

Indices of diagnostic abdominal ultrasonography in acute appendicitis. Influence of gender and physical constitution, time evolution of the disease and experience of radiologist

Índices diagnósticos da ultrassonografia abdominal na apendicite aguda. Influência do gênero e constituição física, tempo evolutivo da doença e experiência do radiologista

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A B S T R A C T

Objective: To assess the value of abdominal ultrasonography in the diagnosis of acute appendicitis and the influence of gender, physical constitution, experience of the radiologist and the time evolution of the disease on the results of diagnostic indices. **Methods:** We prospectively evaluated 156 patients with clinical diagnosis of acute appendicitis who underwent laparoscopic appendectomy and abdominal ultrasonography, together with pathology of the excised appendices. Patients were allocated in relation to BMI in both groups (below or above 25 kg/m²) and radiologists, in three groups according to their professional experience (less than five years, between five and 10 years and more than 10 years). The survey also assessed the influence of gender and time of disease progression using the median of 36 hours. **Results:** The sensitivity and specificity of abdominal ultrasonography for diagnosing appendicitis were 64.9 and 72% respectively. Gender, body mass index, length of experience of the radiologists in the three groups and time of onset of symptoms showed no significant differences in the establishment of sonographic diagnosis of acute appendicitis. **Conclusion:** The abdominal ultrasonography showed low sensitivity and specificity and little contribution to the diagnosis of acute appendicitis. Gender, physical constitution, the experience of the radiologist and time of onset of symptoms did not affect the outcome of the sonography.

Key words: Appendicitis. Ultrasonography. Diagnosis.

INTRODUCTION

The diagnosis of acute appendicitis is based on medical history and physical examination. The classical evolution of pain, described by Murphy in 1905¹, is a strong predictor of clinical diagnosis of acute appendicitis, with accuracy of 95%^{2,3}. However, it is present only in 50 to 60% of patients³. As a result, the number of non-therapeutic appendectomies and of cases operated with complications remains stable, although mortality from acute appendicitis has decreased from 26 to 1% in recent decades⁴.

The presence of an atypical clinical picture makes the diagnosis difficult and is characteristic of certain subgroups of patients: patients at extremes of age; obese; female patients in reproductive age or pregnant; patients using medications such as anti-inflammatories and immunosuppressives; patients with

pelvic or retrocecal appendices. In these patients the use of methods complementary to clinical diagnosis may be important⁵.

Since the first ecographic visualization of the vermiform appendix by Deutsch and Leopold in 1981⁶ and the description of graduated compression technique for abdominal examination by Puylaert in 1986⁷, ultrasound began to be referred to as a complementary diagnostic feature to acute appendicitis.

It features numerous advantages such as: availability and relative low cost; does not emit ionizing radiation and can be used repeatedly and in pregnant women; allows real-time examination and interaction with the patient, which identifies the spot of most tenderness in the abdomen; greater mobility, allowing the examination of the patient in the Emergency Department, intensive care and even in the operating room.

Work conducted in the Emergency Department of the Mount Sinai Maternity and General Hospital, Juiz de Fora – Minas Gerais – Brazil.

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With the spread of the method, factors that influence the accuracy of medical ultrasonography to the diagnosis of acute appendicitis were identified, among them gender and the patient's bodily Constitution, the time evolution of the disease and the experience of the radiologist.

The goal of this study was to verify the value and influence of these variables in the ultrasound diagnosis of acute appendicitis.

METHODS

We prospectively studied 156 patients with clinical diagnosis of suspicion of acute appendicitis, admitted to the Mount Sinai Maternity and Emergency Hospital, Juiz de Fora/MG, Brazil. All patients underwent informed consent through reading and signing the form. This project has been assessed and approved by the Commission of ethics in research of said institution.

We included in this study patients of both genders, aged over 12 years, submitted to abdominal ultrasound, laparoscopic appendectomy and pathological study of the vermiform appendix.

Were excluded patients with hemodynamic instability, coagulation disorders, pregnant women and those who have not agreed to participate in this survey.

