International Journal of Healthcare Sciences ISSN 2348-5728 (Online)
Vol. 5, Issue 1, pp: (439-445), Month: April - September 2017, Available at: www.researchpublish.com

Effect of Pregnancy on the Properties of Vaginal Wall: Overview

[1]Abdulaziz faisal khyat, [2]Mohmad ahmed hamodah, [3]Hesham adnan qary

Abstract: **Objectives of this narrative review was to highlights the most important effects of pregnancy on the properties of vaginal wall, in term of pelvic floor and other conditions that may occur during pregnancy. This narrative review was performed using electronic medical databases; PubMed, Embase, and Google scholar, searched was targeting relevant studies concerned with effects of pregnancy on the wall of vagina published up to 2017. The vaginal area must go through significant modifications during pregnancy to permit passage of a fetus at the time of delivery Although clinically it is understood that these maternal adaptations take place, this study sought to measure how these adaptations are manifested in regards to the mechanical function of the vaginal area. The data confirmed scientific impressions by demonstrating significant changes in the passive mechanical residential or commercial properties and contractility of the vaginal area throughout pregnancy and into the postpartum period. Morphometric and histological parameters, for proximal and distal vaginal wall. The result of repeated pregnancies with vaginal shipments was studied. Morphometric analysis for each vaginal wall layer of the sheep model (squamous epithelium, lamina muscularis, propria and adventitia) was carried out in a clear and detailed method. Base line observations in young virgin animals were made. Exceptional changes were observed during the 3rd pregnancy which were visible one year after 3rd delivery.**

Keywords: **pregnancy, mechanical function, PubMed, Embase, vaginal wall.**

1. INTRODUCTION

The physiologic processes of pregnancy and parturition must impart significant adaptations of the vaginal wall and pelvic floor to permit significant vaginal distention followed by a quick return to a pre-pregnant-like state. Yet, many epidemiologic studies recommend that lots of females cannot entirely recuperate from this occasion; indeed, vaginal distention trauma appears to play an important function in the etiology of pelvic organ prolapse with vaginal delivery providing a 4- to 11-fold increase in the risk of developing prolapse (1, 2).

Recent studies suggest that there are altered histomorphological functions in patients with pelvic flooring disorders such as prolapsed vaginas and incontinence and that these features are accompanied by modifications in the ratio of collagen subtypes and in elastic fiber homeostasis (3,4,5). Less studies have taken a look at the modifications in biomechanical residential or commercial properties related to the physiologic occasions of pregnancy and parturition or the pathologic events of prolapse. Biomechanical homes may be useful tools for comprehending the underlying structural changes that happen in both pathologic and physiologic conditions that change function of the vaginal wall and its assistance (4,5).

Pelvic organ prolapse is a common condition specified as the loss of vaginal assistance to the pelvic organs and their descent into the vaginal canal. Surgical treatment of prolapse incurs a yearly expense of over a billion dollars a year in the United States alone (6,7). Prolapse affects as lots of as half of ladies over the age of 50, with parity being the largest risk factor (6,7,8). The system by which parity increases vulnerability to prolapse is still uncertain (9).

When properly supported the vaginal area supports the urethra, uterus, rectum, and bladder (10). The vagina has four layers along its cross-section. The epithelial layer is the first line of defense versus infection. The subepithelium is a dense collagen layer that provides a large degree of the passive mechanical stability to the vaginal area. The vaginal muscularis right away underneath the vaginal subepithelium offers active assistance to the vaginal area (11). The adventitia is a loose connective tissue layer shown the bladder anteriorly and the rectum posteriorly (10). While it is clear that each of these sublayers likely goes through redesigning to afford passage of the fetus, to this day little has been done to measure the adjustments that moderate increased vaginal distensibility at the time of delivery and subsequent events that permit healing to the non-pregnant state throughout the postpartum duration (12).

