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Diagnostic imaging for acute abdominal pain in an Emergency Department in Italy

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Abstract

Imaging plays a key role in the diagnostic work-up of patients with non-traumatic acute abdominal pain (AAP) in emergency department (ED). We aimed to evaluate the use and diagnostic performance of imaging techniques in adult patients with AAP in an ED in Italy. Patients with non-traumatic AAP admitted at the ED of S. Orsola-Malpighi University Hospital of Bologna (Italy) from the 1st to the 30th November 2016 were included. Demographic and clinical data, data on radiological procedures and discharge diagnosis were collected. Sensitivity and specificity for detecting acute diseases were assessed using the discharge diagnosis from the ED as reference standard. Of the 578 patients (female 52.8%, mean age 51.3 years) admitted to the ED for AAP, 433 (74.9%) underwent abdominal imaging. The most frequent techniques used were abdominal plain radiography and ultrasonography (US), performed in 38.4% and 37.9% of patients, respectively, followed by computed tomography (CT) in 28% of patients. Plain radiography yielded a sensitivity of 28% and specificity of 91.1%; the sensitivity increased to 79.4% in patients with small bowel obstruction. Ultrasonography's sensitivity and specificity were 61.8% and 98.4%, respectively; the sensitivity of US reached 85.2% and 90% in patients with acute cholecystitis/biliary colic and urolithiasis, respectively. The sensitivity and specificity of CT were 87.8% and 92.9%, respectively. Plain radiography is still overused in the diagnostic work-up of AAP in ED in Italy, despite its unsatisfactory sensitivity. Ultrasonography and CT has a higher sensitivity and should be used as first-level imaging in most patients.

Keywords Non-traumatic acute abdominal pain · Emergency department · Imaging · Ultrasound

Introduction

Non-traumatic acute abdominal pain (AAP) is one of the main reasons for access to the emergency department (ED) [1–4]. It may be caused by a wide spectrum of diseases, and clinical history, physical examination and laboratory tests are often insufficient to establish a correct diagnosis; thus, the use of imaging, including plain abdominal radiography, ultrasonography (US) and computed tomography (CT), plays a pivotal role in the diagnostic work-up of these patients [5]. Plain abdominal radiography is often used as initial imaging

in patients with AAP despite a reported low sensitivity in detecting pathological findings [6]. CT scan has the highest diagnostic value for most diseases, but it is burdened by high radiation exposure and costs [7]. Abdominal ultrasonography has a good diagnostic performance for several diseases without radiation exposure [8], but it is affected by operator ability.

The choice of the most appropriate imaging technique in patients with AAP is not an easy task as it depends on several factors. Clinical evaluation and laboratory tests along with the availability and the diagnostic performance of different imaging techniques should usually drive the clinician to choose the most appropriate techniques, that will obviously impact the timing of diagnosis, radiation exposure and costs [1, 9]. However, the use of US as first-level technique, followed by CT in negative or inconclusive cases, is considered a good approach to patients with AAP in an ED [8].

The general recommendation given by several authors [7, 10] is to avoid redundant imaging examinations resulting in

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additional expenses, excessive radiation exposure and delay in diagnosis. Indeed, the time of characterization of abdominal pain in the ED is among the longest [11], thus, studies providing data on the use and diagnostic value of different abdominal imaging techniques could be helpful to optimize the management and care of patients with AAP in an ED.

Our aim was to evaluate the use and diagnostic value of imaging techniques in adult patients with non-traumatic acute abdominal pain in a large volume in an ED in Italy.

Materials and methods

This is a retrospective cohort study conducted in the ED of the S. Orsola-Malpighi University Hospital of Bologna (Italy), a hospital that every year handles approximately 500,000 patients [12]. The ED staff consists of 30 physicians, 58 nurses and 25 health care support workers. Eligible patients were consecutive adults present in the ED during a 30-day period, from the 1st November 2016 to the 30th November 2016, with non-traumatic abdominal pain lasting more than 2 h and less than 5 days. Patients with an age < 18 years, hemorrhagic shock due to gastrointestinal bleeding or ruptured aortic aneurysm, and pregnant women were excluded. When a patient was evaluated more than once during the study period, only the first access to the ED was considered.

For each patient we extracted, from the ED electronic database, demographic and clinical data, including medical history, physical and laboratory examinations, and data on radiological procedures. For this study we used the following data: age, gender, degree of severity/risk at admission, type and finding of imaging examination, order of imaging modalities (i.e. first level, second level, etc.) and discharge diagnosis from the ED. In particular, we assessed the use of the following three imaging techniques of the abdomen: plain abdominal radiography, abdominal ultrasonography and CT.