Patients were clinically evaluated, valuing abdominal pain and migratory character, typical of acute appendicitis, the complaint of anorexia and the time of onset of symptoms in hours. The presence of painful sudden decompression, on the right iliac fossa or diffuse in the abdomen, was determined, in addition to the research of hyperthermia, regarded as axillary temperature equal to or exceeding 38° C measured with electronic thermometer. The laboratory exam requested was a complete blood count and leukocytosis was deemed present when above 12,000 leucocytes/mm².

Patients had their weight in kilograms and its height in meters measured at admission. Body mass index (BMI) in kg/m² was then estimated from these data, distributing the patients at two levels: normal, with a BMI of less than 25 kg/m² and overweight and obesity, with BMI over 25 kg/m².

Abdominal ultrasound examination was carried out at start, using the graduated compression technique, with the ultrasound apparatus Philips HDI-4000 with transducers of low and high frequency. The following diagnoses were described: compatible with the diagnosis of acute appendicitis, and not indicative of acute appendicitis.

Ecographic examinations were held by 11 radiologists, all with general training in Radiology, having their practice time stratified into three levels: less than five years (three radiologists); between five and 10 years

(four radiologists) and more than 10 years (four radiologists).

All patients were submitted to appendectomy through laparoscopy with pathological study of the operative specimen. The diagnosis of acute appendicitis was confirmed by the presence of neutrophils in the muscular layer (transmural infiltration) of the appendicular wall.

The result of the ecographic examinations was compared to the result of operative specimens for calculation of diagnostic indices. Diagnostic ultrasound guidance was considered correct true-positive when it was conclusive of acute appendicitis and confirmed by pathological examination of the appendix and true-negative when both abdominal ultrasound and pathological study of the appendix did not indicate acute appendicitis.

From crossing of variables of the database we developed the descriptive statistics. Diagnostic indices observed were sensitivity, specificity, positive and negative predictive value. For statistical validation, we used the Chi-square and Kruskal-Wallis tests, with significance level at $p < 0.05$.

RESULTS

Of 156 patients with clinical suspicion of acute appendicitis, the diagnosis was confirmed by pathology in 131 (83.9%), among these 106 (80.9%) displayed a typical clinical picture and 80 (61%) had leukocytosis.

The ultrasound examination asserted the diagnosis of acute appendicitis in 85 of the 131 patients, with a sensitivity of 64.9%. It appointed no acute appendicitis in 18 out of 25 patients who have not had this diagnosis confirmed by pathology, configuring a specificity of 72%. There were seven false-positive results and 46 false-negative ones, resulting in a positive predictive value of 92.4% and negative predictive value of 28.1% (Table 1).

Upon comparison of diagnostic accuracy indices in evaluation of vermiform appendix by ultrasound examination between the two groups of patients, as for the body mass index, there was no significant difference by Chi-square test ($p = 0.62$) (Table 2)

Table 1 - Values of the indices of abdominal ultrasound diagnosis in acute appendicitis (n = 156).

| Diagnostic values of indexes | |
|------------------------------|------|
| Sensitivity | 64.9 |
| Specificity | 72 |
| Positive predictive value | 92.4 |
| Negative predictive value | 28.1 |

Note: values expressed in percentages (%).

The comparison between the three groups of radiologists based on experience showed that there was no significant difference between them by the Chi-square test as to the accuracy of diagnosis in the evaluation of the vermiform appendix ($p = 0.837$) (Table 3).

There was no significant difference by Kruskal-Wallis test for the calculated medians of the variable "time from onset of symptoms" for every possible ultrasound outcome, i.e.: 43.6 ± 35.0 hours, true-positive; 55.3 ± 44.7 hours, true-negative; 52.3 ± 40.8 hours, false-positive; and 42.3 ± 38.1 hours, false-negative, with $p = 0.0748$ (Table 4).

Finally, a comparison of the ultrasound results between genders was made. Among the 82 men, ultrasound guidance returned the right diagnosis of acute appendicitis in 55 (67.1%) and erred in 27 (32.9%). In the 74 women it indicated a correct diagnosis in 48 (64.9%) and a wrong one in 26 (35.1%). There was no significant difference with Chi-square test, $p = 0.156$ (Table 5).