In mechanical terms, remodeling most likely effects; the passive mechanics of the vagina by modifying the composition and organization of the fibrillar extracellular matrixand the active mechanics by modifying the contractile, amount, and organization capability (reactivity) of the smooth muscle. As collagen is the primary part of the fibrillar matrix contributing to the vaginal area's physical stability and smooth muscle is primarily responsible for short-term changes in geometry through contraction and relaxation, it is likely that improvement of both vaginal collagen and smooth muscle play a critical role in mediating maternal adjustments in preparation for vaginal delivery [13].

Objectives of this narrative review was to highlights the most important effects of pregnancy on the properties of vaginal wall, in term of pelvic floor and other conditions that may occur during pregnancy.

2. METHODS AND MATERIALS

This narrative review was performed using electronic medical databases; PubMed, Embase, and Google scholar, searched was targeting relevant studies concerned with effects of pregnancy on the wall of vagina published up to 2017. Search strategy restricted to only English language articles and no restriction to human since animal model studies were included. More search was performed through the references list of the included articles.

3. DISCUSSION

Histology of vaginal layers:

Full thickness high quality histologic pictures of both vaginal wall regions are provided in (**Figure 1**). On all analyzed images, it was possible to discriminate four unique layers: the stratified squamous epithelium, the lamina propria, containing a multidirectional network of collagen and elastin fibers, a muscularis of smooth muscles cells, and below, loose connective adventitia (**Figure 1**) [14]. (**Figure 2**) shows the quantitative evaluation of collagen, elastin, smooth muscle cells and myofibroblasts throughout the whole thickness of the vaginal area. The proximal vaginal thickness be less than that of the distal, other than during pregnancy. Thinner vaginal walls accompanied a higher collagen, yet lower elastin content and less smooth muscle cells. In pregnancy, local differences were not present, except for elastin, which was lower in the proximal vagina. When comparing life process phases, the proximal vagina of pregnant sheep had a reduction in collagen, a boost in elastin and smooth muscle cell count. Modifications induced by pregnancy were similar in distal and proximal vagina. Changes for para-3 animals followed the exact same trends, but were not considerably different except for smooth muscle cells [14].

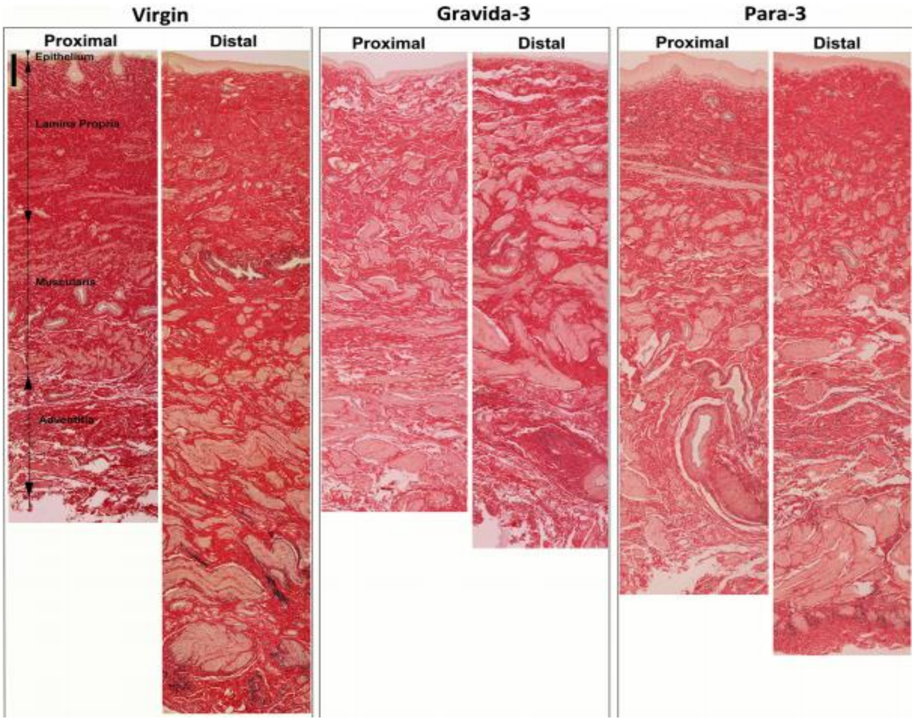

Figure 1: Histological structure of the proximal and distal ovine vaginal wall using Miller's Elastica staining of virgin, parous and pregnant sheep.

