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REVIEW ARTICLE

Sonographic Evaluation of Obstetric Anal Injuries

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ABSTRACT

Intrapartum damage to the anal sphincter is an important factor in fecal incontinence. Obstetric anal sphincter injuries (OASIS) vary from 1 to 18% of vaginal deliveries, including instrumental deliveries. The severity of anal sphincter injuries vary from superficial lacerations to deep injuries that can extend to the epithelium. Obstetric anal sphincter injuries are associated with both short-term complications (heavy bleeding, difficulties in recovery, increased incidence of infections, increased perineal pain) and long-term complications (rectovaginal fistulae or facal incontinence). A significant number of these anal sphincter injuries can be detected promptly after a good clinical examination, but still that does not exclude the possibility of these women suffering long-term complications. What is more when some of these so called 'occult tears' go undetected further increase the morbidity of the woman. Sonography of the perineum and the anal sphincter appears to offer a better diagnosis and detection of these injuries after vaginal delivery, which allows a timely and better treatment with less complications, with endoanal sonography offering the best detection rates so far.

Keywords: Anal injuries, Postpartum, Ultrasound.

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INTRODUCTION

Obstetric anal sphincter injuries (OASIS) represent a group of perineal tears with a reported incidence varying between 1 and 18%[1-7] of the vaginal deliveries. Obstetric anal sphincter injuries include a wide spectrum of defects, ranging from a superficial involvement of the anal sphincter to tears that extend to both the anal sphincter and the anorectal epithelium.[8] Obstetric anal sphincter injuries are associated with both short-term consequences, such as hemorrhage, wound breakdown, abscess formation, perineal pain and long-term complications which may include rectovaginal fistulae or anal incontinence.[9,10] Anal sphincter damage after childbirth is considered the most important etiological factor in the pathogenesis of anal incontinence in women.[11] Up to 53% of young healthy women, who sustained OASIS, may develop anal incontinence despite having these lacerations diagnosed and repaired at delivery.[12-15]

These sequelae may have a devastating effect on the women's physical and emotional well-being leading to social exclusion, loss of self-confidence and impairment of their quality of life.[16] Furthermore, the occurrence of OASIS has legal implications; medical litigation is becoming increasingly common in women with OASIS and fecal incontinence.[17] The fear of these injuries and of their consequences may have had a significant contribution to the almost 60% increase in cesarean deliveries in the USA.[18] For the above mentioned reasons a prompt diagnosis of OASIS following vaginal deliveries is crucial for the provision of appropriate care, management and future follow-up.

During the last two decades, the advent of endoanal ultrasonography (EAUS) allowed an accurate evaluation of the anal sphincter complex and has revolutionized the understanding of the pathophysiology of anal incontinence. Aim of this study is to review the current evidence on the methodology of ultrasonographic examination of the anal sphincter, the imaging of OASIS and the clinical implications of their sonographic evaluation.

ANATOMY OF ANAL SPHINCTER

The anal sphincter is composed of several cylindrical layers. The innermost layer is the subepithelium that seals off the anal canal (anal cushions).[19] The next layer is the internal anal sphincter (IAS), which is a thickened continuation of the circular muscle layer of the rectum into the anal canal.[20] The outermost layer is the striated muscle of the external anal sphincter (EAS), which is made up of voluntary muscle deriving from the levator ani and puborectalis muscle.[21] Although EAS forms a cylinder of muscle that encompasses the IAS, EAS and IAS are distinct structures that are separated by the intersphincteric plane that consists of a fibromuscular layer, the 'conjoint' longitudinal coat and the intersphincteric space with its connective tissue components. The 'conjoint' longitudinal coat is a continuation of the longitudinal muscle of the bowel.[22] Overall, five separate anatomical layers have

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been described, including: mucosa, submucosa, IAS, intersphincteric plane and EAS.

CLASSIFICATION OF PERINEAL TEARS AND RISK FACTORS

In 1999, Sultan introduced a descriptive classification of the perineal traumas which is based on the clinical examination of the perineum and the anal sphincter following delivery.[23] First degree tears include lacerations of the vaginal epithelium or the perineal skin only, whilet the second degree tears include injuries involving the perineal muscles but not the anal sphincter. The third degree perineal tears involve injuries of the anal sphincter, whereas fourth degree tears involve both the anal sphincter and the anorectal epithelium. Sultan's classification is now widely accepted and has been used by various national and international scientific societies, such as the Royal College of Obstetricians and Gynaecologists[24] and the International Consultation on Incontinence[25] (Table 1). Various studies identified a number of factors associated with an increased risk of occurrence of OASIS[6,26-43] (Table 2).