At admission, each patient was categorized by a specialized nurse (certified) as patient with urgent condition in the presence of an extreme (red) or high degree (yellow) of severity and non-urgent condition in presence of moderate–mild (green) degree of severity, based on the Simple Triage and Rapid Treatment (START) criteria for urgent care and hospitalization [13].

The discharge diagnosis from the ED for each patient was assigned by the emergency physician after evaluating medical history, physical and laboratory analyses, imaging reports, and advises from surgeons or other specialists (if needed). Patients without an identifiable cause of APP were discharged from the ED with the diagnosis of "non-specific abdominal pain".

Based on the discharge diagnosis, we grouped patients into six diagnostic categories [2, 14]: (a) non-specific abdominal pain, including patients without pathological signs of organic diseases that may explain abdominal pain; (b) gastrointestinal urgent diseases, including acute appendicitis, diverticulitis, bowel occlusion or perforation; (c) gastrointestinal non-urgent diseases, including gastritis, gastroenteritis, peptic ulcer, gastro-esophageal reflux disease, Crohn's disease, ulcerative colitis; (d) hepato-pancreatic-biliary diseases, including acute cholecystitis, cholangitis, biliary colic, hepatitis and pancreatitis; (e) genito-urinary diseases, including ovarian diseases, testicular torsion, salpingitis, epididymitis, renal and ureteral stones, pyelonephritis, urinary tract infection and "others" including other diseases, such as hernia and pneumonia. The Study protocol was approved by the Ethical Committee of the S. Orsola-Malpighi Hospital of Bologna, on 16th May 2017. Informed consent was not required by the Ethical Committee. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki.

Statistical analysis

We performed descriptive analyses using mean with standard deviation (SD) for continuous variables and percentages for categorical variables. We calculated the proportion of patients with AAP who underwent one or more abdominal imaging examinations, and we performed the same analysis, stratifying by diagnostic categories. We calculated sensitivity and specificity with 95% confidence interval (CI) for detecting an acute organic disease causing APP for each of the three imaging modalities by comparing the result of the procedure with the discharge diagnosis used as reference standard. If an imaging technique reported findings suggestive of an acute organic disease, we considered it as a positive result, otherwise, when non-specific or inconclusive findings were reported we defined the cases as negative results. The discharge diagnosis of "non-specific abdominal pain" was considered as absence of an acute organic disease causing AAP, whereas, any other discharge diagnosis was classified as presence of organic disease.

We constructed 2×2 tables that contained the number of cases found to be true positive (positive imaging results in a patient with a discharge diagnosis different from "non-specific abdominal pain"), true negative (negative imaging results in a patient with discharge diagnosis of "non-specific abdominal pain"), false positive (positive imaging results in a patient with discharge diagnosis of "non-specific abdominal pain") and false negative (negative imaging results in a patient with a discharge diagnosis different from "non-specific abdominal pain").

Statistical analyses were carried out with STATA statistical software (StataCorp, College Station, Texas, USA).

Results

During the study period, a total of 5908 patients were evaluated at the ED of the S. Orsola-Malpighi University Hospital of Bologna. Of these patients, 578 (9.9%) presented with non-traumatic acute abdominal pain and met the inclusion criteria of the study. Nineteen (3.3%) out of 578 patients were evaluated more than once, but only the first access to the ED was considered. The mean age of the included subjects was 51.3 years (SD 20.1), and 305 (52.8%) were females. At admission, 336 (58.1%) were defined as urgent (red level = 6, yellow level = 330) and 242 (41.9%) as non-urgent patients (green level).

The most frequent ED discharge diagnosis was non-specific abdominal pain (31.1%), followed by genito-urinary diseases (26.5%), gastrointestinal non-urgent (16.1%) and urgent (11.6%) diseases, and hepato-pancreatic-biliary diseases (9.7%) (Table 1).

Of the 578 patients, 433 (74.9%) underwent abdominal imaging examinations, 45 (7.8%) only extra-abdominal imaging modalities and 100 (17.3%) were discharged without imaging examinations. In particular, 271 (46.8%) subjects underwent only one abdominal imaging examination, while 154 (26.6%) and 8 (1.4%) patients underwent 2 and 3 abdominal imaging examinations, respectively. The most frequent abdominal imaging procedures used were plain radiography (supine and upright or decubitus) and US, which were performed on 222 (38.4%) and 219 (37.9%) patients, respectively, followed by CT performed on 162 (28%) patients. All abdominal plain radiographs (100%, 222/222) and most US (71.2%, 156/219) were performed as first-line imaging examination. As second-line examination, ultrasonography was always performed after a negative or inconclusive plain radiograph (100%, 63/63). Computed tomography was used as first-line imaging examination in 34% (55/162) of cases and as a second- or third-line in 66% (107/162) of cases. Computed tomography followed a negative or inconclusive US in 71% (76/107) of cases and plain radiographs in 29% (31/107) of cases. Table 2 summarizes type and order of abdominal imaging examinations performed.