DISCUSSION

The diagnosis of acute appendicitis is based on clinical history and physical examination of patients, a true statement that persists today, as demonstrated in 2004 by Bergeron⁸. In that study, the evaluation of the surgeon had a positive predictive value of 83.9%. This data, comparable to that found in the literature, reinforce the importance of clinical symptoms and signs for the diagnosis of acute appendicitis, configuring an index of non-therapeutic

interventions in 16.0% of patients, very similar to data cited in the literature^{9,10}.

In this research, the clinical picture presented typically, with the classical evolution of pain in 80.9% of patients, including those with confirmed diagnosis of acute appendicitis. Certain studies^{2,3} claim that the accuracy of clinical examination in these patients is close to 95%, not being improved by the use of methods of image and, therefore, these patients should be operated without additional exams.

The use of repeated clinical examination is a widely used diagnostic option in patients with atypical clinical picture and may be used safely in those with time evolution under 24 hours who, according to Bickell *et al.*¹¹, present a low risk of perforation, from 0 to 2% every 12 hours. Clinical observation should be exercised with caution in patients with longer evolution time, because the risk of perforation in those with more than 36 hours of evolution is 5% every 12 hours, mainly in the elderly. Birnbaum and Wilson³ advocate that the intra-hospital clinical observation can increase the accuracy of clinical diagnosis without increasing the incidence of perforations.

The sensibility of abdominal ultrasound was 64.9%, representing 85 patients with conclusive result of acute appendicitis. This index is higher than the previous series studied by the same radiologists¹², with diagnostic accuracy of 55.8% of cases, and also higher than the published by Franke *et al.*¹³ in a multicenter study conducted in Germany and Austria, with sensitivity of 55%. However, it is lower than other previous works, such as that from

Table 2 - Comparison between diagnostic ultrasound for acute appendicitis with body mass index less than or greater than 25 kg/m².

| BMI | Abdominal ultrasound | | | | Total |
|------------------------|----------------------|---------------|----------------|----------------|-------|
| | True-Positive | True-Negative | False-Positive | False-Negative | |
| < 25 kg/m ² | 56 | 10 | 5 | 30 | 101 |
| > 25 kg/m ² | 29 | 8 | 2 | 16 | 55 |
| Total Geral | 85 | 18 | 7 | 46 | 156 |

BMI = body mass index, Chi-square test $p = 0.62$.

Table 3 - Ecographic diagnosis of acute appendicitis compared to radiologist experience.

| Radiologist Experience | Abdominal ultrasound | | | | Total |
|------------------------|----------------------|---------------|----------------|----------------|-------|
| | True-positive | True-negative | False-positive | False-negative | |
| < 5 anos | 38 | 9 | 3 | 19 | 69 |
| 5 a 10 anos | 29 | 3 | 2 | 15 | 49 |
| >10 anos | 18 | 6 | 2 | 12 | 38 |
| Total | 85 | 18 | 7 | 46 | 156 |

Chi-square test $p = 0.837$.

Table 4 - Comparison of median time of onset of symptoms of acute appendicitis with diagnostic ultrasound guidance.

| Diagnostic ultrasound guidance of acute appendicitis | Median time to onset of symptoms |
|--|----------------------------------|
| True-positive | 43.6 ± 35.0 h |
| True-negative | 55.3 ± 44.7 h |
| False-positive | 52.3 ± 40.8 h |
| False-negative | 42.3 ± 38.1 h |

Kruskal-Wallis Test: $p = 0.0748$.

Table 5 - Comparison between male and female patients with regard to ultrasound diagnosis of acute appendicitis.

| Patient's Gender | Abdominal ultrasound | | | | Total |
|------------------|----------------------|---------------|----------------|----------------|-------|
| | True-positive | True-negative | False-positive | False-negative | |
| Male | 49 | 6 | 2 | 25 | 82 |
| Female | 36 | 12 | 5 | 21 | 74 |
| Total | 85 | 18 | 7 | 46 | 156 |

Chi-square test: $p = 0.156$.

Lake *et al*¹⁴, with 83.1%, Birnbaum and Wilson³, mentioning values between 75 and 90%, Vidmar *et al*¹⁵, with sensitivity of 91%, and Douglas *et al*¹⁶, with sensitivity 94.7%.