ULTRASONOGRAPHIC IMAGING OF ANAL SPHINCTER

Endoanal ultrasonography was first described by Law and Bartram,[44] in 1989, using a BandK type 1846 (Bruel&Kjaer, Naerum, Denmark) ultrasonographic scanner with a 7 MHz rotating endoprobe. Sultan et al[45] initially validated the endosonographic anatomy of the anal sphincter complexby *in vivo* and *in vitro* correlation with anatomical dissections of anorectal specimens and later demonstrated the normal sonographic anal sphincter anatomy and the differences between males and females.[46]

Table 1: Classification of perineal trauma[23]

Type of tear	*Definition*
First-degree	Injury to the perineal skin
Second-degree	Injury to the perineum involving the perineal muscles, but not involving the anal sphincter
Third-degree	Injury to the perineum involving the anal sphincter complex:
(3A)	< 50% of the EAS thickness torn
(3B)	> 50% of the EAS thickness torn
(3C)	Both the EAS and the IAS torn
Fourth-degree	Injury to the perineum involving the anal sphincter complex (both the EAS and the IAS) and anal epithelium

Table 2: Risk factors associated with increased occurrence of OASIS[6,26-43]

Birth weight over 4 kg	Second stage longer than 1 hour
Persistent occipito-posterior position	Shoulder dystocia
Nulliparity	Midline episiotomy
Induction of labor	Forceps delivery
Epidural analgesia	

The classic approach of EAUS is by using a 2D 7 to 10 MHz rotating endoprobe (focal range 5–45 mm), 12 to 17 mm in diameter, filled with degassed water, which allows a 360° axial view of the anal canal. The patient lies in the left lateral or prone/lithotomy position,[47,48] although the latter is generally preferred for the acquisition of optimal images and also to avoid deformation of the anterior anatomic elements.[48] Digital anal examination prior to the sonographic examination is recommended, to obtain information on the anatomy of the anal canal and to exclude the presence of scars or stenotic lesions.[48] The endoscopic probe, covered with a lubricated condom is inserted about 6 cm into the rectum and as the probe is withdrawn down the anal canal, images of the puborectalis muscle, the anal mucosa and submucosa, IAS, longitudinal and EAS become visible. Two-dimensional endoanal ultrasonography generates cross-sectional images in the axial plane only.

More recently, 3D-EAUS has been introduced. Images are obtained using the same probe that is utilized for 2D imaging. It is mounted onto a hand-held mechanical rig which moves the probe in the caudal direction at a constant velocity when in use and constructs a 3D image.[49] Three-dimensional endoanal ultrasonography creates volumetric images which can be extrapolated to multiplanar (coronal, sagittal and axial) or tomographic slicing images[50-52] (Fig. 1). The use of appropriate software allows the analysis of stored 3D volumes for a later review, keeping the duration of the examination short.[53]

In 1999, Gold et al[54] defined four sonographically distinct levels for the assessment of the anal canal in the axial plane[53,55] (Fig. 2).

1. *Puborectalis level*: Identified as a U-shaped hyperechoic band situated just proximal to the formation of the EAS (Fig. 3).
2. *Proximal (high) anal canal*: At most cranial level of the EAS where EAS, longitudinal muscle and IAS are visible.
3. *Middle anal canal*: The level where the EAS forms a complete circular region (ring) around the IAS. The lower end is identified at the distal end of the IAS.
4. *Subcutaneous (low) anal canal*: The level immediately below the termination of the IAS, where only the EAS is seen.

