predictor of the presence and type of intra-abdominal adhesions; and to determine the time taken to demonstrate this sign.

Design A prospective, observational, triple-blind study using tests of diagnostic accuracy.

Setting Single-centre tertiary health institution in north-east Nigeria.

Participants 67 women in the third trimester scheduled for repeat elective caesarean sections (CS) had transabdominal sonography to determine the absence or presence and degree of sliding sign. The time taken to make these decisions were noted. Surgeons blinded to the ultrasound findings graded adhesions intraoperatively and comparison between sonographic and intraoperative findings made. Women who were scheduled for emergency CS were excluded.

Main outcome measures Accuracy of preoperative ultrasound to determine no/mild, moderate and severe adhesions. Secondary outcomes were interobserver correlations and time taken to determine sliding.

Results When classified as adhesion and no adhesion, the sliding sign demonstrated a sensitivity of 100.00% (CI_{95} 85.18% to 100.00%), specificity of 100.00% (CI_{95} 92.13% to 100.00%). In predicting presence of moderate intra-abdominal adhesions, a sensitivity of 65.0% (CI_{95} 40.78% to 84.61%) and specificity of 82.98% (CI_{95} 69.19% to 92.35%) was found. For predicting severe intra-abdominal adhesions, it had a sensitivity of 25.00% (CI_{95} 0.63% to 80.59%) and specificity of 98.41 (CI_{95} 91.47 to 99.96). Disease prevalence for mild, moderate and severe adhesions was 33.82% (CI_{95} 22.79% to 46.32%), 29.85% (CI_{95} 19.28% to 42.27%) and 5.97% (CI_{95} 1.65% to 14.59%), respectively. Interobserver Cohen's kappa coefficient and PPA were 0.58 (CI_{95} 0.39 to 0.76) and 58.82 (CI_{95} 52.82 to 64.82), respectively. The mean duration to determine sliding sign was 7.56±2.86 s.

Conclusion This study supports the role of transabdominal sliding sign in preoperative prediction of intra-abdominal adhesions in women with previous CS without significant increase in sonography duration. This information can encourage planning for CS by ensuring that surgeons of appropriate seniority are deployed to undertake anticipated complex operations.

Strengths and limitations of this study

- We were able to include both qualitative and quantitative assessments and we allowed for intermediate findings on ultrasound (limited sliding) and correlation between different grades of adhesions.
- The study was also triple blinded as both sonographers were blinded to the surgical findings, the surgeons blinded to the ultrasound findings and the data analyst blinded to both sonographic and surgical findings.
- A small sample size; a larger sample size is needed to better evaluate subgroup analysis; correlation for mild, moderate and severe adhesions.
- There is poor reproducibility with interobserver variability.
- We did not consider the effect of body mass index on sliding sign and surgical blood loss and operating time were not assessed.

INTRODUCTION

Caesarean sections (CS) are life-saving procedures and can prevent adverse obstetric outcomes. Rates have been rising with studies documenting between 5% to 75%.[1] The ideal rate for CS is between 10% and 15%.[2] The average rate at University of Maiduguri Teaching Hospital (UMTH) is 25.95% (Obstetrics and Gynaecology UMTH 2019 Annual Report), 21.4% at the University of Abuja Teaching Hospital, 2.1% in Nigeria, 32% in the USA.[3–5] Adhesions remain adverse consequences following abdominal and pelvic surgeries, including Caesarean deliveries especially in settings were most CS are

performed as emergencies.[6] Adhesions are fibrous bands of tissue made up of fibroblasts, connective tissue and at times blood vessels that abnormally forms between the surfaces of internal organs and tissues in the process of wound healing as a response to injury/inflammation.[7] The minimum requirement for intraoperative diagnosis is the presence of filmy band of connective tissue, without vasculature, that forms between two tissue/organ surfaces that is lysed by blunt dissection. Different tissues are involved namely, bowel, uterus, bladder, vesico-uterine pouch, and internal surface of the anterior abdominal wall.

