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Original Article

SONOGRAPHIC ASPECTS AND ANATOMY OF THE APONEUROSIS OF TRANSVERSUS ABDOMINIS MUSCLE

Aspectos ultrassonográficos e anatomia da aponeurose do músculo transverso do abdome

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ABSTRACT - *Background*: Ultrasound, computed tomography, and magnetic resonance imaging of abdominal wall has increasingly been used for hernia diagnosis when clinical examination is uncertain. Anatomical study of abdominal wall along with the ultrasound of transversus abdominis muscle aponeurosis can help identify a Spigelian hernia in this region, a disease of difficult diagnosis. ***Aim*:** To compare the ultrasound findings of anterolateral wall of the abdomen, focusing on Spigelian aponeurosis, to the anatomy of abdominal wall studied in cadavers. ***Methods*:** The evaluation of the transversus abdominis aponeurosis was performed during routine ultrasound exams of the anterolateral wall of the abdomen in 90 individuals of both genders, over 25 years, and data were correlated with 60 dissections of the abdominal wall, held on cadavers. ***Results*:** Ultrasound showed no significant defects in the aponeurosis of transversus abdominis muscle in the 90 subjects studied and the width of the Spigelian aponeurosis ranged from 0.83 to 2.93 cm (mean 1.72 cm). During dissections of the transversus abdominis, some defects were found in 14 out of 60 muscles and aponeurosis studied (23.3%) and the width of the Spigelian aponeurosis ranged from 1.5 to 3.5 cm (mean 2.26 cm). Comparisons between age groups and genders evaluated by ultrasound with cadaver dissections performed were not statistically significant. ***Conclusion*:** Sonographic examinations found no defects in the aponeurosis of transversus abdominis muscle compatible with hernias, and anatomical variations and defects found during dissections were not as well accompanied by Spigelian hernias in the studied corpse.

HEADINGS - Ventral hernia. Ultrasonics. Abdominal wall. Anatomy.

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RESUMO - *Racional*: A avaliação da parede abdominal pela ultrassonografia, tomografia computadorizada e ressonância magnética tem sido cada vez mais indicada para auxiliar no diagnóstico das hérnias quando o exame clínico deixa dúvidas. A correlação de estudos da anatomia da parede abdominal com o exame ultrassonográfico da aponeurose do músculo transverso do abdome pode auxiliar no diagnóstico de uma hérnia desta localização, a hérnia de Spiegel, que se apresenta como doença de diagnóstico clínico difícil. ***Objetivo***: Comparar os achados ultrassonográficos da parede anterolateral do abdome, com foco na aponeurose de Spiegel, e a anatomia da parede abdominal estudada em cadáveres não fixados. ***Método*:** A avaliação da aponeurose do músculo transverso do abdome foi realizada durante exames ultrassonográficos de rotina da parede anterolateral do abdome em 90 indivíduos de ambos os gêneros, maiores de 25 anos e estes dados foram relacionados com 60 dissecções da parede abdominal realizadas em cadáveres não fixados. ***Resultados*:** Os exames ultrassonográficos não evidenciaram falhas significativas na aponeurose do músculo transverso do abdome nos 90 indivíduos estudados e a largura das aponeuroses de Spiegel variou de 0,83 a 2,93 cm (média de 1,72 cm). Durante as dissecções do transverso do abdome foram encontradas alterações anatômicas em 14 de 60 músculos e aponeuroses estudadas (23,3%) e a largura da aponeurose de Spiegel variou de 1,5 a 3,5 cm (média de 2,26 cm). A comparação entre os grupos etários e gêneros avaliados pelo estudo ultrassonográfico com as dissecções efetuadas em cadáveres não apresentou significância estatística. ***Conclusão*:** Os exames ultrassonográficos não encontraram defeitos na aponeurose do músculo transverso do abdome compatíveis com hérnias, assim como as variações anatômicas e os defeitos encontrados durante as dissecções também não foram acompanhados de hérnias de Spiegel nos cadáveres estudados.

DESCRITORES - Hérnia ventral. Ultrassom. Parede abdominal. Anatomia.