The different levels of the normal anal canal appear as hypoechoic or hyperechoic layers[49] (Fig. 4). Starting from inside and moving outwards the first layer is hyperechoic and corresponds to the interface of the transducer with the anal mucosal surface. The second layer is moderately

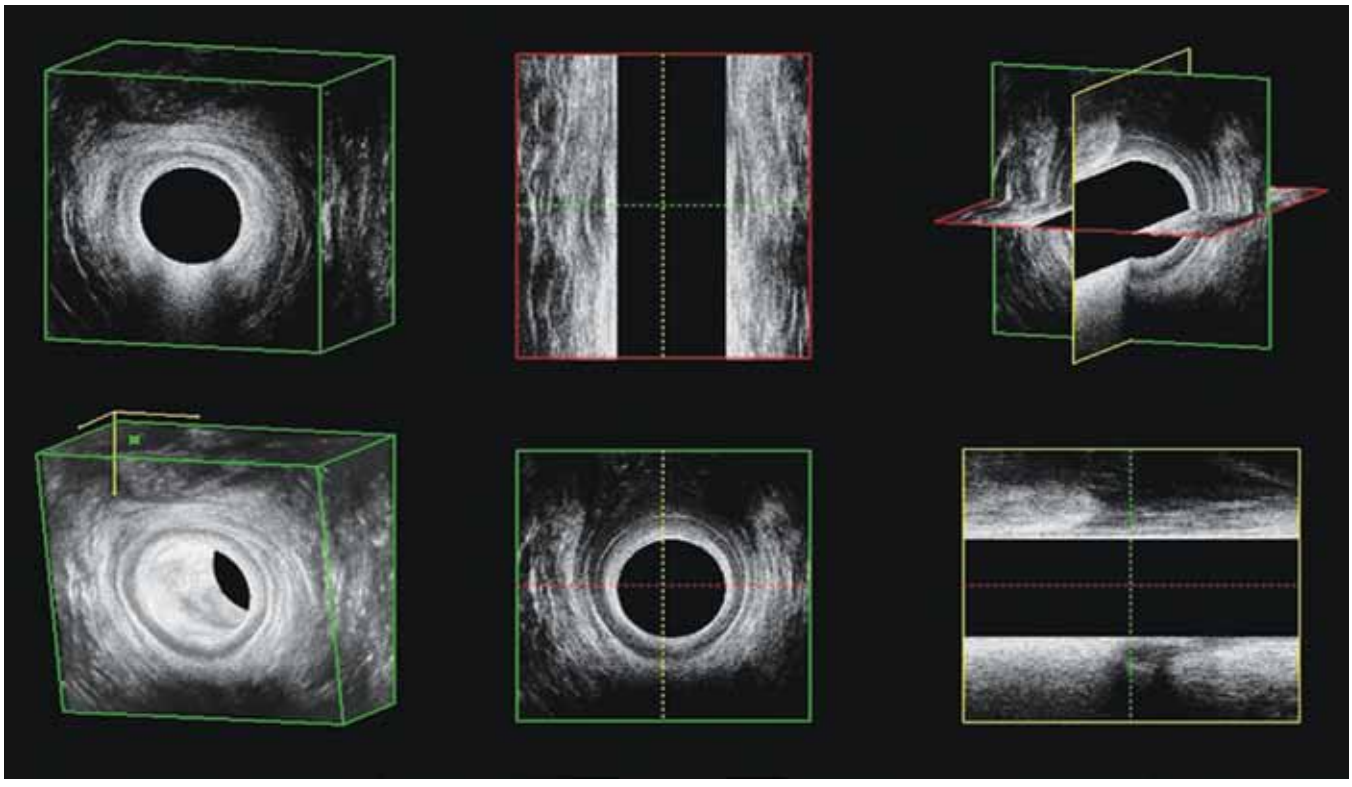

Fig. 1: Three-dimensional-EAUS allowing multiplanar imaging

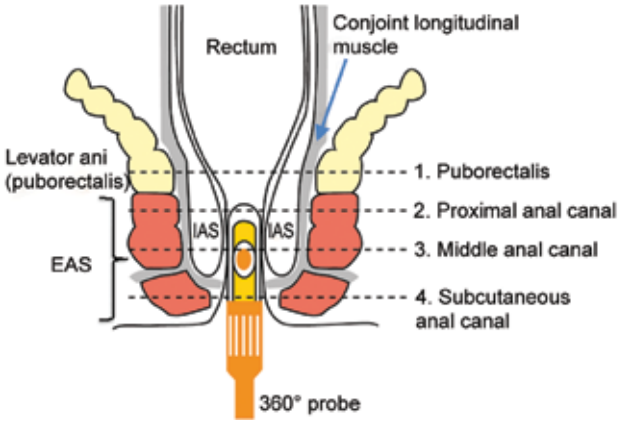

Fig. 2: Levels of sonographic assessment of the anal canal[49]