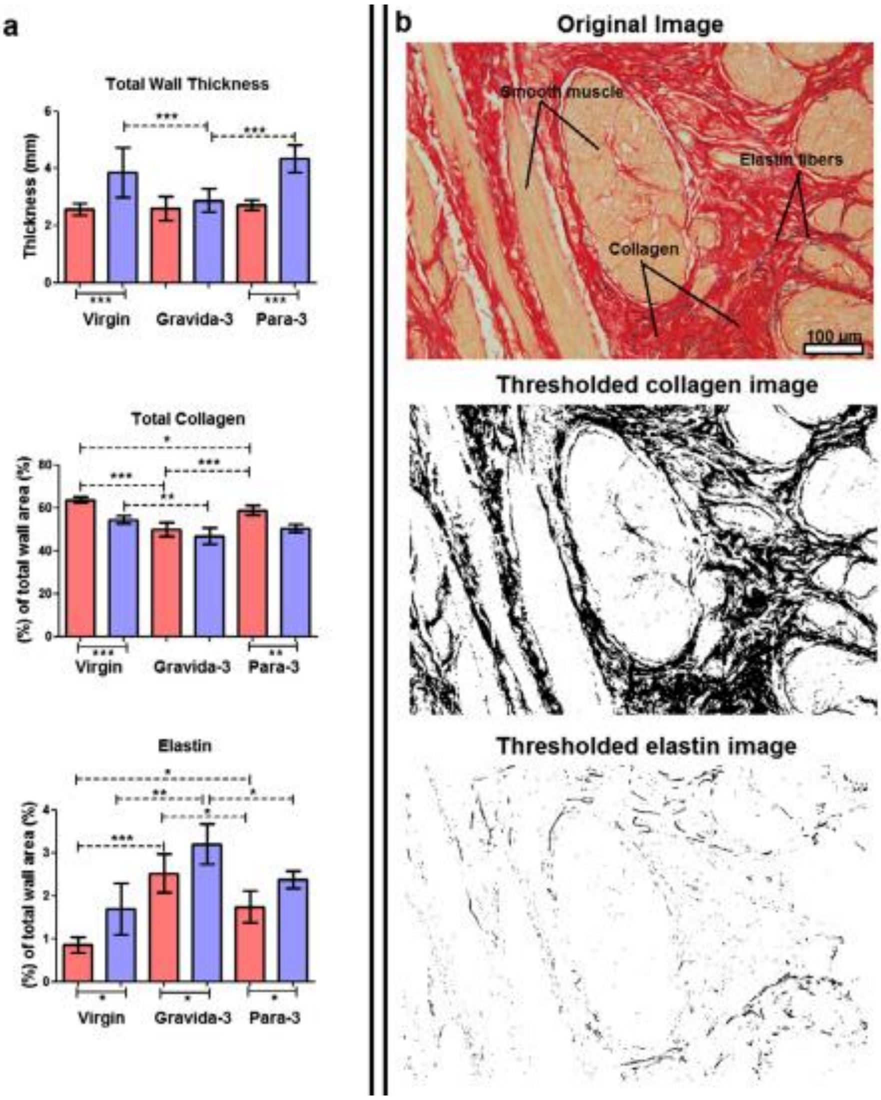

Figure 2: Vertical column bar graphs (mean with ± SEM) representing vaginal wall thickness (mm), total collagen (%), elastin (%) and smooth muscle and myofibroblasts content.

