Abdominal Pain Management and Point-of-care Ultrasound in the Emergency Department: A Randomised, Prospective, Controlled Study

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ABSTRACT

Objective: To determine the effect of point-of-care ultrasound (POCUS) performed during the initial evaluation phase of patients with acute abdominal pain.

Study Design: Randomised controlled, parallel-group trial.

Place and Duration of Study: Sakarya University Training and Research Hospital, Sakarya, Turkey, from October 2019 to March 2020.

Methodology: Patients who presented to the Emergency Department (ED) with acute abdominal pain were included in the study. Exclusion criteria were permanent mental disability, age <18 years, abdominal trauma within the last 24 hours, pregnancy, morbid obesity, repeated admissions, referral from an external centre to the ED, and missing patient information. Patients were divided randomly into two groups: The control group where standard diagnostic strategies were applied and the POCUS group where POCUS was performed together with standard diagnostic strategies. The length of stay (LOS), differential diagnoses, cost and hospitalisation or discharge from ED were compared.

Results: The application of POCUS reduced the average number of preliminary differential diagnoses from four to two ($p < 0.001$). Regarding patient outcomes, POCUS reduced LOS in ED in both the discharged and hospitalised patients ($p = 0.003$, and $p = 0.049$, respectively). In all patients, POCUS reduced LOS in ED but led to no significant changes in cost ($p < 0.001$, $p =$ and 0.403, respectively).

Conclusion: POCUS in patients with acute abdominal pain is very useful in reducing the number of differential diagnoses and LOS in ED.

Key Words: *Abdominal pain, Cost, Emergency department, Length of stay, Point-of-care ultrasound.*

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INTRODUCTION

Acute abdominal pain is one of the most common causes of admission to the emergency department (ED) and accounts for approximately 10% of all ED admissions. However, patients can sometimes describe their complaints as stomach pain, cramping, or spasms instead of abdominal pain.[1] The fact that abdominal pain can occur owing to a wide range of causes, ranging from mild and self-limiting conditions to life-threatening diseases, often puts clinicians in a difficult position during the diagnostic approach.[2]

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The age of the patient, detailed anamnesis, and physical examination findings constitute the main elements of the standard diagnostic approach.[1] However, when these are insufficient, additional examinations including laboratory parameters and imaging studies (X-ray, ultrasonography [USG], computed tomography [CT], and magnetic resonance imaging [MRI]) are generally required.[3]

Another method that has gained traction in diagnostic approach in recent years is point-of-care ultrasound (POCUS). Point-of--care ultrasound refers to the practice of trained medical professionals using ultrasound to diagnose problems wherever a patient is being treated, whether that's in a modern ED or an ambulance. Unlike regular ultrasound, certain points in terms of pathologies are selected as focus and evaluated as positive or negative. Worldwide, the application of POCUS has come to the forefront by supporting physicians in advanced diagnosis and treatment processes of patients, especially in emergency care.[4] In fact, studies on POCUS have reported excellent diagnostic

accuracy for common diseases.[5-7] POCUS in the diagnostic evaluation may also reduce costs and morbidity and mortality rates.[8] Therefore, the idea of using POCUS as an integral part of the examination is becoming increasingly common in the medical community.[9] However, despite the body of evidence and approaches, additional studies are needed on the effect of POCUS on diagnosis and treatment processes in ED.[7]

In this study, it was hypothesised that POCUS will contribute positively to the diagnosis of patients admitted to the ED, reduce the length of stay (LOS) in the ED, and reduce average hospitalisation and healthcare costs. Therefore, this study aimed to evaluate the effect of hepatobiliary, renal, and upper and lower abdominal POCUS on diagnostic processes, LOS in ED, hospitalisation, and costs in patients presenting to the ED with acute abdominal pain.

METHODOLOGY

This study was conducted as a prospective, randomised, controlled, and parallel-group study in the Emergency Department, Sakarya University Training and Research Hospital, between October 2019 and March 2020. Informed consent was obtained from all participants involved in the study. In addition, all procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and subsequent amendments or comparable ethical standards. The study was approved by the Ethics Committee of Clinical Research at Sakarya University Faculty of Medicine (Decision no: 152 of 20.09.2019). This study was registered with ClinicalTrials.gov, No. NCT05402774.

Patients who presented to the ED with acute abdominal pain were included in the study. Exclusion criteria were permanent mental disability, age <18 years, abdominal trauma within the last 24 hours, pregnancy, morbid obesity, repeated admissions, referral from an external centre to the ED, and missing patient information.