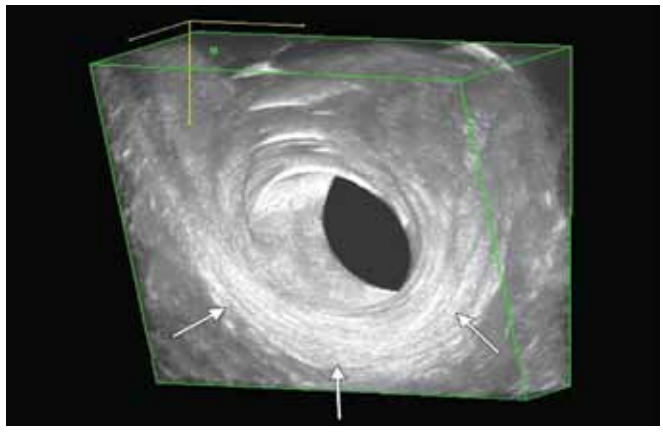

Fig. 3: Three-dimensional-endoanal ultrasonography demonstrating the 'U'-shaped puborectalis muscle (arrows)

reflective and represents the submucosa which is composed of connective tissue and smooth muscle. The third layer corresponds to the IAS which is hypoechoic, giving an impression of a ring-like hypoechoic formation around the submucosa. It does not extend inferiorly beyond the subcutaneous external sphincter. The fourth layer is hyperechoic and represents the longitudinal muscle. The longitudinal muscle layer is not always distinguishable from the external sphincter, and has been reported as being seen in only 40% of females as they are of similar echogenicity and, therefore, indistinguishable. The fifth layer corresponds to the EAS which usually appears hyperechoic and has a heterogeneous appearance due to variations in the orientation of some fibers of the EAS.

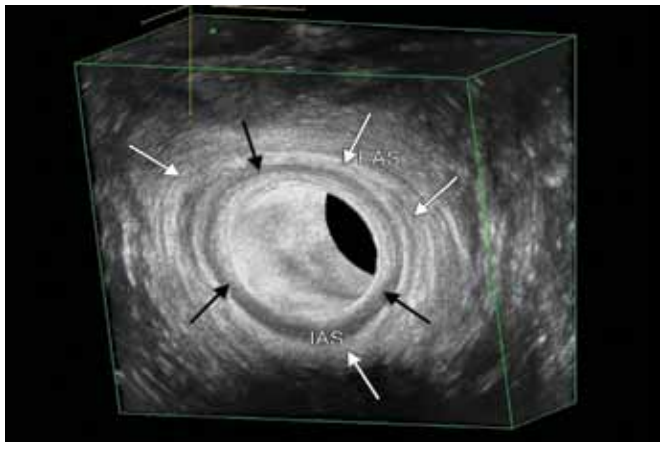

Fig. 4: Three-dimensional-endoanal ultrasound of the anal canal showing the hypoechoic IAS (white arrows) and the hyperechoic EAS (black arrows)

ENDOANAL ULTRASONOGRAPHY IMAGING OF OASIS

The anal sphincter defects, when evaluated with EAUS, have specific sonographic images. A laceration of the IAS can be noted as lack of continuity in the concentric hypoechogenic ring which runs along the submucosal level at the middle or proximal anal canal.[53] The presence of an incomplete circular pattern in the anterior compartment of EAS before the end of the IAS represents an EAS trauma at the level of the middle anal canal.[53] It should be noted that in 98% of women the EAS is shorter anteriorly compared to the posterior part and therefore any discontinuity of the EAS anteriorly at the proximal level should not be confused with an injury of the EAS. [56] Starck et al[57] have shown that the mean length of the anterior part of the EAS in nulliparous women is 7 mm less than is that of the posterior part. At the level of distal anal canal, any disruption of the continuity in the concentric ring of hyper or mixed echogenicity that represents the EAS, also describes a laceration of the EAS.[53]

Starck et al[58] devised a scoring system using 2D-EAUS images, with assessments every 5 mm from the puborectalis muscle to the distal end of the anal canal, evaluating length, depth and radial extent of defects to the IAS and EAS (Table 3). Scores range from 0 (no defect) to 16 (maximal defect).