Vaginal wall Changes with Pregnancy:

In one study [15] using full-thickness sections of isolated mouse vagina, we found that pregnancy provides amazing physiologic changes in biomechanical homes. During pregnancy, the resting size of the vaginal wall is increased and may distend up to 3 times in diameter compared with vaginal tissues from non-pregnant animals (i.e., 2-fold boost in strain). Tissue stiffness is reduced. These seem intuitive compensations to permit parturition. These modifications, nevertheless, come at the cost of vaginal wall strength; the pregnant vaginal area withstood less optimum tension (force per unit area). Thus, while the vagina appears to undergo considerable adaptations during pregnancy to enable maximal versatility and distention, late-pregnancy is ripe for considerable vaginal wall injury if the vaginal wall is stretched beyond these adjustments [15].

These findings are in contract with a recent report by Lowder, et al where the whole reproductive system of the rat with the vagina and its helpful connective tissue attachments were evaluated as a complex. The system was tensioned in a uniaxial load-to-failure test by pulling the distal vagina downward in its longitudinal axis. Using this method, mean direct stiffness and supreme load at failure were decreased in pregnancy and at delivery while optimum distention was increased sometimes of delivery [16]. By testing the entire complex with the surrounding connective tissue accessories undamaged, their model was sensitive to the compensatory adaptations and interactions of the uterosacral ligaments, perineal membrane, vagina, and paravaginal accessories. Our study expands and complements their findings by examining the biomechanical properties of one part of this system in isolation: the vaginal wall. Our testing procedure involved period rests in between progressive increases in vaginal diameter to allow for tissue healing in between succeeding stretches.

This protocol maybe offers more information regarding the biomechanical homes of the vagina throughout parturition with progressive and cyclic distention of the vaginal area (15,16).

The function of the cervix from this minute is to maintain and secure the growing conceptus. An efficient barrier is mostly accomplished through keeping a sufficient length of closed cervix within which the mucus plug can prevent ascent of microorganisms from the lower genital system (17). This is aided by keeping sufficient strength at the level of the internal os to dissuade descent of the fetal membranes and conceptus down the cervical canal, which may shorten this barrier and/or dislodge the mucous plug.

The appearances of the cervix throughout pregnancy have actually been well recorded using transvaginal ultrasound imaging. In regular pregnancy, sonographic measurements show that cervical length shows a bell-shaped circulation, like the majority of biologic variables (18), with the majority of ladies keeping a cervical length in between 30 and 40 mm throughout pregnancy (**Figure 3A**) (19). Pregnancies in whom the cervical length is less than 20 mm are most likely to provide preterm (before 37 finished weeks of pregnancy, (**Figure 3B**). Methods utilized to prevent this include reinforcement of the weak or brief cervix by inserting an encircling suture (20).

Maintenance of length may also be assisted in typical pregnancy by displacement of the internal cervical os, which has actually likewise been observed utilizing ultrasound imaging. In a research study looking at singleton and twin pregnancies, 2 transperineal scans were performed 12 weeks apart (20 and 32 weeks). Both scans were registered utilizing the pubic symphysis as a set point of referral to enable the internal os to be tracked. Comparable displacement of the internal os was observed in both groups (21 mm vs. 20 mm), nevertheless the instructions of displacement was anteriorly in singletons and inferiorly in twin pregnancies. Additionally, cervical shortening was just connected with inferior displacement (21). It was therefore speculated that the increased inferior displacement seen in twin pregnancies was as a result of increased uterine weight, resulting in the stretching of the cervical assistance structures and increased uterine distension, which in turn may accelerate physiologic cervical changes. The use of physician-inserted cervical pessaries in pregnancies at risk of preterm birth is hypothesised to highlight anterior displacement and may explain their efficacy (22).

The three-dimensional (3D) anatomy of the cervix during pregnancy is badly comprehended (23), and it is just in the last ten years that the structural changes that happen have been studied. The favored methods of examination consist of magnetic resonance imaging (MRI) (24,25) and 3D ultrasonography (26,27), with restorations based on these anatomic information and others stemmed from the known physical properties of the sub-epithelial stromal components. Although there are some constraints with the techniques, these are some of the very first studies that have actually thought about the three-dimensional cervical changes that happen during pregnancy. In one research study, women who were going through MRI for thought fetal irregularities were thereby able to offer morphologic information regarding uterine structural modifications. Images were gotten at 17 - 36 weeks using a 1.5 T fast-spin echo proton density-weighted pulse sequence. It was observed that as gestational age increased, both the cross-sectional area of cervical canal and cervical stroma increased by around one-third. It was recommended that the modifications could be attributed to a decline in tensile strength of the stroma due to collagenolysis and reduced collagen material, with the increase in stromal location being a consequence of collagen network relaxation (24).