INTRODUCTION

The study of aponeurosis of the transversus abdominis muscle is clinically important, since a failure in the fibers disposition of this aponeurosis may be responsible for the development of uncommon hernia, with difficult clinic diagnostic, called Spigelian hernia, which would be represented by the protrusion of a peritoneal sac and preperitoneal fat, due to a defect of this aponeurosis between the semilunar line and the lateral border of the rectus abdominis[13]. With the use of ultrasound, computed tomography[8,27] and magnetic resonance[24], the diagnosis of this disease has increased in recent years.

Ultrasonography has been used for the evaluation of Spigelian hernia from the pioneering studies of Leif Spangen in 1976[25]. It is a rapid, non-invasive exam that provides good quality images and properly shows the structures of the abdominal wall even in obese and can be easily performed in emergency[4]. This test has also been extensively used in the study of other hernias and also for the differentiation of palpable masses, in case of doubt in the clinical examination, in order to figure out whether they originate were in the cavity or in the abdominal wall[7]. The improvement in image quality with the use of high-frequency transducers, the possibility of dynamic evaluation of the abdominal wall in supine position, with the aid of the Valsalva maneuver and the detailed study of the muscular plans, this exam is more widely recommended[24].

Computed tomography clearly shows the plans of the abdominal wall, being an option when doubt persists; it also allows evaluation with increased intra-abdominal pressure induced by the Valsalva maneuver. The peritoneography with contrast was described to complement the evaluation when the clinical suspicion of hernia is significant and the clinical examination is not conclusive[6,24].

Magnetic resonance has begun to be used, and is considered accurate, but all methods of diagnostic imaging are subjected to flaws that can interfere with the quality of the exam[20,29], being particularly useful in obese[9].

The three muscles of the anterolateral abdominal wall (external oblique, internal oblique and transversus abdominis), become aponeurotic medially and form the sheath of the rectus abdominis. Above the arcuate line the internal oblique aponeurosis splits, merging in the upper side with the aponeurosis of the external oblique and in the lower side with the aponeurosis of the transversus abdominis muscle, forming this sheath. Below the arcuate line, this division of the aponeurosis of the internal oblique aponeurosis is absent and the three muscles pass in front of to the rectus abdominis. The transversus abdominis muscle is the deepest, its lateral portion is muscular and the medial is aponeurotic. The boundary separating these portions describes a curve of external convexity, from costal margin to the pubis, the semilunar line (Linea Semilunaris) or Spiegel line. The portion of the transversus abdominis aponeurosis between the semilunar line and the lateral edge of the rectus sheath is called Spiegel aponeurosis[12,26,27].

The aim of this paper was to compare the results of ultrasound examinations of transversus abdominis muscle aponeurosis to the anatomy of the abdominal wall studied in unfixed cadavers (Figure1).

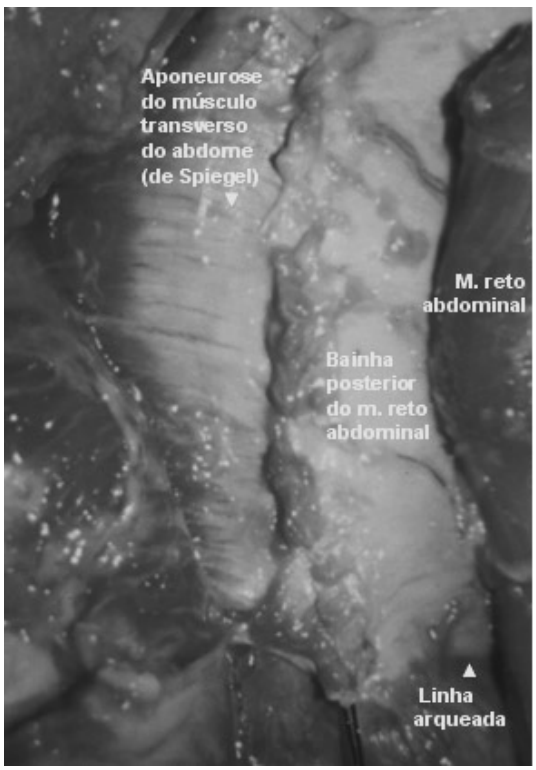

FIGURE 1 - Dissection of the aponeurosis of the transversus abdominis muscle above the arcuate line cadaver not formalin-fixed

METHOD

For sonographic evaluation 90 individuals were assessed, 45 females and 45 males. Each of these larger groups were divided by age into groups of 15 individuals of each gender, two groups aged between 25 and 44 years, two aged between 45 and 64 years and two groups over 65.