Recently, Norderval et al[59] reported a simplified system for analyzing defects, with fewer categories compared with the Starck score and not recording partial defects of the IAS. Using this system, the maximal score of 7 denotes defects in both the EAS and the IAS exceeding 90° in the axial plane and involving more than half of the length of each sphincter. Both scoring systems seem equally reproducible with good intraobserver and interobserver agreement in classifying.[59]

ROLE OF EAUS IN EVALUATING OASIS

In 1993 Sultan et al[60] found that up to 35% of primiparous women had sonographic evidence of obstetric traumas involving the sphincter muscles as opposed to a clinical diagnosis of OASIS of only 3%. This observation was reinforced by subsequent endosonographic studies of the anal complex.[61] Thus, EAUS performed several weeks after vaginal deliveries, detected higher rates of rupture, suggesting that some sphincter tears were not diagnosed by clinical examination alone at delivery.[61] A few prospective studies reported that between 20 and 41% of women who delivered vaginally had sonographic evidence of anal sphincter injuries that were not diagnosed clinically.[61] Such defects that are not visible at delivery but can be detected with ultrasound imaging of the anal sphincter immediately postpartum are considered 'occult' anal sphincter injuries.[53]

Undiagnosed or 'occult' OASIS is believed to be clinically relevant as some asymptomatic women with clinically undiagnosed anal sphincter injury seem to develop symptoms of fecal incontinence after a second vaginal delivery.[62] Faltin et al[63] found that women who were found to have 'occult' anal sphincter injuries had an increased risk of anal incontinence 3 months after delivery [odds ratio (OR) 8.8; 95% CI 2.9, 26.5]. However, recent evidence suggests that most anal sphincter injuries previously classified as occult represent cases of clinically missed OASIS and that true occult anal sphincter injuries are rare.[61] In a prospective trial[64] where women after delivery were re-examined by a trained research fellow before suturing of the perineum, the detection rate of OASIS increased significantly from 11 to 24.5% suggesting that the genuine occult sphincter injuries are uncommon. The authors concluded that there is need for better and more focused training of staff at delivery suite to recognize OASIS. Similar results were found in a recent prospective observational study[53] of primiparous women delivered vaginally, where 12% of women evaluated by 3-D EAUS were diagnosed with sphincter disruption compared to only 6.5% which were clinically diagnosed at delivery. The authors commented that these results do not imply that all primiparous women without clinical anal sphincter lacerations should undergo US examination postpartum and emphasis should be placed on careful examination of the rectovaginal wall and perineum in all women following delivery. Other studies also found that the accuracy of the clinical recognition of OASIS is depended on the training and the experience of the examiner[61,64] reinforcing the notion that an appropriate training of health providers is essential to reduce the likelihood of a clinically missed OASIS.[64,65]

Table 3: The Starck scoring system for endosonographic sphincter defects[58]

Score	*0*	*1*	*2*	*3*
External sphincter				
Length of defect	None	Half or less	More than half	Whole
Depth of defect	None	Partial	Total	—
Size of defect	None	>90°	91–180°	>180°
Internal sphincter				
Length of defect	None	Half or less	More than half	Whole
Depth of defect	None	Partial	Total	—
Size of defect	None	>90°	91–180°	>180°

ENDOANAL ULTRASONOGRAPHY AFTER PRIMARY REPAIR OF OASIS

The value of EAUS has been studied for the evaluation of women who underwent primary repair of OASIS. In the

literature, there are studies reporting a high frequency of endosonographic sphincter defects, as high as 90% among the women who underwent primary suture of sphincter tears.[58] Interestingly, Starck et al[58] found that the extent of the endosonographic defects 2 to 7 days after delivery and primary repair seems to be determined mainly by the surgical experience of the doctor performing the repair, and not by the clinical degree of the tear. In another study, Starck et al[66] assessed women who had suffered OASIS with EAUS and anal manometry 1 week, 3 months and 1 year after primary suture and their subjective symptoms at 1 and 4 years after delivery. Endosonographic sphincter defect score 1 week after primary repair was positively correlated with the risk of reported anal incontinence at 4 years. The authors concluded that it might be valuable to check the result of primary repair with anal endosonography immediately after the repair and to re-suture if a large defect is still seen.