Stratifying by diagnostic category based on ED discharge diagnosis, we found that abdominal plain radiography was the most frequent imaging examination in patients with non-specific abdominal pain (69.2%, 90/130) and in those with gastro-intestinal urgent (77.1%, 47/61) and non-urgent (72.9%, 43/59) diseases, whereas, US was the most frequent imaging examination in patients with hepato-pancreatic-biliary diseases (69%, 29/42) and the second most frequent in those with genito-urinary diseases (65.6%). Computed tomography was the most frequent imaging technique used for patients with genito-urinary diseases

Table 1 Discharge diagnosis of 578 patients with non-traumatic acute abdominal pain

	Subjects n (%)
Non-specific abdominal pain[a]	180 (31.1)
Genito-urinary diseases	153 (26.5)
Acute pyelonephritis	9 (1.4)
Ureteral stones	25 (4.3)
Renal colic	69 (11.9)
Acute cystitis	37 (6.4)
Acute urine retention	6 (1)
Gynecological disorders	6 (1)
Epididymitis	1 (0.2)
Gastrointestinal urgent diseases	67 (11.6)
Acute appendicitis	13 (2.2)
Acute diverticulitis	9 (1.6)
Bowel occlusion	41 (7.1)
Bowel perforation	4 (0.7)
Gastrointestinal non-urgent diseases	93 (16.1)
Dyspepsia	37 (6.4)
Crohn's disease	2 (0.4)
Acute gastroenteritis	44 (7.6)
Gastroesophageal reflux disease	7 (1.2)
Peptic ulcer	3 (0.5)
Hepato-pancreatic-biliary diseases	56 (9.7)
Acute pancreatitis	9 (1.6)
Acute cholecystitis	11 (1.9)
Biliary colic	33 (5.7)
Liver cirrhosis	3 (0.5)
Other	29 (5)
Musculo-skeletal disorders	11 (1.9)
Hernia	8 (1.4)
Herpes zoster	2 (0.4)
Cardiac disorders	3 (0.5)
Pneumonia	5 (0.9)

[a]Absence of organic disease

(75.4%, 92/122), followed by gastrointestinal urgent diseases (49.2%) (Table 3). In patients with bowel obstruction, abdominal plain radiography was most frequently used (87.2%, 34/39), followed by CT (30.8%, 12/39) and US (12.8%, 5/39). Of the 34 patients who underwent plain radiographs, 12 (35.3%) also received either CT (n. 8) or US (n. 4).

Table 4 shows the diagnostic performance of the three abdominal imaging examinations for detecting acute organic diseases causing APP according to the emergency physician discharge diagnosis.

Abdominal plain radiography yielded an overall sensitivity of 28% and specificity of 91.1%; however, the sensitivity of plain radiography increased to 79.4% in patients with a

Table 2 Type and order of abdominal imaging performed in 578 patients with non-traumatic acute abdominal pain

	Subjects n (%)
Type and line of abdominal imaging[a]	
One examination	271 (46.8)
Plain radiograph	128 (22.1)
Ultrasonography	88 (15.2)
Computed tomography	55 (9.5)
Two examinations	154 (26.6)
Ultrasonography and computed tomography	68 (11.4)
Plain radiograph and ultrasonography	55 (9.5)
Plain radiograph and computed tomography	31 (5.4)
Three examinations	
Plain radiograph and ultrasonography and computed tomography	8 (1.4)

[a]All imaging examinations are reported according to the chronological order of execution

discharge diagnosis of small bowel obstruction yielding a true-positive result in 27 out of 34 patients. Ultrasonography showed an overall sensitivity of 61.8% and a specificity of 98.4%; the sensitivity of US increased to 85.2% (23/27) and 90% (45/50) among patients with biliary diseases (acute cholecystitis and biliary colic) and urinary diseases (renal and ureteral stones/colic), respectively. Computed tomography showed an overall sensitivity of 87.8% and specificity of 92.9% in detecting acute organic diseases in patients with APP. We found a slight increase of sensitivity of US (61.8% vs 70.7%) and TC (87.8% vs 91.1%), but not of abdominal plain radiography (28% vs 26.4%), in detecting acute organic diseases in patients who needed urgent care due to the severity of their clinical conditions.