Patients were randomly assigned to POCUS (n=103) or control groups (n=104). The responsible researcher randomised the assignment of patient forms to the study groups using a random number generator before the study was initiated. When the patients admitted to the ED, it was determined in advance which number form was in which group. The POCUS operator worked different shifts at the ED, thus allowing patients from different hours and days to be included in the study.

All patients admitted to the emergency department underwent primary clinical evaluation by their responsible physician. After primary clinical evaluation, the demographic data of all patients; character, location, spread, duration of abdominal pain, and preliminary diagnosis of the responsible physician were recorded in the study form. No advice or direction was given to the responsible physician regarding any procedure of the patients.

There were no restrictions on the responsible physician requesting a full blood count, biochemical analyses and urine examination, and electrocardiogram and other imaging methods (lung and direct abdominal X-ray, CT, USG, and MRI) among the standard tests in ED, and all test results were available within approximately two hours.

At this stage, the patients were divided into two groups: POCUS was applied to patients in the POCUS group after primary clinical evaluation. This procedure was performed in the first hour after the primary clinical evaluations of the patients by evaluating the predetermined parameters in the study form for hepatobiliary, renal, and upper and lower abdominal findings. All processes and results for patients in the control group were followed without any intervention and the results were recorded in the study form.

POCUS was performed according to the American College of Emergency Physician imaging criteria. All POCUS procedures were performed by an experienced operator who did not take part during the primary clinical evaluation. Xario 100 (Toshiba, Japan) USG system was used.

POCUS findings were presented to the responsible physicians. Preliminary diagnoses, diagnostic tests and treatment were re-evaluated by the responsible physician. Afterwards, all processes were recorded in the study form without interference.

After all these processes were completed, the final diagnoses of the patients were made by a supervisory emergency specialist who was blinded to POCUS findings and did not know who the patient's responsible physician was. The emergency specialist reached the final diagnoses by evaluating the epicrisis forms of hospitalised patients and ED patient examination forms of discharged patients, together with laboratory and imaging examinations.

The primary endpoint was to determine the effect of POCUS on LOS in the patient presenting with acute abdominal pain in ED. Secondary endpoints were to determine the effect of POCUS on patients' mean cost, rate of change in physician's pre-diagnosis, hospitalization, and discharge rate in patients presenting to the ED with acute abdominal pain.

Normality of measurable variables was assessed with Shapiro-Wilk Test. For both groups, categorical endpoints were presented as the number and percentage of patients corresponding with 95% confidence interval (CI). Continuous endpoints were presented as mean, standard deviation, median, and range. The rule of three was used to calculate 95% CI in categories with no events. According to distributions the Mann–Whitney U-test was used for comparison of continuous endpoints, and either McNemar or Wilcoxon test was used for comparison of endpoints expressed as counts and percentages. All tests were conducted with a two-tailed significance of 5%. For each endpoint, the absolute and relative effects and their corresponding 95% CIs were calculated as recommended by Altman *et al*.[11] All analyses were performed using IBM SPSS 21.

Table I: Patient characteristics in the POCUS and control groups.