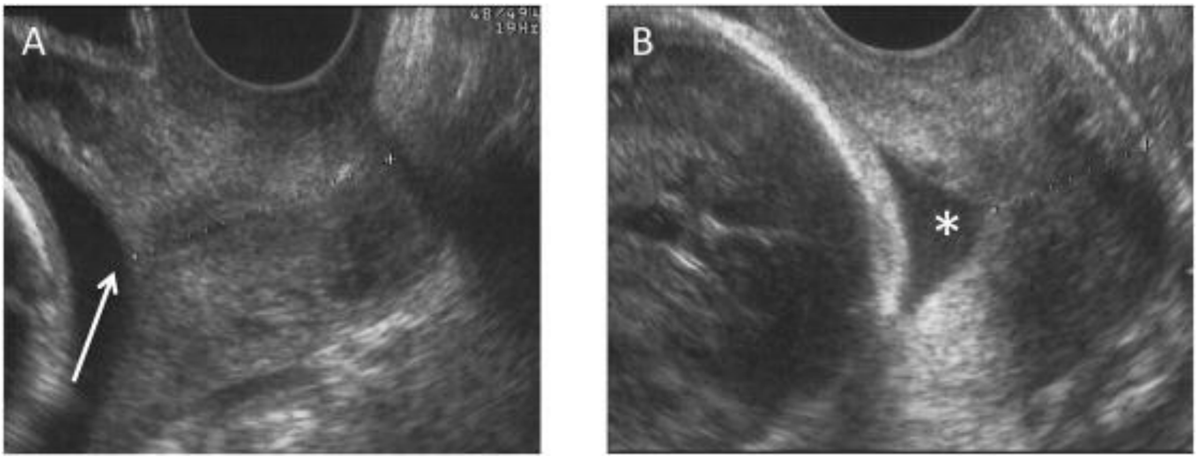

Figure 3: Transvaginal ultrasound scan images displaying changes in the appearance of the cervix in the mid-trimester of pregnancy.

Biochemical analyses are" gold standard" methods used for exact overall collagen and elastin content measurements (28). These methods have been compared with histomorphometric image analysis. Some research studies, utilizing image analysis methods for histology have been released (29). It was concluded that morphometric analysis proved to be adequate and can be utilized as a simple, inexpensive and fast technology for assessing overall collagen (30). in some articles the used image analysis techniques, allowed an in-depth analysis of tissue structure. It was observed that proximal vaginal area has a greater amount of collagen and a lower amount of elastin than distal vagina. A greater total collagen and lower elastin count accompanied a greater supreme stress and Young's modulus. A recent review concluded that the vaginal area predominantly comprises collagen type I which is mostly responsible for its tensile strength (31).

Pregnancy effect with Prolapse of vaginal wall:

The etiology of prolapse is multifactorial and complex, but many human and animal research studies indicate the associated injury of giving birth as playing a substantial role. DeLancey, et al. have revealed that gross changes to the surrounding pelvic muscle support, i.e. the levator rectum, appear in females with prolapse. These patients have the ability to create less vaginal closure force during muscle contractions, and their genital hiatus is larger than in nonprolapsed controls (32). In general, it appears that parturition with vaginal distention can adversely affect the integrity of gross muscular assistance of the levator rectum, the striated and smooth muscle of the urethral and vaginal walls, and the connective tissue network crucial to pelvic visceral assistance.