ALTERNATIVE TECHNIQUES FOR IMAGING OF THE ANAL SPHINCTER

Although EAUS is considered the gold standard technique for the assessment of the anal sphincter complex,[67] the availability of both the required equipment and the trained personnel is limited. Furthermore, EAUS is an invasive technique which might cause discomfort to the patient particularly when performed in the immediate postpartum period. Additionally, the insertion of the ultrasound probe into the anal canal may distort the normal anatomy precluding dynamic evaluation of the anal sphincter and mucosa on sphincter contraction which seems to enhance the definition of muscular defects.[68]

ENDOVAGINAL ULTRASONOGRAPHY

In 1994 Sultan et al[69] described a transvaginal technique for the assessment of the anal canal. A B&K rotating endoprobe fitted with a 7 MHz transducer was inserted 3 cm into the vagina and was gradually withdrawed to visualize the puborectalis muscle, EAS, IAS, anal submucosa and anal cushions. Later Kammerer-Doak et al[70] employed a simple technique to image the anal sphincter by means of a transvaginal ultrasound probe. They were able to detect separated anal sphincters in 40% of women with obstetric lacerations. Timor-Tritsch et al[71] described a similar technique by using a common 5 to 8 MHz transvaginal probe which was placed in the posterior fourchette, first in the transverse and then in the longitudinal fashion. The authors reported that the images obtained using this imaging modality show the sphincter muscle anatomy as well as other possible pathology. With this technique a new sonographic sign was described: the 'mucosal star' which is seen on transverse sections, created by the normal, empty lower rectal mucosal folds and the constricted anus. They concluded that due to its simplicity and availability Endovaginal ultrasonography (EVUS) should be used whenever the anatomical integrity of the anal sphincter mechanism is questioned.

More recently, Olsen et al[72] reported that the use of 3D-EVUS allows imaging of the anal canal and its neighboring structures without the distortion caused by a straight ultrasound rod inserted in the anal canal as when performing EAUS. In addition, 3D-EVUS allows a real time functional assessment of the anal canal during voluntary squeeze, adding thus important insight into the mechanisms of continence and its disorders. However, among the limitations of this technique is the difficult interpretation of the images which have been reported in up to 24% of the cases, requiring more experienced operators and the increased possibility of failure in obtaining clear images of the full length of the anal canal, mainly due to inadequate acoustic contact within the vagina.[73,74] Furthermore TVUS demonstrated limited precision in revealing lateral tears probably as a result of the lack of anal distention which keeps the muscular fibers relaxed hiding the defect through overlapping.[74]

TRANSPERINEAL ULTRASONOGRAPHY

The technique of transperineal ultrasonography (TPUS) of the anal canal (exoanal ultrasound) was first described in 1997 by Peschers et al,[75] using a 5 MHz convex probe to a group of 68 females (25 with fecal incontinence, 11 asymptomatic nulliparous and 32 asymptomatic parous females). In this study, all the layers of the anal sphincter complex were visualized as described by EAUS and the detected sphincter defects were confirmed at sphincter reconstructive surgery which was performed in five patients. Transperineal ultrasonography is usually performed with the patient placed in the dorsal lithotomy position by applying an external convex transducer on the perineum between the mons pubis and the anal sphincter.[76] Although variations of the technique have been described,[77] the original approach by Peschers et al[75] is widely and increasingly used to evaluate the anal sphincters.[78]

Yagel and Valsky[79] first introduced the 3D-TPUS for the assessment of the anal sphincter, using a 5 to 9 MHz 3D vaginal probe, placed in the area of the fourchette. However, the authors did not establish a definition for anal sphincter defects on tomographic imaging. In a group of 139 primiparous females, Yagel and Valsky[79] found that using 3D-TPUS 7.9% of women had occult damage to the anal sphincter. These authors described the 'half moon sign' as a thinning of the IAS in the area of damage and thickening on the opposite side, as well as an abnormal appearance of the 'star sign' of the mucosal

folds in almost half of the patients, as signs indicative of sphincter damage.

More recently D Guzmán et al[78] studied retrospectively women at 35 to 37 weeks of gestation and 3 to 6 months postpartum. In this study, a translabial 4D US examination using a 8 to 4 MHz curved array volume transducer. Twenty-eight percent of those delivered vaginally had sonographic evidence of significant EAS defects of which 87% were not diagnosed clinically. The incidence of clinically undetected OASIS was comparable to those reported in the literature using EAUS. Transperineal ultrasonography is considered more accessible to obstetricians than EAUS due to the wider availability of conventional convex abdominal transducers and is well-tolerated by the patients, since the probe used for the examination is applied externally.[54] However, with TPUS, excessive pressure applied by the transducer on the perineum or an inappropriate angle of incidence of the ultrasound beam to the anal canal may result in erroneous results.[80] Compared with 3D-EAUS, 3D-TPUS is unable to identify clearly the conjoined longitudinal layer and the superficial transverse perineii muscle or to measure the anterior longitudinal length of the EAS, but has the advantage of demonstrating not just the IAS and EAS but also the perineal body and the entire sling of the puborectalis muscle.[80]