Post-CS intra-abdominal adhesions are not uncommon and may pose risks on abdominal re-entry. Rates of adhesions found at second CS range from 24% to 46%, third CS 43% to 75% and up to 83% at fourth CS.[8–10] Notable post-adhesion sequelae are difficult repeat abdominal procedures, damage to the bowel or bladder, haemorrhage, longer surgery duration, risk of hysterectomy, infections[10–14] and adverse neonatal outcomes in cases of prolonged deliveries. Long-term maternal consequences include chronic pelvic pain, bowel obstruction, ectopic pregnancies and infertility.[12–14] Presently, there is no reliable method for preoperative prediction of intra-abdominal adhesions before repeat CS.[15] Previously described predictive methods like surgical/postoperative history and skin scar visual features are marred by lack of reproducibility and unavailable relevant history prior to the first repeat CS.[15–17]

From our review of literature, this is the first study of its kind in Africa and the third globally after the first description of transabdominal sliding sign. Drukker *et al* and Baron *et al* individually described a novel technique using sliding sign on transabdominal ultrasound (US) to predict adhesions in high-risk and low-risk women.[18 19] Their focus was on predicting severe adhesions and/or did not study the additional time required to determine sliding during US. Planning and counselling of patients for repeat elective CS on likely complications during surgery would be more thorough if preoperative third trimester transabdominal sonography is done to determine the presence and extent of intra-abdominal adhesions. Our objective was to determine if the presence or absence of sliding sign preoperatively is a good predictor of the presence and type of intra-abdominal adhesions and whether demonstrating this increases US duration. Accordingly, obstetricians preoperative planning is improved while decreasing patient operative risks.

METHODS

This was a prospective, observational, triple-blind study of women scheduled to undergo a repeat elective CS conducted at the UMTH between May and November 2019.

Patients were recruited while on admission in the antenatal ward of the department in preparation for a repeat elective CS. Women in their third trimester of pregnancy with a history of at least one CS delivery were included in the study. Exclusion criteria included non-consent, emergency CS, those with known collagen or muscular diseases, and women with prior abdomino-pelvic surgeries other than CS. A numbered, pretested proforma containing demographic information was filled for each patient prior to performing the transabdominal USs.

A day preceding the caesarean deliveries, all women underwent transabdominal US using Nemio XG model SSA-550A ultrasound system (Toshiba Medical Systems, Japan) using a curvilinear trans-abdominal 3.75 MHz transducer as part of preoperative evaluation by the researchers, MB and AUM. Preoperative US was done to assess fetal biometrics and well-being as part of departmental protocol before visceral sliding test was performed. The US examinations were done irrespective of whether the bladder was full or not. The transducer was placed midline, 3 cm above and perpendicular to transverse skin scars or 8 cm above the superior border of the pubic symphysis in midline infraumbilical skin scars. A plane in which the anterior uterine wall and anterior abdominal muscles were seen was obtained.

At this position, the patients were requested to take deep breaths and exhale; the presence or absence of sliding of the uterine wall under the parietal peritoneum and fascia transversalis was observed over two respiratory cycles. Video clips of real-time US images were recorded on android phones, numbered and saved for interobserver variability assessment.

Sliding sign was said to be present when sliding of the uterus caudally against the abdominal wall muscles was seen. The degree of sliding was observed; free movement, ≥2 cm in the longitudinal plane, suggested no or mild intra-abdominal adhesions (positive sliding sign; see supplemental material- video). When no sliding was observed or movement was <1 cm, a prediction of severe intra-abdominal adhesions was made (negative sliding sign). Between 1 and < 2 cm, a prediction of moderate adhesions was made; positive sliding sign with restricted movement. The time taken to make these decisions, in seconds, was noted.

The US examinations were performed by two physicians: one (MB), certified in obstetric and gynaecological US for over 6 years and an author of an US textbook[20] and the other (AUM), a senior registrar in the department of obstetrics and gynaecology. The surgeons were either registrars, senior registrars or consultants experienced in caesarean deliveries. The sonographers were blinded to the intraoperative findings and the surgeons were blinded to the US findings. All surgical findings, including descriptions of adhesions encountered, were documented in the operation notes.