The research studies of biomechanical residential or commercial properties that have actually been carried out in ladies with prolapse have actually yielded conflicting outcomes. Goh, et al. studied pre- and postmenopausal women with prolapse and discovered similar degrees of tissue deformation (i.e. maximal pressure) in spite of menopausal status. Tissues from women without prolapse were not evaluated (33). Lei, et al. described substantial differences between pre- and postmenopausal women with and without prolapse; in general, prolapse provided less flexibility and higher stiffness although vaginal tissues from women with severe prolapse showed low forces at failure (34). A third study showed marked irregularity in maximal strength and pressure with no discernable trends in biomechanical residential or commercial properties of vaginal samples taken from 16 postmenopausal females with prolapse (35).

Part of the irregularity in present human studies of biomechanical residential or commercial properties of vaginal prolapse is most likely due to the technique of tissue acquisition. When vaginal wall is excised throughout a prolapse surgery (e.g. from an anterior colporrhaphy), the vaginal muscularis is frequently split or separated from the adventitia. The tissue biopsy may be highly variable depending upon the supreme amounts of epithelium, sub-epithelial connective tissue, and muscularis. In an animal model, complete density vaginal area can be analyzed in all cases. In particular, there is worth in using an animal model with prolapse to study the changes in biomechanical homes. The majority of Fbln5 mice will develop pelvic organ prolapse with increasing age, however about 10% do not. In this study, these non-prolapsed Fbln5-mice, which were age-matched to the prolapsed animals, were not statistically various than non-pregnant controls with respect to maximum tension, stress, or stiffness. Prolapsed knockout animals, however, showed biomechanical homes similar to those of the pregnant animals when compared to non-pregnant controls: the vaginal areas of prolapsed mice demonstrated increased strain and reduced tightness with reduced optimum tension. That is, problems in elastin synthesis alone are insufficient to trigger changes in the biomechanical homes of the vaginal wall. The presence of abnormal flexible fibers in knockout mice typically leads to an increase in matrix-metalloprotease (MMP) activity in the extracellular matrix (36); MMPs will digest collagen fibers in addition to elastin degradative products, and the irregular or decreased collagen content might eventually be the determinant of modified biomechanical residential or commercial properties (37). When a combination of factors-- be it age, parity with vaginal distention trauma, or other factors that change collagen fiber integrity promote the development to overt prolapse, the biomechanical properties of the vaginal wall are essentially altered.

4. CONCLUSION

The vaginal area must go through significant modifications during pregnancy to permit passage of a fetus at the time of delivery Although clinically it is understood that these maternal adaptations take place, this study sought to measure how these adaptations are manifested in regards to the mechanical function of the vaginal area. The data confirmed scientific impressions by demonstrating significant changes in the passive mechanical residential or commercial properties and contractility of the vaginal area throughout pregnancy and into the postpartum period. Morphometric and histological parameters, for proximal and distal vaginal wall. The result of repeated pregnancies with vaginal shipments was studied. Morphometric analysis for each vaginal wall layer of the sheep model (squamous epithelium, lamina muscularis, propria and adventitia) was carried out in a clear and detailed method. Base line observations in young virgin animals were made. Exceptional changes were observed during the 3rd pregnancy which were visible one year after 3rd delivery.

REFERENCES

[1] Mant J, Painter R, Vessey M. Epidemiology of genital prolapse: observations from the Oxford Family Planning Association Study. Br J Obstet Gynaecol. 1997;104(5):579–85.

[2] Patel DA, Xu X, Thomason AD, Ransom SB, Ivy JS, DeLancey JO. Childbirth and pelvic floor dysfunction: an epidemiologic approach to the assessment of prevention opportunities at delivery. Am J Obstet Gynecol. 2006;195:23–8.

[3] Fitzgerald MP, Mollenhauer J, Hale DS, Benson JT, Brubaker L. Urethral collagen morphologic characteristics among women with genuine stress incontinence. Am J Obstet Gynecol. 2000;182:1565–74.

[4] Drewes PG, Yanagisawa H, Starcher B, Hornstra IK, Csiszar K, Marinis SI, et al. Pelvic organ prolapse in Fibulin-5 knockout mice: pregnancy changes in elastic fiber homeostasis in mouse vagina. Am J Pathol. 2007;170:578–89.

