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Original Research Article

The Role of Pocus in the Diagnosis of Hollow Viscus Non-Traumatic Acute Abdomen

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Abstract

Point-of-care ultrasound (POCUS) is a non-invasive diagnostic bedside imaging modality which is a fast, safe, accurate and valuable tool for diagnosing gastrointestinal pathology, clinical decision making in emergency situations within a very short time. The aim of the study was to assess the role and clinical effects of the initial Point-of-Care ultrasound (POCUS) evaluation in the diagnosis of non-traumatic acute abdomen due to hollow viscus gastrointestinal pathology. The retrospective study included two hundred twenty-seven patients with abdominal pain admitted at the Emergency Department. Every patient underwent an initial POCUS examination. According to the clinical and sonographic findings, the patients were divided into three groups: patients with suspected inflammatory pathology of gastrointestinal origin, patients with bowel obstruction and patients with suspected gastrointestinal perforation. For each group, the sensitivity, specificity, and diagnostic accuracy were calculated and the coincidence of the initial clinical diagnosis and POCUS results with the discharge diagnosis based on intra-operative and histological findings was evaluated. Statistical analysis was performed using SPSS software for Windows version 16.0. POCUS could not detect any pathology in 31/227 (13.65%) cases, revealed a different diagnosis towards the clinical one in 7/227 (3.08%) and changed the treatment management in 33/227 (14.53%) patients. US diagnosis confirmed the clinical one in the inflammatory group in 56/57(98.24%); in the second one with ileus in 93/98 (94.89%) and in the third one with the perforation in 42/72 (58.33%) patients. A coincidence between the sonographic results and the discharge diagnosis was observed in 180/227 (79.29%) patients. POCUS could be a valuable and reliable first imaging modality for the diagnosis of non-traumatic acute abdomen due to hollow viscus gastrointestinal pathology.

Keywords: Ultrasonography, Point-of-Care ultrasound (POCUS), non-traumatic acute abdomen, hollow viscus

INTRODUCTION

The acute abdominal pain is the cardinal symptom of acute abdomen and one of the most frequent causes for emergency department (ED) visiting. Sometimes, an adequate history and physical evaluation alone are sufficient to put an accurate clinical diagnosis and to choose the appropriate treatment. Patients however may present with vague complaints and varying associated symptoms ranging from insignificant to life-threatening

conditions (Agboola et al., 2014; Mostbeck et al., 2016). The hospital admission is about 4-5% of all ED patients with an abdominal pain but only 1/4 of patients who have previously been classified with an acute abdomen, actually receive surgical treatment. The clinical dilemma is whether the patient should be operated or not and, furthermore, in which cases surgery should to be urgently performed (Jain and Gupta, 2017; Cartwright and Knudson, 2008; Abu-Zidan and Cevik, 2018).

In some cases the clinical features are not specific that is why it is very important to perform POCUS examination and interpret the sonographic, clinical and laboratory findings together in order to reach timely proper diagnosis and management (Abu-Zidan and Cevik, 2018). The lower cost and in particular the lacks of radiation exposure are the most important advantages of POCUS. Furthermore, the abdominal ultrasonography (US) is areal-time examination and this characteristic conveys dynamic information (Mazzei et al., 2013).

US abdominal examination is the first investigation in almost all cases with moderate and severe abdominal pain (Stoker et al., 2009). The main reasons for acute non-traumatic abdomen are acute appendicitis, bowel obstruction, acute diverticulitis and gastrointestinal perforations (Powers and Guertle, 1995; Venkateswarlu et al., 2015). US is the first imaging modality of choice in case of acute non-traumatic abdomen with a sensitivity of 85% to 90% in the hands of an experienced sonographer (Mazzei et al., 2013; Orr et al., 1995).

Acute appendicitis is a common emergency pathology and the inflamed appendix may perforate in one-third of the cases if the diagnosisis delayed (Mazzei et al., 2013). US is recommended as a first modality of choice for all age groups, especially in children and pregnant women, mainly because of its safety (Mazzei et al., 2013; Mostbeck et al., 2016; Benabbas et al., 2017; Riazi et al., 2003). The reported sensitivity of US in diagnosing acute appendicitis is 91%(83-96%), specificity 97% (91%-99%), PPV 91% and NPV 94% (Matthew et al., 2017).