The specificity of ultrasound in this work was 72%, lower than described by Franke *et al*¹³, 95%, by Vidmar *et al*¹⁵, 95.9%, and by Birnbaum and Wilson³, 86 to 100%.

The positive predictive value was 92.4%, consistent with that described by Vidmar *et al*¹⁵, 95.9%, Birnbaum and ³Wilson, between 91 and 94%, but higher than that of Franke *et al*¹³, 81%. It is in this variable that lies the main contribution of ultrasound examination for the diagnosis of acute appendicitis in this work.

There were seven cases of false-positives; the literature justifies these findings by the confusion of ileal loops with the vermiform appendix, by erroneous judgment of normal appendix and an inflamed one and by the occurrence of appendicitis with spontaneous resolution^{3,17}.

There were 46 false-negatives, resulting in a negative predictive value of 28.1%, far below the described usually in the literature^{3,13,15,18,19}. This can be due to the dichotomization of the report of the ultrasound examination in conclusive and not indicative of the diagnosis of acute appendicitis, hampering the decision of the radiologist in more complex cases. This low negative predictive value requires prudence in ruling out the diagnosis of acute appendicitis and this patient should be observed clinically, awaiting resolution of the symptoms before discharge from hospital. Persistence of the symptoms should prompt the use of other diagnostic methods, tomography and laparoscopy among them.

We did not find influence of body mass index in accuracy of ultrasound for the diagnosis of acute

appendicitis in this work. This agrees with Puylaert²⁰, who attests to be possible the use of graduated compression technique with high frequency transducers, even in obese patients, and this is primarily the method of choice among imaging techniques. Another assertion to that effect is found in the work of Tsai *et al*²¹, that even with the stratification for the use of ultrasound as diagnostic option for patients with a BMI of less than 30 kg/m², no better results were recorded.

Conversely, Blebea *et al*²² suggest that the ecographic technique is more suitable in pediatric and lean adult patients, the constitution of the obese being a limiting factor. These authors claim that the sensitivity and accuracy are lower for patients with a BMI above 30 kg/m², for whom they advocate that tomography would be a better diagnostic method.

It was noted, in that research, that there was influence of the radiologist experience in the diagnostic ultrasound accuracy for acute appendicitis.

A very interesting fact is that the more experienced group had lower accuracy diagnoses, even without statistical difference. This can be justified by the fact that young radiologists meet more patients in the emergency room and acquire more experience in the diagnosis of acute appendicitis. This item was examined by Vidmar *et al*¹⁵, which determined the radiologist experience based on the number of ecographic exams held in the year, finding a statistical difference between examiners.

The time of symptoms evolution is important for both clinical and diagnostic accuracy. Patients with very recent symptoms may still not have the clinical signs and symptoms or image findings duly characterized so as to allow accurate diagnosis²³. On the evaluation of the variable

"time of onset of symptoms" a large amplitude (238 hours) was identified and the median was preferred, whose value was 36 hours, a time evolution in which usually symptoms and radiological findings are already established²⁴. It was demonstrated that this variable does not influence the diagnostic ultrasound of appendicitis.

Interesting data emerged when the time of onset of symptoms was compared to the experience of the radiologist, starting from the premise that most patients assisted in emergency rooms would be examined by less-experienced radiologists, who tend to work more in ER shifts. Patients examined by this group of radiologists were evaluated in early period of their clinical picture, which would theoretically make the diagnosis of acute appendicitis more difficult.

In relation to the possible benefit from the use of ultrasound to the diagnosis in female patients, there was no difference between the sensitivity of the method between genders in this series. The occurrence of more false-positive results among women (five out of seven – 71.4%), associated with a low negative predictive value (28.1%) reinforces this idea. This finding contrasts with the view of Paulson *et al.*², who define abdominal ultrasound as the method of choice among pregnant women and women with a high degree of suspicion of gynecological diseases as differential diagnosis. The use of laparoscopy seems especially opportune for female patients, allowing correct diagnosis and treatment²⁵.