US findings on sliding sign and intraoperative adhesion findings were compared with assess whether the preoperative and intraoperative findings concurred. Diagnosis of intra-abdominal adhesions were made by individual surgeons and descriptions documented in the operative notes as either no/mild adhesions, moderate adhesions

and severe adhesions. Mild adhesions were thin and filmy, with no vascular structures and could be released by gentle, blunt, manual dissection. Moderate adhesions required sharp dissection but did not involve the bladder or bowel and severe adhesions were described as those making access to the lower uterine segment difficult, involving the bladder or bowel and requiring sharp dissection to release. There was no external observer.

To evaluate the interobserver variability, all video clips were assessed by the two sonographers (MB and AUM) after 5 months from the commencement of the study. The only information available to the sonographers during the interobserver assessment was the saved video clips of the participants. This evaluation was performed by the data analyst who was blinded to both the initial US and surgical findings.

The data obtained were analysed to establish the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and likelihood ratios (LR+ and LR−) of the sliding sign as a means to predict the presence or absence of intraabdominal adhesions.

We estimated the sample size for our study using a sample size formula for adequate sensitivity reported by Jones *et al*.[21] The required sample size was calculated to be 60 patients using a prevalence of 35% from a study by Baron *et al* where the true positive (n=16) and false negative (n=5) and total study population (n=59) values were known.[19] We included 67 women in the study.

PATIENT AND PUBLIC INVOLVEMENT STATEMENT

Neither patients nor the public were involved in conceptualisation, planning, performing or analysis of the research.

RESULTS

Sixty-seven women were examined during the period of study and there was no attrition due to the study design, as their sonograms were performed as routine evaluation protocol while on admission in preparation for repeat CS, which was done a day later. The demographic characteristics of the study population are presented in table 1; the mean maternal age at presentation was 30.72±5.54 with a mean gestation age of 37.78±1.10 at CS while the mean gravidity and mean parity were 3.67±1.38 and 2.42±1.17, respectively. The majority (63.8%) had CS order of 3–4. Most of the women 49 (71.0%) had their gestational age estimated by US. The mean duration for the examination (US) for the sliding sign was 7.56±2.86 s as shown in table 1.

The three most documented indications were 2 previous CS (32; 46.38%), 3 previous CS (11; 15.94%) and 1 previous CS with short interpregnancy interval (9; 13.04%). Disease prevalence for mild, moderate and severe adhesions is 33.82% (CI_{95} 22.79% to 46.32%), 29.85% (CI_{95} 19.28% to 42.27%) and 5.97 (CI_{95} 1.65 to 14.59), respectively.

Table 2 represents the diagnosis of severity of intra-abdominal adhesions based on sliding sign on transabdominal US and findings during CS. Absent movement (severe adhesion), limited sliding (moderate adhesion) and free sliding (no/mild adhesion) was observed with US in 2, 21 and 44 patients, respectively. Surgical findings, however, confirmed 1 out of 2 for severe adhesions, 13 out of 21 for moderate adhesions, and 36 out of 44 for no/mild adhesions.

Table 3 presents diagnosis of intra-abdominal adhesions based on sliding sign on transabdominal US and findings during CS in women undergoing repeat CS. Complete absence of sliding movement of the uterus was observed in 23 patients while sliding was present in 45 patients. These findings from the US were all confirmed at the surgery in women undergoing repeat CS; 45 out of 45 suspected low risk for intra-abdominal adhesions and 23 out of 23 suspected high risk for intra-abdominal adhesions. The sliding sign demonstrated a sensitivity of 100.00% (CI_{95} 85.18 to 100.00), specificity of 100.00% (CI_{95} 92.13 to 100.00), PPV of 100.00% and NPV of 100.00%.