US should be a method of choice for diagnosing acute diverticulitis supported by clinical evidence at that time (Liljegren et al., 2007). The sensitivity and specificity of USand CT are statistically similar in diagnosing acute colonic diverticulitis (91%-92% and 90%-100% for US, 94%-95% and 99% for CT) (O'Malley and Wilson, 2001; O'Malley and Wilson, 2003; Laméris et al., 2008; Toorenvliet et al., 2010; Sartelli et al., 2015). Besides, POCUS may detect complications of acute diverticulitis depending on its stage as abscess formation, free intraperitoneal fluid and free intraperitoneal air, which can be correlated with the classification of acute diverticulitis (Lim, 2000; Hefny and Abu-Zidan, 2011; Hefny et al., 2012).

Intestinal obstruction is a common gastrointestinal emergency that needs rapid and efficient management.

The role of ultrasonography in diagnosing intestinal obstruction is recognized since nearly four decades (Scheible and Goldberger, 1979; Dawson and Mallin, 2013). Additionally, US may help in detecting the cause and level of theobstruction (Dawson and Mallin, 2013; Suri et al., 1999). POCUS provides answers to important clinical questions like: (1) Is there an obstruction? (2) Is the obstruction mechanical or functional? (3) Where is the location ofthe obstruction? (4) Is there ischaemia or necrosis of the bowel? and (5) What is the clinical progress of the patient who was treated conservatively (Hefny et al., 2012). The diagnostic accuracy of emergency ultrasound for intestinal obstruction is 96-98% (Danse et al., 1996). Specificity was 100%, sensitivity 93%, PPV 100%, NPV 73% for sonography (Musoke et al., 2003) the sensitivity and specificity for dilated loops and peristalsis is 91% and 84%, 27% and 98% respectively (Unluer et al., 2010; Jang et al., 2011; Barzegari et al., 2016).

Ultrasoundmay detect free intraperitoneal air (IFA) when bowel perforationis present (Hefny and Abu-Zidan, 2011). The sensitivity of US in detecting IFA is 85.7%-92% and specificity of 99.6%(30, 31) in 80% of the cases the site of perforation can be detected by experienced sonographer (Smereczyński and Kołaczyk, 2015).

We report our clinical experience from the practice illustrating the possibilities of ultrasonography to detect acute abdomen due to hollow visceral pathology.

MATERIALS AND METHODS

The retrospective study included two hundred twenty seven patients with abdominal pain admitted at the Emergency Department between April 2013 and January 2018 year. Patients with traumatic acute abdomen were excluded from the study.

Abdominal US examinations were performed with Aloka SSD 3500 (linear probe 7.5MHz), GE Logiq 6 (linear probe 6-12 MHz) and Sonoscape S6 in 2DB-mode.

We used graded compression technique with variable maneuvers if needed. The US exam started at the point of the most intensive abdominal pain - “Point-of-Care” ultrasound (POCUS). All abdominal regions were inspected by “S” approach with transversal and longitudinal scans. The patients were positioned on their backs and when necessary their position was changed in left or right lateral (decubitus) one. In case of a suspected perforation the patient was asked to make a deep breath and to sit with thorax rose up at 30-40 degrees.

US pathological findings to look for

- increased loop dimensions
- thickened wall of more than 2.5-3.0 mm

- increased intestinal content
- increased (to and fro) or decreased peristaltic movements
- enlarged and visible *valvulae conniventes* (more than 2 mm)
- diameter of the appendix larger than 6 mm
- diameter more than 25 mm for the small intestine
- diameter more than 50 mm for the colon
- non-compressibility in the painful region
- inflammation of the surrounding tissue
- free fluid
- free intraperitoneal air

RESULTS

The patients were divided by suspected clinical diagnosis in three main groups: inflammatory - acute appendicitis, diverticulitis; ileus - obstructive or paretic; and gastrointestinal perforations. Abdominal US was performed and the results were compared with operative/discharge diagnosis (Table 1).