ENDOANAL ULTRASONOGRAPHY FOR POST-PARTUM EVALUATION OF OASIS AND FUTURE PREGNANCY

The management of a subsequent delivery following previous OASIS remains controversial due to lack of objective and subjective evidence regarding outcome and quality of life as assessed with validated measurement tools.[81] The main issues to be considered in such cases are the risk of OASIS recurrence and the risk of developing or worsening of anal incontinence.

In the literature, there is evidence that 17 to 25% of women who had sustained a 3d degree OASIS and have a subsequent vaginal delivery, experience an aggravation of anal incontinence symptoms.[82-86] Fynes et al[84] demonstrated that 75% of women with objective anal sphincter compromise but no anal incontinence after the index delivery, developed *de novo* anal incontinence compared to 5% without evidence of anal sphincter compromise. However, a recent prospective study[81] revealed that women who sustain OASIS have a 7% risk of recurrence and women who do not have substantial compromise of anal sphincter function can deliver vaginally without risking significant deterioration in anal sphincter morphology and function or quality of life. The exact 'criteria of security' for vaginal delivery after previous obstetric sphincter trauma are still the subject of debate and remain to be determined.[87]

Mahony et al[86] studied prospectively 52 women who had forceps assisted and normal vaginal deliveries antenatally and again at 12 weeks after second delivery using a standardized bowel function questionnaire, EAUS, and anal manometry. The presence of an anal sphincter defect defined by EAUS was associated with a minor but not significant symptomatic deterioration after second vaginal delivery. More than one-quarter of women (10/38) with an anal sphincter defect identified by EAUS experienced minor symptomatic alteration (≤3 point increase in incontinence score) after second vaginal delivery compared with 14% (2/14) of women with a normal EAUS, but this difference was not significant. Recently, Daly et al[88] prospectively evaluated 381 antenatal women with a history of OASIS (38.4 ± 22 months following the index OASIS). All women routinely had a St Mark's incontinence score (SMIS), EAUS and anal manometry. In their practice a vaginal delivery is recommended to those women with minimal symptoms, an intact sphincter or a external sphincter scar of less than 30° and a squeeze incremental pressure of more than 20 mm Hg, whereas a cesarean section is recommended to all other women. Using these criteria 321 (84.3%) women were recommended to have a vaginal delivery, with 19 (7.6%) recurrent OASIS. Their results confirmed that the majority of women with minimal symptoms, an intact or minimally scarred anal sphincter with an incremental squeeze pressure of >20 mm Hg can achieve a vaginal delivery without clinical deterioration in anorectal symptoms and lifestyle at 3 months postpartum.

Concluding, EAUS can provide useful information for the management of women with a history of OASIS. Ultrasound may contribute establishing the sonographic appearance of damage early after repair, monitoring the progress of healing process over time in the anal area, and comparing the sonographic appearance with any degree of incontinence symptoms. By providing this information, ultrasound assessment of the anal sphincter can contribute to the antenatal counseling of women who have sustained OASIS serving probably even as a screening examination for high risk patients prior to subsequent trial of labor or elective cesarean delivery.[87]

CONCLUSION

Currently, EAUS is considered the gold standard investigation in the assessment of anal sphincter integrity providing an assessment of high precision and accuracy.[55,67] Furthermore, EAUS has been proved to be equivalent to magnetic resonance imaging and superior to electromyographic sphincter mapping in

detecting sphincter defects.[67] However, limitations of the EAUS, either 2D or 3D, is the need for a specialized, expensive equipment and access to staff trained in endoanal ultrasound on the labor ward which may not be available in a general obstetrics and gynecology unit. This technique may also prove to be uncomfortable for the patient and there is a small risk for disruption of the anal sphincter structure during the examination. The need to use more common transducers which are widely available to the gynecological wards led to the introduction and development of other techniques, such us the EVUS and TPUS. Advantages of such routes include availability of low cost transducers, absence of distortion of the anal canal caused by the EAUS and recently the assessment of real time functional studies. Future studies should focus on the predictive value of both EVUS and TPUS as compared with EAUS in the detection of sphincter defects.[55]

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