	POCUS group (n = 103)	Control group (n = 104)
Age (Years; Mean [SD])	52.42 (19.85)	48.8 (18.94)
Gender		
Male	44 (43%)	52 (50%)
Female	59 (57%)	52 (50%)
Medical history		
Diabetes mellitus	5 (5%)	10 (10%)
Coronary artery disease	2 (2%)	2 (2%)
Hyperlipidemia	-	1 (1%)
Heart failure	3 (3%)	3 (3%)
Arterial hypertension	19 (19%)	8 (8%)
Stroke	3 (3%)	1 (1%)
Chronic kidney disease	4 (4%)	2 (2%)
Chronic obstructive pulmonary disease	-	1 (1%)
Asthma	1 (1%)	-
Malignancy	5 (5%)	5 (5%)
Intra-abdominal operation history	19 (18%)	1 (1%)
*Vital signs at admission		
Respiratory rate (breaths per min)	12 (11–12)	12 (12–14)
Saturation (%)	98 (97–99)	98 (96–98)
Systolic blood pressure (mmhg)	120 (110–140)	120 (110–140)
Diastolic blood pressure (mmhg)	70 (70–80)	75 (70–80)
Heart rate (beats per min)	85 (77–88)	86 (78–93)
Temperature (°C)	36.7 (36.5–36.9)	36.7 (36.5-36.9)
Patient-reported symptoms		
Nausea	54 (52%)	43 (41%)
Vomiting	26 (25%)	10 (10%)
Diarrhoea	4 (4%)	2 (2%)
Anorexia	11 (11%)	3 (3%)
Dysuria	4 (4%)	2 (2%)
Character of acute abdominal pain		
Colic	46 (45%)	15 (14%)
Continuous	57 (55%)	89 (86%)
Location of acute abdominal pain		
Whole abdomen	46 (45%)	44 (42%)
Upper right quadrant	20 (20%)	16 (15%)
Lower right quadrant	25 (24%)	21 (20%)
Right flank	3 (3%)	7 (7%)
Upper left quadrant	3 (3%)	1 (1%)
Lower left quadrant	9 (9%)	3 (3%)
Left flank	3 (3%)	6 (6%)
Epigastric	9 (9%)	7 (7%)
Suprapubic	5 (5%)	7 (7%)
Periumbilical	6 (6%)	3 (3%)
Intensity of acute abdominal pain		
Mild	2 (2%)	-
Moderate	61 (59%)	72 (69%)
Severe	40 (39%)	32 (31%)
Physical examination findings		
Tenderness in right lower quadrant	39 (38%)	23 (22)
Tenderness in right upper quadrant	21 (21%)	15 (14%)
Tenderness in costovertebral angle	3 (3%)	11 (11%)
Tenderness in left lower quadrant	11 (11%)	3 (3%)
Tenderness in left upper quadrant	3 (3%)	1 (1%)
Tenderness in suprapubic	13 (13%)	7 (7%)
Palpable mass	1 (1%)	1 (1%)
Tenderness in whole abdomen	37 (36%)	43 (41%)
Tenderness in epigastric area	19 (18%)	7 (7%)
Rebound pain	5 (5%)	2 (2%)
Imaging methods		
X-ray	42 (41%)	48 (46%)
Ultrasonography	49 (48%)	29 (28%)
Computed tomography	58 (56%)	89 (86%)
Hospitalisation of patient		
Discharged	60 (58%)	79 (76%)
Hospitalised	43 (42%)	25 (24%)

*Data are presented as number (%) or mean unless otherwise indicated.; *The median values (25p–75p).*

RESULTS

In total, 207 patients were selected randomly and included in the study. The mean age was 52.42 ± 19.85 years in the POCUS group and 48.8 ± 18.94 years in the control group. While it was seen that the number of women was higher in the POCUS group (n=59; 57%), the gender distribution was found to be equal in the control group. Arterial hypertension was the most common comorbid disease in the POCUS group (n=19; 19%), while diabetes mellitus was found in the control group (n=10; 10%). Patient characteristics are presented in Table I.

The application of POCUS revealed a total of 113 pathological findings in 66 patients (64%). The most common of these was stone or mud in the gallbladder (n=23, 22%), while the least common were hepatorenal free fluid (n=1, 1%) and free fluid in the Douglas (n=1, 1%). In the POCUS group, POCUS findings were confirmed by USG or CT performed by an expert radiologist, and six additional pathologies were detected in 5 patients (5%). Detection of a pathology in POCUS had no significant effect on hospitalisation rate, LOS in ED, and average costs ($p = 0.151, 0.557$, and $p = 0.171$, respectively).

It was observed that the responsible physician made an average of four preliminary diagnoses based on patient history and physical examination. The average number of preliminary diagnoses decreased from four to two after POCUS ($p < 0.001$). A significant difference was found in the preliminary diagnoses of appendicitis, cholecystitis, cholelithiasis, pancreatitis, nephrolithiasis, pyelonephritis, ileus, and although ureterolithiasis with POCUS where major portion of ureter is not visualised, ureterolithiasis after POCUS ($p<0.001$, $p<0.001$, $p = 0.008$, $p<0.001$, $p<0.001$, $p<0.001$, $p<0.001$, and $p<0.001$, respectively).

In addition, the application of POCUS reduced LOS in patients that presented with both colic and continuous pain ($p=0.034$, and $p=0.004$, respectively). With regard to pain moderate or severe, the application of POCUS significantly reduced LOS in ED in the moderate pain group ($p=0.030$, and $p=0.006$, respectively). Regarding preliminary diagnoses, POCUS was found to reduce LOS in the emergency department in patients with cholelithiasis, pancreatitis, nephrolithiasis, ileus, and ovarian diseases ($p=0.042$, $p=0.012$, $p=0.015$, $p=0.013$, and $p=0.024$, respectively) while costs were reduced only in the patient group with suspected bowel perforation ($p=0.021$, Table II). Therefore, CT combined with POCUS significantly increased average costs ($p=0.026$). In the discharged patient group, the application of POCUS reduced LOS in ED ($p=0.001$). When the entire patient group was evaluated, the application of POCUS in the ED was found to significantly reduce LOS in ED, but did not have a significant effect on average costs ($p<0.001$, Table II).