The use of methods complementary to clinical data aims to reduce the incidence of non-therapeutic appendectomies, which causes unnecessary consumption of resources, both from the health system and the patients^{26,27}. The cost of radiological diagnosis is smaller in relation to unproductive surgical approach, besides the latter not being devoid of immediate and late complications, such as the formation of adhesions, which can lead to obstruction and infertility^{5,27}. Similarly, the correct and early diagnosis aims to reduce the most serious cases, accompanied by perforation and peritonitis, which increases the incidence of complications from 3 to 47%⁴.

The employment of imaging methods to assist the diagnosis of appendicitis is still far from consensus, as works like the one from Flumen *et al.*²⁸ show that even with the use of ultrasound and CT scan, the rate of non-therapeutic resection persists in expressive percentage (15%), notably in women of reproductive age and patients in extremes of age.

Another very important aspect is whether the routine use of diagnostic ultrasound will result in clinical benefit, allowing surgical approach in uncomplicated stages. The result of this research suggests that patients with typical clinical pictures should be forwarded to surgical treatment without the use of abdominal ultrasound.

The decision between the use of ultrasound and CT should be based on availability and preference of the institution and in the experience of radiologists, although age, sex and constitution are important factors.

Sensitivity and specificity of CT and ultrasound exams in diagnosis of acute appendicitis are near or even above 95% in research environment. These data may not be the guide for the daily practice of all hospitals and services²⁹⁻³⁶. This fact was demonstrated by Frankeet *al.*³ in a prospective, multicenter study in which the sensitivity of ultrasound was only 55%, a percentage that can be caused by various factors, including indication of the ultrasound exam in a routine or selective way and different experience with the method between the centers assessed.

In this study, the sensitivity of 64.9% for the ecographic diagnosis of acute appendicitis confirms the difficulty extrapolate results of other centers to the reality of a general hospital, without University affiliations. The fact that this research involves general, non-ultrasound-specialized radiologists, reinforces this idea and demonstrates that, in those circumstances, the clinical impression is still predominant and should serve as guidance for further examinations in the diagnosis of acute appendicitis.

Another important fact is that an ultrasound not indicative of acute appendicitis diagnosis should only be valued in association with favorable clinical evolution of the patient in the due to the high incidence of false-negative results. This is corroborated by Paulson *et al.*², according to whom the failure to identify the appendix limits the usefulness of ultrasound guidance in acute appendicitis.

The adoption of laparoscopy with diagnostic, and, if necessary, therapeutic, intention can be very useful in patients with still doubtful diagnosis. Further studies will be important to define its role in the management of acute appendicitis.

Closer interaction between radiologists and surgeons undoubtedly results in more appropriate care and safety for the patient with suspected acute appendicitis, avoiding diagnosis delay and its consequences and minimizing non-therapeutic interventions.

R E S U M O

Objetivo: Verificar o valor da ultrassonografia abdominal no diagnóstico da apendicite aguda e a influência do gênero, constituição física, experiência do radiologista e o tempo evolutivo da doença nos resultados dos índices diagnósticos. **Métodos:** Avaliou-se prospectivamente 156 pacientes com diagnóstico clínico de apendicite aguda, submetidos à ultrassonografia abdominal e apendicectomia laparoscópica, acompanhado de estudo anatomopatológico dos apêndices extirpados. Os pacientes foram alocados quanto ao IMC em dois grupos (abaixo ou acima de 25kg/m²) e os radiologistas, em três grupos conforme a experiência profissional

(menos de cinco anos, entre cinco e 10 anos e mais de 10 anos). A pesquisa avaliou também a interferência do gênero e do tempo de evolução da doença utilizando-se a mediana de 36 horas. **Resultados:** A sensibilidade e especificidade da ultrassonografia abdominal para o diagnóstico da apendicite aguda foram 64,9 e 72%, respectivamente. O gênero, o índice de massa corpórea, o tempo de experiência dos radiologistas nos três grupos estudados e o tempo de início de sintomas da doença, não demonstraram diferenças significativas no estabelecimento do diagnóstico ecográfico da apendicite aguda. **Conclusão:** A ultrassonografia abdominal apresentou baixa sensibilidade e especificidade e pouco contribuiu para diagnóstico da apendicite aguda. O gênero, a constituição física, a experiência do radiologista e tempo de início de sintomas da doença não interferiram no resultado do exame ecográfico.

Descritores: Apendicite. Ultrassonografia. Diagnóstico.

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