Limited sliding movement (suggestive of moderate adhesion) was observed in 21 patients while non-limited sliding movement (complete absence or presence of free-sliding movement) was noted in 46 patients. The suspicion of moderate intra-abdominal adhesions was confirmed in 13 out of 21 cases with observed limited sliding movement while the prediction of absent moderate intra-abdominal adhesions was confirmed in 39 of the 46 cases without limited sliding movement (cases with either complete absence or free-sliding movement). Thus, in predicting presence of moderate intra-abdominal adhesions in women undergoing repeat CS, the sliding sign has sensitivity of 65.0% (CI_{95} 40.78% to 84.61%), specificity 82.98% (CI_{95} 69.19% to 92.35%), PPV of 3.82 (CI_{95} 1.88 to 7.76),

Table 1 Demographic characteristics of the study population of 67 women undergoing repeat caesarean section

Factors		Value
Age (years)		30.72±5.54
Gravidity		3.67±1.38
Parity		2.42±1.17
Duration of US (seconds)		7.56±2.86
GA at CS (Weeks)		37.78±1.10
Order of CS		
	2	23 (34.33)
	3	31 (46.27)
	4	12 (16.42)
	≥5	2 (2.98)
Method of dating		
	LMP	20 (29.0)
	US	49 (71.0)

CS, caesarean section; GA, gestational age; LMP, last menstrual period; US, ultrasound.

Table 2 Diagnosis of severity of intra-abdominal adhesions based on sliding sign on transabdominal ultrasound (US) and findings during caesarean section (CS) in women undergoing repeat CS

		Surgical findings			
		No/mild	Moderate adhesion	Severe adhesion	Total
US Finding	No/mild	36	7	1	44
	Moderate adhesion	6	13	2	21
	Severe adhesion	1	0	1	2
		43	20	4	67

NPV 84.78% (CI_{95} 75.15% to 91.12%), LR + of 3.82 (CI_{95} 1.88 to 7.76) and LR– of 0.42 (CI_{95} 0.23 to 0.78).

Complete absence of sliding movement, suggestive of severe intra-abdominal adhesions, was observed in 2 cases while either limited or free-sliding movement (suggestive of the absence of severe intra-abdominal adhesions) was noted in 65 cases of women undergoing repeat CS. The suspicion of severe intra-abdominal adhesions was established at surgery in 1 of the 2 cases with complete absence of sliding movement (US-rated high risk for severe adhesion), whereas the suspicion of absent severe adhesions was confirmed at surgery in 62 out of the 65 cases with either limited or free-sliding movement. Therefore, in predicting presence of severe intra-abdominal adhesions in women undergoing repeat CS, the sliding sign had a sensitivity of 25.00% (CI_{95} 0.63% to 80.59%), specificity of 98.41 (CI_{95} 91.47 to 99.96), PPV of 50.00 (CI_{95} 7.04 to 92.96), NPV of 95.38% (CI_{95} 92.14% to 97.33%), LR+ of 15.75 (CI_{95} 1.19 to 208.07), and LR– of 0.76 (CI_{95} 0.43 to 1.34).

Table 4 shows the results of cross tabulation of interobserver correlation analysis using Cohen's kappa for the two observers' findings from US. The first observer noted cases of free sliding movement out of which 33 were corroborated by the second observer. While corroborating 20 of 22 cases of observer 2, observer 1 noted absent free-sliding movement (suggestive of presence of adhesion). Interobserver Cohen's kappa coefficient and PPA was 0.58 (CI_{95} 0.39 to 0.76) and 58.82 ($CI_{95;}$ 52.82 to 64.82), respectively.

Table 3 Diagnosis of intra-abdominal adhesions based on sliding sign on transabdominal ultrasound (US) and findings during caesarean section (CS) in women undergoing repeat CS

		Surgical findings		
		No adhesion	Adhesion	Total
US findings	No adhesion (present)	44	0	44
	Adhesion (absent)	0	23	23
		44	23	67
		No moderate adhesion	Moderate adhesion	Total
US findings	No moderate adhesion	39	7	46
	Moderate adhesion	8	13	21
	Total	47	20	67
		No severe adhesion	Severe adhesion	Total
US findings	No severe adhesion	62	3	65
	Severe adhesion	1	1	2
		63	4	67

Adhesion = moderate +severe. No adhesion = no/mild.