The dynamic study of the abdominal wall was performed by ultrasound Nemio Toshiba®, with a 7.5 MHz linear transducer. All examinations were performed by the same observer. The evaluation focused on the transversus abdominis muscle and its aponeurosis above (Figure 2) and below the arcuate line (Figure 3) during routine examinations of the anterolateral wall of the abdomen, in individuals who have accepted the experiment, in accordance with a consent term previously established. The choice of the aponeurosis to be assessed and measured, if right or left was at random, but the measurements were always performed above the arcuate line (Figure 2).

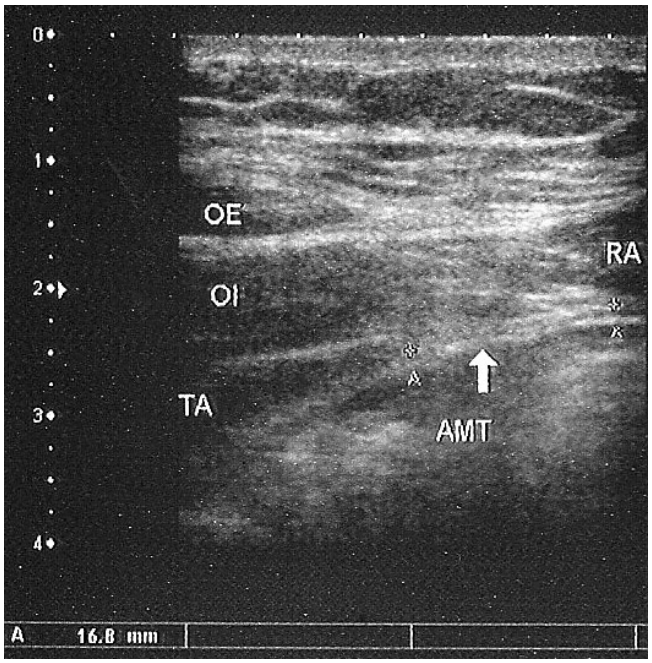

FIGURE 2 - Ultrasonographic image of the aponeurosis of the transversus abdominis muscle above the arcuate line. OE (external oblique), OI (internal oblique), TA (transversus abdominis) and RA (rectus abdominis) represent the muscles studied. AMT: aponeurosis of the transversus abdominis muscle above the arcuate line, in this image measuring 1.68 cm

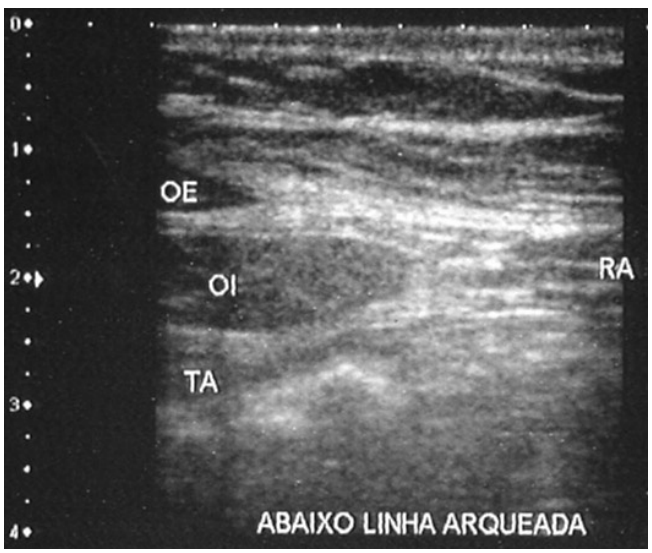

FIGURE 3 - Ultrasound image of the abdominal wall below the arcuate line. OE (external oblique), OI (internal oblique), TA (transversus abdominis) and RA (rectus abdominis) represent the studied muscles

The values obtained were related to anatomical data of the anterolateral wall of the abdomen of cadavers studied by Leme in 1996[12], who dissected 31 unfixed corpses with an average age of 65 years, having been held unilateral dissection in the first two cadavers and in the 29 remaining the study of bilateral abdominal wall, performing 60 dissections (Figure 1).