[5] Boreham MK, Wai CY, Miller RT, Schaffer JI, Word RA. Morphometric analysis of smooth muscle in the anterior vaginal wall of women with pelvic organ prolapse. Am J Obstet Gynecol. 2002;187(1):56–63.

[6] Drutz HP, Alarab M. Pelvic organ prolapse: demographics and future growth prospects. Int. Urogynecol. J Pelvic Floor Dysfunct. 2006;17(Suppl 1):S6–S9.

[7] Subak LL, Waetjen LE, Va Den Eeden S, Vittinghoff DH, Brown JS. Cost of pelvic organ prolapse surgery in the United States. Obstet. Gynecol. 2001;98(4):646–651.

[8] Olsen AL, Smith VJ, Bergstrom JO, Colling JC, Clark AL. Epidemiology of surgically managed pelvic organ prolapse and urinary incontinence. Obstet. Gynecol. 1997;89(4):501–506.

[9] DeLancey JO. The hidden epidemic of pelvic floor dysfunction: achievable goals for improved prevention and treatment. Am. J. Obstet. Gynecol. 2005;192(5):1488–1495.

[10] Abramowitch SD, Feola A, Jallah Z, Moalli PA. Tissue mechanics, animal models, and pelvic organ prolapse: a review. Eur. J. Obstet. Gynecol. Reprod. Biol. 2009;144(Suppl 1):S146–S158.

[11] DeLancey JO. Anatomic aspects of vaginal eversion after hysterectomy. Am. J. Obstet. Gynecol. 1992;166(6 Pt 1):1717–1724. discussion 1724–8.

[12] Yanagishita M. Proteoglycans and hyaluronan in female reproductive organs. EXS. 1994;70:179–190.

[13] Wen Y, Zhao YY, Li S, Polan ML, Chen BH. Differences in mRNA and protein

[14] Junqueira, L.C., Mescher, A.L., 2009. Junqueira's Basic Histology, 12th. McGraw-Hill Medical, New York. Chapter 22.

[15] Rahn DD, Ruff MD, Brown SA, Tibbals HF, Word RA. Biomechanical Properties of The Vaginal Wall: Effect of Pregnancy, Elastic Fiber Deficiency, and Pelvic Organ Prolapse. *American journal of obstetrics and gynecology*. 2008;198(5):590.e1-590.e6. doi:10.1016/j.ajog.2008.02.022.

[16] Lowder JL, Debes KM, Moon DK, Howden N, Abramowitch SD, Moalli PA. Biomechanical adaptations of the rat vagina and supportive tissues in pregnancy to accommodate delivery. Obstet Gynecol. 2007;109:136–43.

[17] N. Becher, K. Adams Waldorf, M. Hein, N. Uldbjerg. The cervical mucus plug: structured review of the literature. Acta Obstet. Gynecol. Scand., 88 (2009), pp. 502-513,

[18] V.C. Heath, T.R. Southall, A.P. Souka, A. Elisseou, K.H. Nicolaides. Cervical length at 23 weeks of gestation: prediction of spontaneous preterm deliveryUltrasound Obstet. Gynecol., 12 (1998), pp. 312-317.

[19] H. GeeMechanics, biochemistry and pharmocology of the cervix and labourJ. Singer, H. Jones III, M. Shafi (Eds.), The Cervix (second ed.), Blackwell, Malden, Massachusetts (2006), pp. 183-193

[20] Royal College of Obstetricans and GynaecologistsGreen-top Guideline No. 60: Cervical Cerclage(2011).

[21] R. Parikh, A. Patel, T. Stack, S. Socrate, M. HouseHow the cervix shortens: an anatomic study using 3-dimensional transperineal sonography and image registration in singletons and twinsJ. Ultrasound Med., 30 (2011), pp. 1197-1204.