The initial clinical impression was confirmed with US in 191/227(84.1%) patients. After the US investigation, the management plans were as follows: conservative medical treatment for 16/227(7.04%), surgery for 180/227 (72.29%) patients, and 31/227(13.65%) patients were discharged with ambulatory follow-up.

Based on the history of the patients and the clinical-laboratory results 57 patients were included in the first group: 51/57 (89.47%) with suspected appendicitis and 6/57(10.52%) with acute diverticulitis. The initial diagnosis ileus was suspected in 98/227 (43.17%) and they were included in the second group and the other 72/227(31.71%) patients with suspected gastrointestinal perforations were included in the third group.

US diagnosis confirmed the clinical one in the inflammatory group in 56/57(98.24%); in the second one with ileus in 93/98 (94.89%) and in the third one with the perforation in 42/72 (58.33%).

Results in the acute abdomen inflammatory group

Acute appendicitis subgroup

Initial clinical diagnosis acute appendicitis was suspected in 51 patients, 41(80.39%) male and 10 (19.61%) female, age between 18-81 years, mean 39.98 and median 36. US diagnosis was positive for acute appendicitis in 50/51(98.03%) and negative in 1(1.96%) female with US findings- ovarian cyst. Operative/histological findings confirmed the initial diagnosis in 44 (86.3%) patients. A coincidence was not found in 7 (13.7%) patients: two of them were with Crohn's disease, one with infectious terminal ileitis and 3 with histological results - chronic appendicitis. In our study the total sensitivity of US in acute appendicitis subgroup was 81. 61%, specificity– 31.85%, PPV –42.61 %, NPV – 85.71%, diagnostic accuracy –42.64%. The sensitivity, specificity, PPV, NPV and diagnostic accuracy for each separate main US pathologic criteria were calculated (Table 2).

Results in acute diverticulitis subgroup

Acute diverticulitis was suspected in 6 patients: 5 female and 1 male, age between 36-88 years, with left and right lower quadrant abdominal pain respectively in 4 and 2 of them. US investigation was performed to all 6 patients and 5 were operated for acute diverticulitis, one underwent colonoscopy and conservative treatment (Table 3).

Results in the bowel obstruction group

To examine the accuracy of US in diagnosing ileus 98 patients with clinical findings suggestive of a bowel obstruction were evaluated. US positive signs were found in 93/98 (94.89%) patients and in 86 (87.75%) of them the operative findings confirmed US diagnosis. The sensitivity and specificity of the sonographic diagnosis of intestinal obstruction was 88% and 96% respectively. The statistical analysis included both small bowel and large bowel obstructions. The specific ultrasound criteria of bowel obstruction were fluid-filled, dilated noncompressible small bowel and large bowel loops (>2,5 cm; >5,0cm) increased bowel wall thickness, abnormal peristalsis and free fluid between the dilated loops -"tanga sign" (Table 4).

The small bowel luminal diameter in bowel obstruction varied from 2 to 8 cm and the large bowel luminal diameter varied ≥4–6 cm.

The wall thickness ranged from 2 to 5.9 mm with a maximal bowel wall thickness up to 6 mm (Table 5).

The sensitivity, specificity, PPV, NPV and the diagnostic accuracy of US in general and for each separate US sign were calculated (Table 6).

Results in the perforation group

72 patients with a severe pain in different abdominal quadrants were analyzed. All of them underwent US, then X-ray in a standing position or in left lateral position and chest X-ray. X-ray was provided to 65/72 (90.3%) patients and positive for IFA were 20/65 (27.8%) and negative -45/65 (62.5%). Ultrasonography was positive for IFA in 42/72 (58.33%) and negative for IFA in 30/72(41.66%) (Table 7).