Measures of aponeurosis between each of the groups divided by gender and by age were compared to measurements obtained during cadaver dissections. The results were statistically analyzed by Student's t test.

RESULTS

There were no flaws compatible with hernias during the sonographic evaluation of the aponeurosis of the transversus abdominis muscle in 90 subjects studied and the width of the aponeurosis of Spiegel ranged from 0.83 to 2.93 cm, measuring an average of 1.72 cm.

The average width in inches of the aponeurosis of the transversus abdominis muscle obtained by ultrasound was similar among the 45 individuals of each gender, being 12.5 % higher in men. The largest difference occurred in the group of men between 25 and 44 years which presented as an average 42.5 % higher compared to women of the same age. The width of the aponeurosis of this age group was 25.2 % higher than the average of other age groups of males and 34.5 % higher than the average female age groups. When individual measures of each group were compared there was statistically significant difference ($p<0.05$) when comparing the groups of men between 25 and 44 years with over 65 years ($p=0.01$) and when the groups of women between 25 and 44 years were compared to the women between 45 and 64 years ($p=0.04$).

During the 60 dissections of the transversus abdominis muscle, besides the unusual arrangement of muscle fibers, several spindle defects in its aponeurosis (14 dissections - 23.3 %) were found, but there was no Spigelian hernia in dissected cadavers. The semilunar line was studied in all dissections, aponeurosis was measured, and values between 1.5 and 3.5 cm was found, with a mean of 2.26 cm (Table 1).

Comparison of measures of aponeurosis between age groups and genders evaluated by ultrasonography with the values found during dissections performed on cadavers showed no statistical significance ($p>0.05$).

TABLE 1 - Distribution of study groups with ultrasound and average values in centimeters of the transversus abdominis aponeurosis.

Gender and number of individuals	Male (45)	Female (45)
Age (years) 15 individuals / group	inches average of the transversus abdominis aponeurosis	
25 to 44	2,46	1,41
45 to 64	1,44	1,78
over 65	1,64	1,64
group average	1,84	1,61

DISCUSSION

Ultrasonography of the abdominal wall is a suitable method for the study of the aponeurosis of the transversus abdominis and images, usually performed bilaterally, are analyzed by comparing the left and right aponeurosis of the same person. Spangen[27] considers the accuracy of ultrasound and computed tomography very similar to detect Spigelian hernia.

There is a difference in echogenicity between the skin, more echogenic, and the subcutaneous tissue, which has variable thickness, but the fatty layer is show hypoechoic on ultrasound. Muscle layers can be recognized by their peculiar lamellar characteristic. The tests are usually performed with high frequency linear transducers, ranging between 5 and 12 MHz. Examination can be started with panoramic images to show the structures of the abdominal wall. There is no need for specific training and even when the skin is injured, transducer can be covered with a protective sterile or even a glove, allowing appropriate examination[7].

Jamadar et al.[11] did not described difficulties in assessing the lateral edge of the rectus abdominis sheath when looking for Spigelian hernias. When evaluating the inguinal region, they considered the structures in this region shallow, so that a 10 MHz linear transducer would already be effective, although in subjects with greater muscle mass a 7 MHz transducer may be needed. In obese, anatomical structures can be more difficult to be individualized, especially when studying the inguinal region, but this statement is refuted by Spangen[27] who, evaluating the aponeurosis of the transversus abdominis, found that fat tissue does not affect penetration or reflection of ultrasound. The Valsalva maneuver is important and can identify smaller hernias with no content in the hernia sac. When this study was standardized the same 7.5-MHz transducer was chosen to perform all tests and obesity was not a limiting factor to obtain adequate images. Spigelian hernia is uncommon, but the classic discussion about being a poorly recognized hernia and not properly rare remains[18,19]. It is a type of hernia rarely reported in Brazilian literature[14]. Most of its symptoms are associated with complaints of pain or bowel incarceration. In the last decade there has been significant increase of the indication of computed tomography in emergency situations, being currently considered the best option for the diagnosis of abdominal emergencies related to hernias[4,8,16].