[22] M. Goya, L. Pratcorona, C. Merced, C. Rodó, L. Valle, A. Romero, *et al.*Cervical pessary in pregnant women with a short cervix (PECEP): an open-label randomised controlled trialLancet (Lond. Engl.), 379 (2012), pp. 1800-1806,

[23] M. House, R. McCabe, S. SocrateUsing imaging-based, three-dimensional models of the cervix and uterus for studies of cervical changes during pregnancyClin. Anat., 26 (2013), pp. 97-104,

[24] M. House, M. O'Callaghan, S. Bahrami, D. Chelmow, J. Kini, D. Wu, *et al.*Magnetic resonance imaging of the cervix during pregnancy: effect of gestational age and prior vaginal birthAm. J. Obstet. Gynecol., 193 (2005), pp. 1554-1560,

[25] M. House, R.A. Bhadelia, K. Myers, S. SocrateMagnetic resonance imaging of three-dimensional cervical anatomy in the second and third trimesterEur. J. Obstet. Gynecol. Reprod. Biol., 144 (Suppl) (2009), pp. S65-S69,

[26] M. Parikh, M. Rasmussen, L. Brubaker, C. Salomon, K. Sakamoto, R. Evenhouse, *et al.*Three dimensional virtual reality model of the normal female pelvic floorAnn. Biomed. Eng., 32 (2004), pp. 292-296,

[27] C.T. Lang, J.D. Iams, E. Tangchitnob, S. Socrate, M. HouseA method to visualize 3-dimensional anatomic changes in the cervix during pregnancy: a preliminary observational studyJ. Ultrasound Med., 29 (2010), pp. 255-260

[28] Ulrich, D., Edwards, S.L., Su, K., White, J.F., Ramshaw, J.A., Jenkin, G., Deprest, J., Rosamilia, A., Werkmeister, J.A., Gargett, C.E., 2014a. Influence of reproductive status on tissue composition and biomechanical properties of ovine vagina. Publ. Lib. Sci. 9.

[29] De Landsheere, L., Brieu, M., Blacher, S., Munaut, C., Nusgens, B., Rubod, C., Noel, A., Foidart, J.M., Nisolle, M., Cosson, M., 2016. Elastin density: link between histological and biomechanical properties of vaginal tissue in women with pelvic organ prolapse? Int. Urogynecol. J. 27, 629–635.

[30] Caetano, G.F., Fronza, M., Leite, M.N., Gomes, A., Frade, M.A., 2016. Comparison of collagen content in skin wounds evaluated by biochemical assay and by computer-aided histomorphometric analysis. Pharmaceut. Biol. 14, 1–5.

[31] Ulrich, D., Edwards, S.L., Su, K., White, J.F., Rosamilia, A., Gargett, C.E., Werkmeister, J.A., 2014b. Regional variation in tissue composition and biomechanical properties of postmenopausal ovine and human vagina. Publ. Lib. Sci. 9.

[32] DeLancey JO, Morgan DM, Fenner DE, Kearney R, Guire K, Miller JM, et al. Comparison of levator ani muscle defects and function in women with and without pelvic organ prolapse. Obstet Gynecol. 2007;109:295–302.

[33] Goh JT. Biomechanical properties of prolapsed vaginal tissue in pre- and postmenopausal women. Int Urogynecol J Pelvic Floor Dysfunct. 2002;13:76–9.

[34] Lei L, Song Y, Chen R. Biomechanical properties of prolapsed vaginal tissue in pre- and postmenopausal women. Int Urogynecol J Pelvic Floor Dysfunct. 2007;18:603–7.

[35] Cosson M, Lambaudie E, Boukerrou M, Lobry P, Crépin G, Ego A. A biomechanical study of the strength of vaginal tissues. Results on 16 post-menopausal patients presenting with genital prolapse. Eur J Obstet Gynecol Reprod Biol. 2004;112(2):201–5.

[36] Drewes PG, Yanagisawa H, Starcher B, Hornstra IK, Csiszar K, Marinis SI, et al. Pelvic organ prolapse in Fibulin-5 knockout mice: pregnancy changes in elastic fiber homeostasis in mouse vagina. Am J Pathol. 2007;170:578–89.

[37] Rundgren A. Physical properties of connective tissue as influenced by single and repeated pregnancies in the rat. Acta Physiol Scand Suppl. 1974;417:1–138.