DISCUSSION

This study demonstrates the merit of careful preoperative transabdominal sonographic assessment in the third trimester of pregnancy, using sliding sign, to predict intraperitoneal adhesions without significant increase in US duration. At present, prediction of adhesions is based on clinical evaluation of previous operations as well as the number of preceding CS. Advantages of having such data include thorough planning and counselling of patients before repeat elective CS on likely complications during surgery, proper assignment of the cadre of surgeon to operate, and anaesthetic considerations for intraoperative and postoperative care.[22 23]

Our institution has a CS rate of 25.95% (Obstetrics and Gynaecology 2019 Annual Report). This value is above the WHO recommendation but as a result an adequate number of women were recruited during the period of study. Most of the cases for elective CS were indicated by multiple previous CS.

A review of the literature revealed two studies that researched sliding sign to evaluate intra-abdominal adhesions in women undergoing repeat CS: one of which was specific to correlation with severe adhesions and the other specific to third trimester CS.[18 19] Our study focused on third trimester sliding sign prediction and our correlations were for no/mild adhesions, moderate adhesions and severe adhesions. We were able to demonstrate a

Table 4 Interobserver agreement

		Observer 1		
		No adhesion (free-sliding movement)	Adhesion (absence of free movement)	Total
Observer 2	No adhesion (free-sliding movement)	33	2	35
	Adhesion (absence of free sliding movement)	12	20	32
	Total	45	22	67

sensitivity and specificity of 100% each in determining the presence or absence of intraperitoneal adhesions in this subset of women. Baron *et al* reported a sensitivity of 76.2% and a specificity of 92.1%.[19] The prevalence for the presence of adhesions in this study was 33.82%, comparable to 35.59% by Baron *et al*.[19] Our findings may have been as a result of training our patients on deep breathing technique prior to the sonograms, this facilitated prominent sliding when present. Proper placement of US transducer around the skin scar, where the anticipated site of adhesion formation was, allowed us to determine whether sliding was present or not. This transducer placement overcame the limitation mentioned by Drukker *et al*, where the probe was placed lateral to the umbilicus.[18] Adhesions, however, may not necessarily be centrally located and as such we recommend checking for sliding at different abdominal regions in future studies.

Furthermore, our study was able to predict the different degrees of intraperitoneal adhesions, a parameter not assessed by Baron *et al*. For moderate adhesions, there was a sensitivity of 65.0% and specificity 82.98%. The somewhat lower sensitivity observed for moderate adhesions in our study was probably because of the subjectivity in determining the degree of sliding present, as there are no specific landmarks that differentiate free and limited movement. We found a prevalence of 29.85% for moderate adhesions. This parameter was not evaluated by the previous studies.

Severe adhesions were picked with a sensitivity and specificity of 25.0% and 98.41%, respectively. The prevalence of severe adhesions was calculated to be 5.97%, similar to 6% prevalence reported by Shi *et al*.[24] The high specificity for severe adhesions may be due to the fact that when severe adhesions are present, especially with multiple previous CS, they are typically found between the lower uterine segment, urinary bladder and anterior abdominal wall thus restricting the sliding of the uterus.[9 23] Therefore, when sliding is absent, it is more objectively observed on US. With low prevalence of severe adhesions obtained, focus on the high specificity, rather than low sensitivity, was justified. More importantly, our high NPV of 95.38% means that we can confidently expect that there would be no severe adhesions at surgery when some degree of sliding is observed on US.

With focus on prediction of severe adhesions only, Drukker *et al* reported a sensitivity of 56% and specificity of 95%.[18] The sensitivity differs from what we observed and this disparity may have resulted from a variance in grading of adhesions intraoperatively, since multiple classification systems exist and unfortunately none have been validated with clinical outcomes.[25] Severe adhesions have been associated with lower neonatal Apgar scores (Appearance, Pulse, Grimace, Activity and Respiration), lower umbilical artery cord gases and operative blood loss as a result of the increased operation time required to release these adhesions.[9 18 26] High-risk surgeries may therefore be allocated to more skilled obstetricians with involvement of general surgeons and urologists when damage to pelvic organs is anticipated with prediction of severe adhesions. Anaesthetic preparations for prolonged surgery and number of blood units required for possible transfusion should be planned preoperatively.[19 27] This study, however, did not evaluate operating time and blood loss at surgery.