Discussion

This study showed that the most frequent imaging techniques used in patients with AAP in a large number of ED in Italy were abdominal plain radiography (38.4%) and ultrasonography (37.9%), followed by abdominal CT (28%). Among patients with organic lesions, the overall sensitivity of abdominal plain radiography was very low (28%), except for those with small bowel obstruction (sensitivity 79.4%). Ultrasonography and CT showed a moderate (61.8%) and high overall sensitivity (87.8%), respectively; however, the sensitivity of US was high in patients with biliary (85.2%) or urinary diseases (90%). All abdominal imaging procedures showed a good specificity in detecting organic causes of AAP.

We found an extensive use of abdominal plain radiography in patients with AAP in the ED in our center similar

Table 3 Type and combination of abdominal imaging stratified by diagnostic categories based on the discharge diagnosis

Diagnosis	No. patients	Total imaging n (%)			1 imaging test n (%)			2 or more imaging tests n (%)			
		All X-rays	All US	All CT	X-ray alone	US alone	CT alone	US and CT	X-ray and US	X-ray and CT	X-ray and US and CT
Non specific abdominal pain	130	90 (69.2)	62 (47.7)	14 (10.8)	62 (44.6)	31 (22.3)	6 (4.3)	6 (4.3)	23 (16.5)	8 (5.8)	3 (2.2)
Genito-urinary diseases	122	12 (9.8)	80 (65.6)	92 (75.4)	3 (2.5)	23 (19.2)	36 (29.5)	51 (42.5)	4 (3.3)	3 (2.5)	2 (1.7)
Gastro-intestinal non-urgent diseases	59	43 (72.9)	23 (39)	12 (20.3)	28 (50.9)	9 (16.4)	4 (6.8)	3 (5.5)	10 (18.2)	4 (6.8)	1
Gastrointestinal urgent diseases	61	47 (77.1)	12 (20.7)	30 (49.2)	24 (41.4)	3 (5.2)	9 (14.8)	2 (3.4)	4 (6.9)	16 (26.2)	3 (5.2)
Hepato-pancreatic-biliary diseases	42	27 (64.3)	29 (69)	5 (11.9)	8 (19)	15 (35.7)	0	0	14 (33.3)	5 (11.9)	0
Other	19	3 (15.8)	13 (68.4)	9 (47.4)	3 (15.8)	7 (36.8)	3 (15.8)	6 (31.6)	0	0	0

X-ray plain radiography, *US* ultrasonography, *CT* computed tomography

Table 4 Sensitivity, specificity and accuracy of plain abdominal radiography, ultrasonography and computed tomography in patients with non-traumatic non-localized acute abdominal pain for detecting acute organic lesions

	Plain abdominal radiography n. 222	Ultrasonography n. 219	Computed tomography n. 162
True positive	37	97	130
True negative	82	61	13
False positive	8	1	1
False negative	95	60	18
Sensitivity, % (95% CI)	28.0 (20.6–36.5)	61.8 (53.7–69.4)	87.8 (81.5–92.6)
Specificity, % (95% CI)	91.1 (83.2–96.1)	98.4 (91.3–99.9)	92.9 (66.1–99.8)
Accuracy, % (95% CI)	53.6 (46.8–60.3)	72.2 (65.7–78.0)	88.3 (82.3–92.8)

CI confidence interval

to that reported by other studies in Europe [12, 15, 16]. In a large series of about 5000 patients with AAP from UK, 45% had a plain abdominal radiography [15], and a later study carried out in Israel [16] reported that 52% of patients presenting with AAP underwent abdominal plain radiography. On the other hand, a lesser use of abdominal plain radiography was reported in the USA [4, 17]; in the ED of the University of Virginia Heath System on 1000 consecutive patients with AAP a plain radiography was used in only 21% of cases [4]; similarly, another study from the USA reported that plain radiography was used on 18% of patients with AAP [17]. There is little evidence to support the widespread use of abdominal plain radiography in the diagnostic work-up of patients with AAP, and our study provides further evidence of an overuse of plain abdominal radiography examinations in the investigation of patients with AAP in the ED in European countries, in contrast with recommendations from the main International guidelines [1, 14, 18].