Even with the computed tomography it is possible to get images while performing the Valsalva maneuver to increase intra-abdominal pressure. This study can be complemented with contrast injection into the peritoneal cavity (peritoneography), a more invasive method to detect hernias of difficult diagnosis, a method not widespread in the Brazilian usual procedures, but their has to be reported[6,24]. An important caution in the interpretation of this exam must be taken while assessing areas of thinning of the abdominal wall, which does not represent the presence of hernias. Tomography is useful when the adipose tissue is very thick and turns it difficult for an accurate clinical examination[6]. Magnetic resonance imaging has also been used and is considered an accurate test, but the methods of diagnostic imaging are subjected to some circumstances that may interfere with the interpretation of the exams[20]. Even the movements of the abdomen while breathing or the fat of the abdominal wall can produce significant misinterpretation of the magnetic resonance images[29]. As the other tests mentioned, it will depend on the radiologist's interpretation and its indications and use in the hernia studies hernias has recently begun to be widespread, being recommended as an adequate and accurate option whenever there is a diagnostic doubt.

The anterolateral wall of the abdomen has a laminar structure. The external oblique muscle is the largest and strongest of the lateral wall of the abdomen, with a lateral muscular portion and a medial aponeurotic portion. Attachment of its lower fibers portion forms the inguinal ligament between the anterior superior iliac spine and the pubic tubercle. Medially it contributes to the formation of the linea alba and its aponeurotic portion in the inguinal region forms the superficial inguinal ring, the inguinal and lacunar ligament[2,10]. The internal oblique muscle is smaller and thinner than the external oblique, being fused with the costal margin, twelfth rib and xiphoid appendix. It is medially directed to the rectus sheath and inferiorly to the pubis, iliac crest and anterior superior iliac spine. It's anterior fascicles fuse with the transversus abdominis and its medial fascicles end in the anterior external oblique aponeurosis.

The transversus abdominis is deep compared to the last six costal cartilages and it is interconnected with the fibers of the diaphragm. If viewed from inside the abdomen it seems only one muscle[21]. Its lower fibers are parallel to the internal oblique and its aponeurosis contributes to the rectus sheath, covering it posteriorly to the extent determined by the arcuate line[17]. There are controversies regarding the anatomical arrangement of the muscles of the anterolateral wall forming the sheath of the rectus sheath and there are anatomical variations described in all muscles of the anterior abdominal wall. The different arrangements of the abdominal muscles can be just considered variations of the usual arrangement of the fiber groups of these muscles.

Although there is more than one definition for the semilunar line and if is considered that the fusion of muscular and aponeurotic layers on the site is done very inaccurately, making it less visible[12], is considered the definition that describes as the line that marks the transition between muscle and aponeurosis of the transversus abdominis, a curved line of external