The direct US criteria - EPSS, comet tail and pseudokidney sign were found in 32/42 (76.19%) patients and in 10/42 (23.80%) patients only indirect US criteria –

Table 1. Number of patients whose initial clinical diagnosis was confirmed by US and intra-operative findings

	Clinical diagnosis	US /+/	/+/ operative diagnosis
acute appendicitis and diverticulitis	57	56	53
ileus	98	93	86
gastrointestinal perforations	72	42	41

Table 2. Sensitivity, specificity, PPV, NPV and diagnostic accuracy for the main US pathologic criteria

	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
1	**77.42%** (58.90%÷90.41%)	**16.84%** (0.00%÷16.84%)	**54.55%** (49.81%÷59.20%)	-	**47.06%** (32.93%÷61.54%)
2	**85.71%** (72.76%÷94.06%)	**0.00%** (0.00%÷84.19%)	**95.45%** (94.93%÷95.93%)	-	**82.35%** (69.13%÷91.60%)
3	**83.33%** (35.88%÷99.58%)	**13.33%** (5.05%÷26.79%)	**11.36%** (8.09% ÷15.73%)	**85.71%** (46.35%÷97.66%)	**21.57%** (11.29%÷35.32%)
4	**80.00%** (28.36%÷ 99.49%)	**13.04%** (4.94%÷26.26%)	**9.09%** (5.98% ÷13.58%)	**85.71%** (47.17%÷97.58%)	**19.61%** (9.82% ÷33.12%)

1 - appendicular diameter, **2** - wall thickness, **3** - wall structure, **4** - fluid collections

Table 3. US criteria in diagnosis of acute diverticulitis

US criteria	N	%
visualization of the inflamed diverticula	2	0.12
wall thickness	2	0.12
dilated bowel loops	2	0.12
pericolic fluid	1	0.06
pericolic abscess	1	0.06
free abdominal fluid	1	0.06

Table 4. US criteria in bowel obstruction patients group

US criteria	US findings	Male	Female
luminal diameter	dilated lumen	31	62
	small bowel only	26	57
	large bowel only	2	1
	both small and large bowel	3	4
bowel wall	thickened	26	54
	non thickened	5	8
abnormal peristalsis		31	56
free fluid		3	5

Table 5. Sonographic evaluation of bowel wall thickness

Bowel wall (mm)	N	%
2-2.9	13	13.9
3.0-3.9	59	63.5
4.0-4.9	15	16.2
5.0-5.9	6	6.4

Table 6. Sensitivity, specificity, PPV, NPV and diagnostic accuracy of US in general and for each US sign

	Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
US	**86.59%** (77.26%÷93.11%)	**60.00 %** (14.66%÷94.7%)	**97.26%** (92.36%÷99.0%)	**21.43 %** (9.96%÷40.21%)	**85.06%** (75.80%÷91.80%)
free fluid	**4.71%** (1.30%÷11.61%)	**83.33 %** (35.88%÷99.5%)	**80.00%** (34.47%÷96.8%)	**5.81 %** (4.13%÷8.14)	**9.89%** (4.62%÷17.95%)
abnormal peristalsis	**75.32%** (64.18%÷84.4%)	**0.00 %** (0.00%÷60.24%)	**93.55%** (92.73%÷94.28%)	**0**	**71.60%** (60.50%÷81.07%)
colonic luminal diameter≥5 cm	**68.75%** (41.34%÷88.9%)	**0.00 %** (0.00%÷84.19%)	**84.62%** (79.81%÷88.4%)	**0**	**61.11%** (35.75%÷82.70%)
small bowel luminal diameter ≥2.5 cm	**91.46%** (83.20%÷96.5%)	**16.67 %** (0.42%÷64.12%)	**93.75%** (91.25%÷95.5%)	**12.50 %** (2.04%÷49.4%)	**86.36%** (77.39%÷92.75%)
Wall thickening ≥4 mm	**22.35%** (14.03%÷32.6%)	**50.00 %** (11.81%÷88.1%)	**86.36%** (72.17%÷93.9%)	**4.35 %** (1.99%÷9.2%)	**24.18%** (15.81%÷34.2%)