DISCUSSION

Acute abdominal pain is a clinical condition affected in terms of incidence and clinical reflection by demographic characteristics such as age, gender, ethnicity, family history, sexual orientation, cultural practices, and geography. In addition to detailed anamnesis and physical examination, POCUS can also be used in the diagnostic approach. Diagnostic evaluation with POCUS may have a positive contribution to improving health care as well as reducing costs, LOS in ED, morbidity, and mortality.[4] In fact, Lindelius *et al*. reported that POCUS contributes to diagnostic efficiency in abdominal pain.[10] However, in literature no randomised controlled clinical trials was found that investigated the effect of POCUS on LOS in ED and costs in patients who presented to the ED with acute abdominal pain. The present study and its results are therefore important.

Table II: Effects of POCUS on the length of stay and average costs.

	POCUS Group LOS (min)**	Control Group LOS (min)**	p-value*	POCUS Group Average costs ($)**	Control Group Average costs ($)**	p-value*
Character of abdominal pain						
Colic	241 (98–341)	271 (179–598)	0.034	29 (18–39)	29 (18–36)	0.615
Continuous	217 (90–328)	286 (190–395)	0.004	27 (16–39)	32 (21–38)	0.237
Intensity of abdominal pain						
Moderate	221 (95–348)	273 (187–393)	0.030	28 (18–38)	31 (20–37)	0.767
Severe	213 (84–304)	301 (184–498)	0.006	27 (16–40)	34 (26–40)	0.225
Preliminary diagnosis						
Appendicitis	247 (106–417)	286 (230–378)	0.274	31 (22–39)	32 (20–39)	0.994
Cholecystitis	232 (95–359)	305 (185–475)	0.074	32 (19–39)	29 (20–39)	0.883
Cholelithiasis	235 (77–392)	369 (176–487)	0.042	30 (17–39)	28 (20–39)	0.620
Pancreatitis	164 (75–309)	266 (145–367)	0.012	32 (17–42)	33 (26–40)	0.867
GERD****	235 (85–434)	231 (177–376)	0.302	26 (17–37)	31 (21–37)	0.243
Nephrolithiasis	168 (91–349)	279 (217–477)	0.015	26 (20–37)	28 (18–36)	0.627
Bowel perforation	237 (115–496)	288 (184–333)	0.867	27 (19–36)	38 (31–44)	0.021
Ileus	196 (83–263)	299 (215–359)	0.013	32 (21–39)	33 (31–41)	0.194
Ovarian disease	185 (116–261)	351 (200–490)	0.024	19 (18–37)	26 (18–37)	0.390
Nonspecific abdominal pain	147 (79–346)	198 (160–283)	0.560	19 (12–35)	14 (9–15)	0.088
Imaging methods						
X-ray	245 (103–449)	307 (227–391)	0.067	33 (22–40)	33 (25–40)	0.746
Ultrasonography	237 (97–336)	369 (239-532)	0.002	26 (17–39)	33 (20–37)	0.580
Computed tomography	230 (105–318)	300 (198–403)	0.005	37 (29–41)	33 (26–38)	0.026
Diagnosis						
Appendicitis	290 (99–449)	300 (207–441)	0.688	35 (22–41)	39 (32–42)	0.277
Cholecystitis	131 (76–358)	305 (168–448)	0.096	21 (17–32)	37 (21–40)	0.096
Cholelithiasis	120 (68–550)	521 (439–832)	0.250	37 (19–47)	28 (24–34)	>0.99
Pancreatitis	338 (187–452)	226 (124–250)	0.222	40 (20–68)	26 (15–31)	0.222
GERD***	214 (81–337)	218 (138–615)	0.437	31 (18–41)	31 (22–37)	0.841
Nephrolithiasis	135 (91–176)	258 (186–559)	0.018	26 (22–45)	32 (22–36)	>0.99
Bowel perforation	176 (115–237)	176 (132–220)	>0.99	28 (27–29)	46 (41–50)	0.333
Ileus	70 (62–78)	296 (231–312)	0.056	41 (36–46)	33 (32–38)	0.222
Ovarian disease	169 (103–487)	367 (222–504)	0.152	16 (12–37)	22 (15–31)	0.717
Nonspecific abdominal pain	245 (80–323)	286 (148–317)	0.391	31 (15–38)	27 (17–32)	0.560
Hospitalisation of patient						
Discharged	209 (93–316)	286 (185–401)	0.001	25 (15–37)	30 (20–37)	0.164
Hospitalised	232 (94–370)	266 (182–412)	0.115	33 (22–44)	35 (28–42)	0.611
All patients	218 (94–333)	283 (187–400)	p<0.001	28 (17–39)	32 (21–38)	0.403