The average time to decide on the presence or absence of sliding on US was 7.56s in the span of two respiratory cycles in our study. To our knowledge, this is the only study that considered the additional time it may require in assessing sliding while performing sonography. We conclude, therefore, that this novel technique does not increase evaluation time significantly and sonographers may include this method while conducting their routine scans.

Our analysis of interobserver agreement using Cohen's kappa on second evaluation of the US videos was 0.58 with a CI_{95} 0.39 to 0.76. The wide CI_{95} may have resulted from the difference in US experience between our researchers and lack of standardisation of the sliding sign method leading to subjectivity. This was similar to 0.52 by Baron *et al* but at variance with that of Drukker *et al* who had a correlation of 0.87, probably as a result of their higher US experience.[18 19] Baron reported an intraobserver variability correlation of 0.77.[19] This was a limitation in our study as there was no intraobserver variability analysis done. We also did not review incision-delivery interval and blood loss estimation as was done by a previous study. Our small sample size, though reassuring with regards to test accuracy, was another limitation.

Despite these limitations, the strengths in our research were: (1) we were able to include both qualitative and quantitative assessments, (2) our study allowed for intermediate findings on US (limited sliding) and correlation between different grades of adhesions, (3) the study was also triply blinded as both sonographers were blinded to the surgical findings, the surgeons blinded to the US findings and the data analyst blinded to both sonographic and surgical findings, (4) interobserver variability from two studies were available for comparison.

For future studies, we recommend (1) a larger sample size to better evaluate subgroup analysis; correlation for mild, moderate and severe adhesions, (2) sonographers with similar levels of US experience, (3) excluding morbidly obese women with body mass index ≥40 kg/m^2, (4) assessing surgical blood loss and operating time, (4) more experienced surgeons should be advised to perform the surgeries where moderate and severe adhesions are suspected preoperatively.

This study supports the role of transabdominal US using sliding sign in preoperative assessment in women with previous CS without significant increase in sonography duration. It can provide accurate information essential to the planning of women for repeat CS.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by University of Maiduguri Teaching Hospital Research and Ethics Committee UMTH/REC/19/545. Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data are available upon reasonable request. Data from the research may be obtained from Dr Asta Umar Mana (OrchID 0000-0002-9542-3772), Department of Obstetrics and Gynaecology, University of Maiduguri Teaching Hospital. email: ayshaastar@gmail,com.