Table 7. US criteria for IFA

US criteria	N	%
EPSS only	2	4.8
comet tail only	0	
pseudokidney sign only	0	
free fluid only	2	4.8
free fluid + EPSS	10	23.6
free fluid + comet tail	3	7.2
free fluid + pseudokidney sign	1	2.4
free fluid + wall thickness	1	2.4
EPSS + dilated bowel loops	1	2.4
EPSS + wall thickness	1	2.4
comet tail + wall thickness	1	2.4
pseudokidney sign + wall thickness	1	2.4
comet tail + wall thickness + dilated bowel loops	1	2.4
EPSS + dilated bowel loops + wall thickness	1	2.4
comet tail + free fluid + wall thickness	2	4.8
EPSS + free fluid + dilated bowel loops + wall thickness	2	4.8
comet tail + free fluid + dilated bowel loops + wall thickness	2	4.8
pseudokidney sign + free fluid + dilated bowel loops + wall thickness	1	2.4
free fluid + dilated bowel loops + wall thickness	10	23.6
	42	**100**

Table 8. Comparison between US and X-ray imaging modalities for detecting IFA

	Sensitivity (95% Ci)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Diagnostic accuracy (95% CI)
X-ray	72.00% (50.61%÷87.93 %)	100.00 % (47.82%÷100.0 0%)	100.00%	41.67% (27.59%÷57.25 %)	76.67% (57.72%÷90.07%)
US - EPSS	59.26% (38.80%÷77.61 %)	100.00 % (59.04%÷100.0 0%)	100.00%	38.89% (28.76%÷50.07 %)	67.65% (49.47%÷82.61%)
US - comet tail	25.93% (1.11%÷46.28 %)	71.43% (29.04%÷96.33 %)	77.78% (47.98%÷93.00 %)	20.00% (12.95%÷29.58 %)	35.29% (19.75%÷53.51%)

Table 8. Continue

US - pseudo-kidney sign	7.41% (0.91%÷24.29 %)	85.71% (42.13%÷99.64 %)	66.67% (17.38%÷ 95.00%)	19.35% (14.83%÷24.85 %)	23.53% (10.75%÷41.17%)
US - free fluid	77.78% (57.74%÷91.38 %)	14.29% (0.36%÷57.87%)	77.78% (70.87%÷ 83.43%)	14.29% (2.32%÷53.87%)	64.71% (46.49%÷80.25%)
US - wall thickening	48.15% (28.67%÷68.05 %)	71.43% (29.04%÷96.33 %)	86.67% (65.40%÷95.72 %)	26.32% (16.48%÷39.25 %)	52.94% (35.13%÷70.22%)
US - dilated bowel loops	62.50% (35.43%÷84.80 %)	71.43% (29.04%÷96.33 %)	83.33% (59.34%÷94.48 %)	45.45% 27.50%÷64.68 %)	65.22% (42.73%÷83.62%)

free fluid, dilated bowel loops and wall thickness were observed. EPSS only was found in 2 (4.8%) patients, EPSS+free fluid in 10 (23.6%); comet tail and free fluid in 3 (7.2%), pseudokidney sign+free fluid in 1 (2.4%) patient. Four US pathological signs- EPSS + free fluid + dilated bowel loops + wall thickness were found in 2 (4.8%) patients, comet tail + free fluid + dilated bowel loops + wall thickness in 2 (4.8%)and pseudokidney sign + free fluid + dilated bowel loops + wall thickness in 1 (2.4%) patient. The indirect US criteria were nonspecific and the interpretation of US findings should be done in the context of the clinical features.

Two imaging modalities - US and X-ray for detecting IFA were also compared with the operative findings and sensitivity, specificity, PPV, NPV and diagnostic accuracy for each method were calculated (Table 8).

DISCUSSION

In our study we analyzed the role and clinical effects of the initial Point-of-Care ultrasound (POCUS) evaluation in the diagnosis of non-traumatic acute abdomen due to hollow viscous gastrointestinal pathology. We evaluated the impact of POCUS examinations in our clinical practice, and we found that the point-of-care US also has some valuable advantages in the diagnostic process of non - traumatic acute abdomen aiming in particular acute appendicitis, bowel obstruction, acute diverticulitis and gastrointestinal perforations.