convexity, forming an arc of the costal margin to the pubis[25,26,27]. The portion of the transversus abdominis aponeurosis that lies between the semilunar line and the lateral edge of the rectus sheath is called the aponeurosis of Spiegel[26]. This aponeurosis can be covered by muscular or aponeurotic portion of the internal oblique. Spangen[25] appreciates a six inches strip above the imaginary line joining the anterior superior iliac spines, called "belt" of Spigelian hernia, where this aponeurosis and the internal oblique aponeurosis are wider. Most of these hernias are found in this place. In the study on cadavers used in this publication the width of the aponeurosis of Spiegel, the arrangement of the internal oblique and transversus abdominis in bands formed by bundles of muscle fibers as well as adipose tissue on the aponeurosis of Spiegel, though present, are not accompanied by hernias in the region. Askar[3], dissecting the transversus abdominis in 40 cadavers, noted that their muscle bundles were not really transverse. This author studied the decussation of the aponeurotic fibers of the abdominal muscles in the linea alba and found simple decussation of the fibers of the transversus abdominis in 30 % and triple in 70 % of his dissections. Anson et al.[2] found spindle defects of the transversus abdominis in 13 out 100 dissections. Although there are several, most of this anatomical variation was due to muscle insertions from the lower border of its aponeurosis, which can be found from a high position in the rectus sheath to the medial border of the femoral ring. These spindle defects were found in the dissections that have been made in our research, but the muscle proved quite resilient and its defects were small and little significant. In the region of the aponeurosis of Spiegel, the muscle fibers of the internal oblique and transversus abdominis followed a parallel course. Juxtaposed muscle bands in the internal oblique and mainly in the transversus abdominis where found, with little fat tissue between the muscular fascicles, featuring areas of significant weakening of the muscles between the bands, as well as defects such as gaps in the aponeurosis of the transversus abdominis. The anatomical variations and defects found during dissections of the transversus abdominis and internal oblique, did not show evidence of Spigelian hernias in cadavers, but the preperitoneal fat, dissecting the fibers of the aponeurosis of the internal oblique and Spiegel, was found both in operations and dissections, which may represent a relationship between the muscular and aponeurotic defects of the anterolateral abdominal wall and the Spigelian hernia[13].

Leme[12] conducted the study of not fixed corpses by formalin, dissecting materials similar to living tissue in color and texture, reviewed the surgical anatomy, anatomical changes in the anterolateral wall of the abdomen and Spigelian hernias. These studies were useful for comparison with the findings of ultrasound examinations evaluated in this publication. The average age of the cadavers dissected was 65 years, when Spigelian hernias occur more frequently.

Spigelian hernia is difficult to diagnose and sometimes imaging tests such as ultrasound, computed tomography and magnetic resonance imaging may be necessary. Ultrasound is very useful because it is simple, allowing for dynamic evaluation of the abdominal wall, both with the patient standing and during maneuvers that produce increased intra-abdominal pressure, it can be recommended as the first option when there is diagnostic doubt[24]. With the increasingly frequent use of images whit transverse cuts witch allows accurate assessment of anatomical details, the possibilities to perform the diagnosis in difficult cases has increased, but its use has yet to be properly determined[28], since much of the literature available for consultation is based on clinical case reports[4,5,15,22,23,30]. Nowadays there has been some research showing the superiority of a more specific method such as magnetic resonance[1].

CONCLUSION

Sonographic examinations showed no defect in the aponeurosis of the transversus abdominis compatible with hernias, as well as the anatomical variations and defects found during dissections have not as well been followed by Spigelian hernia on the corpse.

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REFERENCES

1 Aguirre DA, Casola G, Sirlinhttp://www.ajronline.org/content/183/3/681.long - aff-1 C. Abdominal Wall Hernias: MDCT Findings. Am J Rad 2004; 183: 3.681-90
2. Anson BJ, Morgan EH, McVay CB. Surgical anatomy of the inguinal region based upon a study of 500 body - halves. Surg Gynecol Obstet 1960; 111: 707-25
3. Askar OM. Surgical anatomy of the aponeurotic expansions of the anterior abdominal wall. Ann R Coll Surg Engl 1977; 59: 313-21.
4. Chung KL, Kam CW. Left lower quadrant abdominal mass: a case of Spigelian hernia diagnosed by emergency ultrasound. Hong Kong J Emerg Med 2006; 13: 90-3
5. Demetriou GA, Nair MS, Al-Abed Y, Alobaid N, Safar-Aly H, Athow A. Appendicular abscess with appendicolith in a Spigelian hernia masquerading caecal volvulus - A case report. Int J Surg Case Rep 2012; 3: 481-2
6. Emby DJ, Aoun G. CT technique for suspected anterior abdominal wall hernia. Am J Rad 2003; 181: 431-3
7. Gokhale S. Sonography in identification of abdominal wall lesions presenting as palpable masses. J Ultrasound Med 2006; 25: 1199-1209
8. Goodman P, Raval B. CT of the Abdominal Wall. Am J Rad 1990; 154: 1207-11
9. Graf JL, Caty MG, Martin DJ, Glick PL. Pediatric hernias. Semin Ultrasound CT MR 2002; 23: 197-200