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REFERENCES

1 Broadhead TJ, James DK. Worldwide utilization of caesarean section. *Fetal Matern Med Rev* 1995;7:99–108.
2 WHO Statement on Caesarean Section Rates. World Health organization (WHO), 2015. Available: https://www.who.int/reproductive health/ [Accessed 23 May 2020].
3 Isah AD, Adewole N, Zaman J. A five year survey of cesarean delivery at a Nigerian tertiary hospital. *Tropical Journal of Obstetrics and Gynaecology* 2018;35:14–17.
4 Adewuyi EO, Auta A, Khanal V, *et al*. Cesarean delivery in Nigeria: prevalence and associated factors-a population-based cross-sectional study. *BMJ Open* 2019;9:e027273.
5 Martin JA, Hamilton BE, Osterman MJK, *et al*. Births: final data for 2015. *Natl Vital Stat Rep* 2017;66:1.
6 Bukar M, Audu BM, Massa AA. Caesarean delivery at the federal medical centre Gombe: a 3-year experience. *Niger J Med* 2009;18:179–83.
7 Awonuga AO, Fletcher NM, Saed GM, *et al*. Postoperative adhesion development following cesarean and open intra-abdominal gynecological operations: a review. *Reprod Sci* 2011;18:1166–85.
8 Morales KJ, Gordon MC, Bates GW. Post-cesaren delivery adhesions associated with delayed delivery of infants. *Am J Obstet Gynecol* 2007;19:461.e461–6.
9 Tulandi T, Agdi M, Zarei A, *et al*. Adhesion development and morbidity after repeat cesarean delivery. *Am J Obstet Gynecol* 2009;201:56.e1–56.e6.
10 Fushiki HIT, Kobayashi H, Yoshimoto H. Efficacy of Seprafilm as an adhesion prevention barrier in caesarean sections. *Obstet Gynecol Treat* 2005;91:557–61.
11 Marana R, Catalano GF, Muzii L. Salpingoscopy. *Curr Opin Obstet Gynecol* 2003;15:333–6.
12 Duffy DM, diZerega GS. Adhesion controversies: pelvic pain as a cause of adhesions, crystalloids in preventing them. *J Reprod Med* 1996;41:19–26.
13 Barmparas G, Branco BC, Schnüriger B, *et al*. The incidence and risk factors of post-laparotomy adhesive small bowel obstruction. *J Gastrointest Surg* 2010;14:1619–28.
14 Holmdahl L, Risberg B. Adhesions: prevention and complications in general surgery. *Eur J Surg* 1997;163:169–74.
15 Tulandi T, Al-Sannan B, Akbar G, *et al*. Prospective study of intraabdominal adhesions among women of different races with or without keloids. *Am J Obstet Gynecol* 2011;204:132.e1–132.e4.
16 Bates GW, Shomento S. Adhesion prevention in patients with multiple cesarean deliveries. *Am J Obstet Gynecol* 2011;205:S19–24.
17 Greenberg MB, Daniels K, Blumenfeld YJ, *et al*. Do adhesions at repeat cesarean delay delivery of the newborn? *Am J Obstet Gynecol* 2011;205:380.e1–380.e5.
18 Drukker L, Sela HY, Reichman O, *et al*. Sliding sign for intra-abdominal adhesion prediction before repeat cesarean delivery. *Obstet Gynecol* 2018;131:529–33.
19 Baron J, Tirosh D, Mastrolia SA, *et al*. Sliding sign in third-trimester sonographic evaluation of intra-abdominal adhesions in women undergoing repeat cesarean section: a novel technique. *Ultrasound Obstet Gynecol* 2018;52:662–5.
20 Bukar M. *Ultrasound imaging in obstetrics and gynaecology*. 1st ed. Maiduguri: Knowledge Insight Services, 2018.
21 Jones SR, Carley S, Harrison M. An introduction to power and sample size estimation. *Emerg Med J* 2003;20:453–8.
22 Reid S, Lu C, Casikar I, *et al*. Prediction of pouch of Douglas obliteration in women with suspected endometriosis using a new real-time dynamic transvaginal ultrasound technique: the sliding sign. *Ultrasound Obstet Gynecol* 2013;41:685–91.
23 Sheth SS, Shah NM, Varaiya D. A sonographic and clinical sign to detect specific adhesions following cesarean section. *J Gynecol Surg* 2008;24:27–36.
24 Shi Z, Ma L, Yang Y, *et al*. Adhesion formation after previous caesarean section-a meta-analysis and systematic review. *BJOG* 2011;118:410–22.
25 El-Mowafi DM, Diamond MP. Pelvic adhesions. Geneva: Geneva foundation for medical education and research. Available: www.gfmer.ch/International_activities_En/El_Mowafi/Pelvic_adhesions.html [Accessed 25 Oct 2019].
26 Doherty DA, Magann EF, Chauhan SP, *et al*. Factors affecting caesarean operative time and the effect of operative time on pregnancy outcomes. *Aust N Z J Obstet Gynaecol* 2008;48:286–91.
27 Tulandi T, Al-Sannan B, Akbar G, *et al*. Clinical relevance of intra-abdominal adhesions in cesarean delivery. *Gynecol Surg* 2011;8:399–403.