In our study ultrasonography was used on about 40% of patients with AAP; this estimate is consistent with other reports in Europe, ranging from 38 to 46% [12, 19, 20]. The use of ultrasonography on patients with AAP in the USA is consistently lower with estimates around 21–25% [4, 17]. Our study confirms that there is a substantial use of ultrasonography in the diagnostic work-up of patients with AAP in the ED in Europe, particularly in comparison with reports from the USA where US seems to be underused. Notably, ultrasonography is a widely available, low-cost and risk-free examination, and is recommended as first-level imaging in most patients with AAP [3, 8, 10, 18, 21].

In our ED, computed tomography was performed on 28% of patients presenting with AAP, within the range of 16–39% reported by previous studies both from Europe and from the USA [4, 12, 17, 22].

As expected, we found that plain radiography has an overall poor diagnostic value in patients with AAP, in line with previous prospective studies that reported a sensitivity of abdominal plain radiography of 30% [11, 23]. However, in our study plain radiography yielded a true-positive result in

27 out of 34 patients with small bowel obstruction showing a sensitivity of about 80%. The reported sensitivity of plain radiography in diagnosing small bowel obstruction ranges widely among studies from 30 to 90% [2, 23–25], as the diagnostic value of abdominal plain radiography can be strongly affected by the experience of the radiologist [25]. However, the results of our study would support the use of abdominal plain radiography in patients with suspected small bowel obstruction as an appropriate time efficient and low radiation modality, even though radiography seems to have limited effect in defining the cause or the site of the obstruction [26].

Moreover, we found that the overall sensitivity of US in patients with an organic cause of AAP was not optimal, being around 60%, comparable to two large prospective European studies providing estimates yielding a sensitivity of 65–70% [3, 27]. However, it should be underlined that the sensitivity of US is twice higher than plain radiography in patients with AAP due to an organic lesion. In particular, in our series the sensitivity of US was high in patients with a discharge diagnosis of acute cholecystitis and biliary colic due to gallstones. A recent large meta-analysis including 5859 patients reported a sensitivity of US of 81% in the diagnosis of acute cholecystitis [28]. Thus, our data further support the strong recommendation of the American College of Radiology guidelines to use ultrasonography as first-line imaging in patients with suspected cholecystitis [14, 29]. Additionally, in our study US yielded a high sensitivity also for patients with urolithiasis, in line with previous studies reporting a sensitivity of US around 80% [30–33]. Our finding would support the recommendation to use US as first-line imaging examination in the presence of a strong suspicion of urolithiasis in patient with AAP in ED, especially considering the widespread availability, the limited cost and the absence of radiation exposure [33, 34].

Regarding computed tomography, our data confirm the high overall diagnostic value of this imaging technique, in agreement with previous studies [3, 11]. Indeed, CT is widely available and highly accurate due to multi-detector

devices, but its use is associated with higher costs and exposure to radiations [35]. However, due to its high accuracy, international guidelines recommend the use of CT as first- or second-line imaging examination in most patients with AAP in ED [1, 18].

Our study has several limitations. The retrospective design is a major limitation of the study, leading to possible known and unknown biases that may affect our results. In addition, we included only a one-month study period, leading to a possible selection bias. However, our series of patients was similar in terms of discharge diagnosis with previous studies; indeed, the most frequent discharge diagnosis in our sample was "non-specific abdominal pain" (31.1%), in line with previous studies reporting rates ranging from 16 to 39% [12, 36–38]. Since this was a single-center study including patients presenting to the ED during a single month, our sample size was not very large. In particular, the sample size of patients with small bowel obstruction, cholecystitis or urolithiasis was rather limited, and this may have caused uncertainty in the estimate. However, the sensitivity of the imaging modalities for these sub-groups of patients is in line with previous studies.

In conclusion, plain abdominal radiography has an unsatisfactory diagnostic value, except for patients with AAP due to small bowel obstruction, and there seems to be an overuse in the ED in Italy, as well as in other European countries, in contrast with the recommendations of the main international guidelines [1, 14, 18]. The use of US is higher in Europe than in the USA, where US is still inappropriately underused, despite its high diagnostic value in patients with cholecystitis, gallstones and urolithiasis. Computed tomography is used in about one-third of patients with AAP in ED and has the highest diagnostic value among the imaging techniques. Thus, our findings further support the use of US as first-level imaging in patients with suspected cholecystitis, biliary colic and urolithiasis, followed by CT in negative or inconclusive cases, and the use of CT in almost all remaining patients with AAP. Finally, the use of abdominal plain radiography in the diagnostic management of patients with AAP should be limited only to those with suspected small bowel obstruction. A better diffusion of international guidelines recommendations on the use of imaging techniques in the diagnostic management of patients with non-traumatic AAP in the ED is needed.

Compliance with ethical standards

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