**Mann–Whitney U-test was used; ** Data are presented as median and ranges; ***GERD: Gastroesophageal reflux disease.*

In this study, the data obtained about the demographic characteristics of the patients were consistent with similar studies in the literature. In a study of 5,340 patients with abdominal pain conducted by Cervellin *et al*., the mean age of the patients was reported to be 49 years. Similarly, the mean age of the patients was 50.6 years in this study. In addition, it was found that most of the patients presenting to the ED with acute abdominal pain were women in this study, which was consistent with the reports of Cervellin *et al*. and Lindelius *et al*.[10,12]

In patients presenting with acute abdominal pain, the character of pain and the accompanying symptoms are crucial and must be assessed. The character of pain can guide the clinician and aid in diagnostic approach.[1] In the literature, Veliassaris *et al*. reported that 56.8% of the cases had continuous pain.[13] Furthermore, Caliskan *et al*. reported that the most common complaints were nausea, vomiting, and loss of appetite in patients who presented to the ED with abdominal pain.[14] In the present study, the character of pain and accompanying symptoms were consistent with the aforementioned literature.

POCUS, a recommended diagnostic tool in differential diagnosis, is highly useful in making quick and accurate decisions, uncovering pathologies, and shaping preliminary diagnosis. POCUS can detect gallbladder pathologies, liver pathologies, appendicitis, intra-abdominal free fluid, aortic aneurysm, aortic dissection, and several organ pathologies.[4] POCUS can also be used as an important tool in the verification or rejection of preliminary diagnosis.[8] In a study conducted by Mancuso *et al*., the application of POCUS led to a change in preliminary diagnosis in 19% of patients.[15] Similarly, Dhillon *et al*. reported that the preliminary diagnosis was confirmed in 29% of patients with abdominal pain, an alternative diagnosis was made in 10% of patients, and the preliminary diagnosis was completely rejected in 43% of patients after POCUS.[16] Consistent with the discussed literature, in the present study, there was a statistically significant reduction in the number of preliminary diagnoses that can be evaluated sonographically and the average number of preliminary diagnoses. This indicates that POCUS narrows the pool of options in preliminary diagnosis, making it easier for physicians to reach a definitive diagnosis.

In the present study, it was found that POCUS reduced LOS by approximately 65 minutes in patients who presented to the ED with acute abdominal pain and this change was statistically significant. However, this is the first study to evaluate LOS in the ED after POCUS and there are no similar studies on acute abdominal pain to support this result. There are other studies in the literature that investigated the relationship between POCUS and LOS in ED in patients with chest pain, appendicitis, pelvic pain, and bleeding. Guner *et al*. found that POCUS reduced LOS in ED in patients with chest pain.[7] Elikashvili *et al*. and Wilson *et al*. also conducted studies on patients who presented to the ED with pelvic pain and bleeding complaints, respectively, and reported that POCUS reduced LOS.[6,17] The results of these studies support the hypothesis that POCUS reduces LOS.

Reducing patient care costs is one of the main objectives in the ED.[18] In the present study, POCUS was applied in patients with abdominal pain for this purpose, but no statistical reduction in average costs was detected except for patients with the preliminary diagnosis of bowel perforation. In this study, it could not be comparatively evaluated this result owing to the lack of a similar study on the subject in the literature.

This study has some limitations. First, the study was conducted in a single centre and all sonographic procedures were performed by a single physician. Therefore, the results may not be the same for other EDs and POCUS practitioners. Second, patients could not be recorded sequentially as there was no permanent POCUS practitioner in the ED. Third, the accuracy of USG-assisted decision-making regarding definitive diagnosis was not examined.

CONCLUSION

In patients with acute abdominal pain, the application of POCUS is especially useful in terms of narrowing the pool of options of preliminary diagnoses and reducing LOS in the ED. However, POCUS does not contribute to the reduction of costs. Owing to the limited number of studies on acute abdominal pain, further studies are needed to validate these results.

ETHICAL APPROVAL:
The study protocol was approved by the local ethics committee [IRB No.16214662/050.01.04/152].

PATIENTS' CONSENT:
Informed consents were obtained from all participants.

COMPETING INTEREST:
The authors declared no competing interest.

AUTHORS' CONTRIBUTION:
YD, YY, NGG: Conceived and designed the study.
YD: Conducted the acquisition of the data.
NGG: Analysed the data and provided statistical expertise.
YD, NA, ED, YK: Interpreted the data.
YD, YY, NGG: Drafted the manuscript.
All the authors have contributed substantially to its revision and approved the final version of the manuscript to be published.

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