The reported sensitivity in diagnosing acute appendicitis is 91% (83-96%), specificity 97% (91%-99%), PPV 91% and NPV 94% (Matthew et al., 2017). In our study the calculated sensitivity was 91.3% and PPV 87.6 %. The highest sensitivity of 85.75%, PPV of 95.45% and diagnostic accuracy of 82.35% were found for the US criteria wall thickness. The study data show that graded compression POCUS is a rapid and reliable image method in diagnosing acute appendicitis and should be the first-line imaging modality when such pathology is suspected. In some publications the sensitivity and specificity of US in diagnosing acute colonic diverticulitis is 91%-92% and 90%-100% respectively (O'Malley and Wilson, 2001; O'Malley and Wilson, 2003; Laméris et al., 2008; Toorenvliet et al., 2010; Sartelli et al., 2015). We could not perform any statistical analysis in the inflammatory subgroup acute diverticulitis because of the small number of patients. Nevertheless, we think that POCUS should be a method of choice for diagnosing acute diverticulitis in context of clinical data and findings.

The sensitivity and specificity of the sonographic diagnosis of intestinal obstruction in our research were 88% and 96%. They are similar to those of Musoke F et al., sensitivity - 93% and specificity - 100%. (27) We also compared the US diagnostic accuracy with those of CT and X-ray in diagnosis of bowel obstruction: 85.06% (75.80%÷91.80%) for US, 74.55% (61.00%÷85.33%) for CT and 73.63% (63.35%÷82.31%) for the radiological findings. The highest sensitivity 91.46% (83.20%÷96.50%), PPV 93.75% (91.25%÷95.57%), diagnostic accuracy 86.36% (77.39%÷92.75%) was found for the US sign small bowel luminal diameter and the lowest sensitivity - 4.71% (1.30%÷11.61%) for the free fluid. The sensitivity of US was 22.35% (14.03%÷32.69%) and specificity 50.00% (11.81%÷88.19%). Abnormal peristalsis had sensitivity 75.32 (64.18%÷84.44%), specificity 60.24%, and diagnostic accuracy 71.60% (60.50%÷81.07%).

In the perforation group we found the sensitivity of US for IFA - 72.00% (50.61%÷87.93%), specificity - 100% (47.82%÷100%), PPV - 100%, NPV - 41.67% (27.59%÷57.25%) and diagnostic accuracy 76.67% (57.72%÷90.07%). In this group we compare US vs. X-ray accuracy. The X-ray diagnostic accuracy in detecting IFA was 76.67% (57.72%÷90.07%), higher than the US one. US - EPSS had accuracy 67.65% (49.47%÷82.61%) and US - dilated bowel loops - 65.22% (42.73%÷83.62%). X-ray sensitivity was 72.00% (50.61%÷87.93%), higher than sensitivity of US – EPSS phenomenon, comet tail, pseudo kidney sign, wall thickening and dilated bowel loops, but lower than US –

free fluid - 77.78% (57.74%÷91.38%). X-ray and US - EPSS had similar specificity 100.00% (47.82%÷100.00%) and 100.00 % (59.04%÷100.00%) respectively. US - comet tail, wall thickening and dilated bowel loops had specificity 71.43%. US - pseudo-kidney had specificity 85.71% (42.13%÷ 99.64%).

CONCLUSION

We suggest that none of the US signs alone was pathognomonic for the diagnosis acute abdomen. The presence of several positive US signs could increase diagnostic accuracy and may facilitate proving the suspected diagnosis. Even that Point-of-Care ultrasound (POCUS) should be an extension of the clinical examination in evaluating an acute abdomen. It is a rapid, safe and reliable diagnostic tool that could be used repeatedly on the bedside of sick and critically ill patients. It is particularly valuable as a first imaging modality in diagnosing patients with non-traumatic acute abdomen due to hollow viscous gastrointestinal pathology.

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