10. Halverson K, McVay CB. Inguinal e femoral hernioplasty. Arch Surg 1970; 101: 127-35
11. Jamadar DA, Jacobson JA, Morag Y, Girish G, Ebrahim F, Gest T et al. Sonography of Inguinal Region Hernias. Am J Rad 2006; 187: 185-90
12. Leme PLS. Hérnia de Spiegel – Cirurgia e Anatomia: estudo de treze doentes e trinta e um cadáveres. Dissertação (Mestrado em Cirurgia Geral). São Paulo. Faculdade de Ciências Médicas da Santa Casa de São Paulo, 1996, 117 p.
13. Leme PLS, Carvalho DLM, Botter M, Höhne OMP, Salinas JA, Viana AT. Estudo anatômico da parede anterior do abdome em cadáver e hérnia de Spiegel. Rev Col Bras Cir 2001; 28: 414-20
14. Leme PLS, Soler WV, Terzian HG, Höhne OMP. Hérnia de Spiegel: relato de quatro casos. Rev Col Bras Cir 1990; 17: 114-8
15. Levy G, Nagar H, Blachar A, Ben-Sira L, Kessler A. Pre-operative sonographic diagnosis of incarcerated neonatal Spigelian hernia containing the testis. Pediatr Radiol 2003; 33: 407-9
16. Martin M, Paquette B, Badet N, Sheppard F, Aubry S, Delabrousse E. Spigelian hernia: CT findings and clinical relevance. Abdom Imag 2012; 3: published online 10.1007/s00261-012-9889-z
17. McVay CB. Abdominal wall. In: Anson & McVay Surgical anatomy. 6 ed. Philadelphia, Saunders, 1984, pp. 484-584
18. Mittal T, Kumar V, Khullar R, Sharma A, Soni V, Baijal M, at al. Diagnosis and management of Spigelian hernia: A review of literature and our experience. J Minim Access Surg 2008; 4: 95-8
19. Olson RO, Davis WC. Spigelian hernia: rare or obscure? Am J Surg 1968; 116: 842-6
20. Palácio GAS, Francisco VV, Abbehusen CL, Tiferes DA, D'Ippolito G, Szejnfelds J. Artefatos em ressonância magnética do abdome: ensaio iconográfico. Radiol Bras 2002; 35: 371-6
21. Rives JD. Anatomy of the attachments of the diaphragm: their relation to the problems of the surgery of diaphragmatic hernia. Ann Surg 1942; 115: 745-55
22. Salemis NS, Kontoravdis N, Gourgiotis S, Panagiotopoulos N, Gakis C, Dimitrakopoulos D. Colonic obstruction secondary to incarcerated Spigelian hernia in a severely obese patient. Int J Surg Case Rep 2010; 1: 27-9
23. Satorras-Fioretti AM, Vázquez-Cancelo J, Pigni-Benzo L, Salem AM, Ramos-Ardá A. Hernias de pared abdominal de localización poco frecuente. Cir Esp 2006; 79: 180-3
24. Sen G, Lochan R, Joypaul BV. Herniography (Peritoneography) for diagnosis of Spigelian hernia. Scottish Med J 2005; 50: 124-5
25. Spangen L. Spigelian hernia. Acta Chir Scand 1976; (suppl.) 462
26. Spangen L. Spigelian hernia. World J Surg 1989; 13: 573-80
27. Spangen L. Spigelian hernia. In: Nyhus LM, Condon RE. Hernia. 4 ed. Philadelphia, Lippincott, 1995, pp. 381-92
28. Toms AP, Dixon AK, Murphy JM, Jamieson NV. Illustrated review of new imaging techniques in the diagnosis of abdominal wall hernias. Br J Surg 1999; 86: 1243-9
29. Wood ML, Runge VM, Henkelman RM. Overcoming motion in abdominal MR imaging. Am J Rad 1988; 150: 513-22
30. Zeina AR, Mahamid A, Sakran N, Troitsa A. Computed Tomographic diagnosis of incarcerated Meckel's diverticulum in a patient with