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Unenhanced CT for clinical triage of elderly patients presenting to the emergency department with acute abdominal pain

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KEYWORDS
Elderly;
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Abstract
Purpose: The purpose of this study was to compare the diagnostic accuracy and inter-reader agreement of unenhanced computed tomography (CT) to those of contrast-enhanced CT for triage of patients older than 75 years admitted to emergency department (ED) with acute abdominal pain (AAP).
Patients and methods: Two hundred and eight consecutive patients presenting with AAP to the ED who underwent CT with unenhanced and contrast-enhanced images were retrospectively included. There were 90 men and 118 women with a mean age of 85.4 ± 4.9 (SD) (range: 75—101.4 years). Three readers reviewed unenhanced CT images first, and then unenhanced and contrast-enhanced CT images as a single set. Diagnostic accuracy was compared to the standard of reference defined as the final diagnosis obtained after complete clinico-biological and radiological evaluation. Correctness of the working diagnosis proposed by the ED physician was evaluated. Intra- and inter-reader agreements were calculated using the kappa test and interclass correlation. Subgroup analyses were performed for patients requiring only conservative management and for those requiring intervention.

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Results: Diagnostic accuracy ranged from 64% (95% CI: 62—66%) to 68% (95% CI: 66—70%) for unenhanced CT, and from 68% (95% CI: 66—70%) to 71% (95% CI: 69—73%) for both unenhanced and contrast-enhanced CT. Contrast-enhanced CT did not significantly improve the diagnostic accuracy ($P = 0.973—0.979$). CT corrected the working diagnosis proposed by the ED physician in 59.1% (range: 58.1—60.0%) and 61.2% (range: 57.6—65.5%) of patients before and after contrast injection ($P > 0.05$). Intra-observer agreement was moderate to substantial (k = 0.513—0.711). Inter-reader agreement was substantial for unenhanced (kappa = 0.745—0.789) and combined unenhanced and contrast-enhanced CT (kappa = 0.745—0.799). Results were similar in subgroup analyses.

Conclusion: Unenhanced CT alone is accurate and associated with high degrees of inter-reader agreement for clinical triage of patients older than 75 years with AAP in the emergency setting.

The world's population and life expectancy are continuously increasing. Consequently, the elderly population is growing and in accordance, the number of their admissions to the emergency department (ED). The management of elderly patients is more challenging for the physicians. They spend more time in ED compared to younger patients because they have nonspecific symptoms or clinical findings, biological results, and an increased incidence of serious surgical emergencies including vascular disease [1—5]. These atypical presentations explain possible difficulties in ED triage, combined with a higher rate of comorbidities and general frailty in the elderly, result in a higher mortality rate in ED compared to younger patients [6,7]. Yet, the delay from admission to surgery is an independent factor of mortality in the elderly patients admitted to ED with an acute abdomen [8], suggesting that saving time may lead to improved patient outcome.

Computed tomography (CT) has proven accuracy in the diagnosis of abdominal diseases and for the exclusion of mimickers of an acute abdomen. It also helps guide appropriate treatment selection [9—11]. Its use for clinical triage is widely accepted [12]. While there is consensus on the use of a contrast-enhanced CT examination for abdominal emergencies that is highly recommended as a first-line investigation, the value of unenhanced CT that is yet performed in may institutions is more controversial. The former can be performed if the baseline serum creatinine level is within the acceptable range, to limit the risk of contrast-induced nephropathy that may lead to substantial morbidity in the elderly. Yet, despite new assay methods, obtaining this laboratory test remains time-consuming and may delay treatment.

Recent studies report a high accuracy for unenhanced CT in the early diagnosis of acute abdominal pain in ED and advocate its systematic use in the elderly in order to expedite treatment and thus reduce morbidity and mortality, even before obtaining the serum creatinine [13,14]. This strategy could be performed to allow early ED triage in order to improve patient care. Yet, if such a strategy were to be adopted, the question of its diagnostic performance, and the added value of subsequent contrast-enhanced CT, remains unanswered.

The purpose of this study was to compare the diagnostic accuracy and inter-reader agreement of unenhanced and contrast-enhanced CT for clinical triage of patients over the age of 75 years admitted to ED with acute abdominal pain.

Materials and methods

Patients population

This was a retrospective monocentric study performed in the Radiology Department of Beaujon Hospital, with institutional review board approval waiving the requirement for informed consent. From January 2012 to May 2016, all consecutive patients over the age of 75 years admitted to our ED for non-traumatic acute abdominal pain were identified. The cut-off value of 75 years was chosen according to Millet et al. [13]. Patients were included when they had CT of the abdomen and pelvis with both pre and post-contrast acquisitions. Exclusion criteria included history of trauma and recent colorectal, hepatobiliary or pancreatic surgery.

Of a total of 578 patients initially identified, 208 (35.8%) patients met the inclusion criteria (Fig. 1). There were 90 men and 118 women with a mean age of 85.4 ± 4.9 (SD) (range: 75—101.4 years). Clinical and laboratory data were obtained from the patient medical records. The initial and final diagnoses were retrieved from patients medical records analyzed at least 3 months after the ED consultation in order to avoid patient new consultation and delayed diagnosis mistakes. Final diagnosis was retrieved from patient medical records after complete clinical, biological and radiological evaluation, and from the operative note or follow-up outpatient consultation when available. Patient characteristics are summarized in Table 1.

CT protocol

All abdominal CT examinations were performed on a multidetector CT (64-detector LightSpeed® VCT; General Electric Healthcare). CT acquisitions covered the entire abdomen and pelvis for both unenhanced and enhanced images. After acquisition of the unenhanced images, non-ionic iodinated

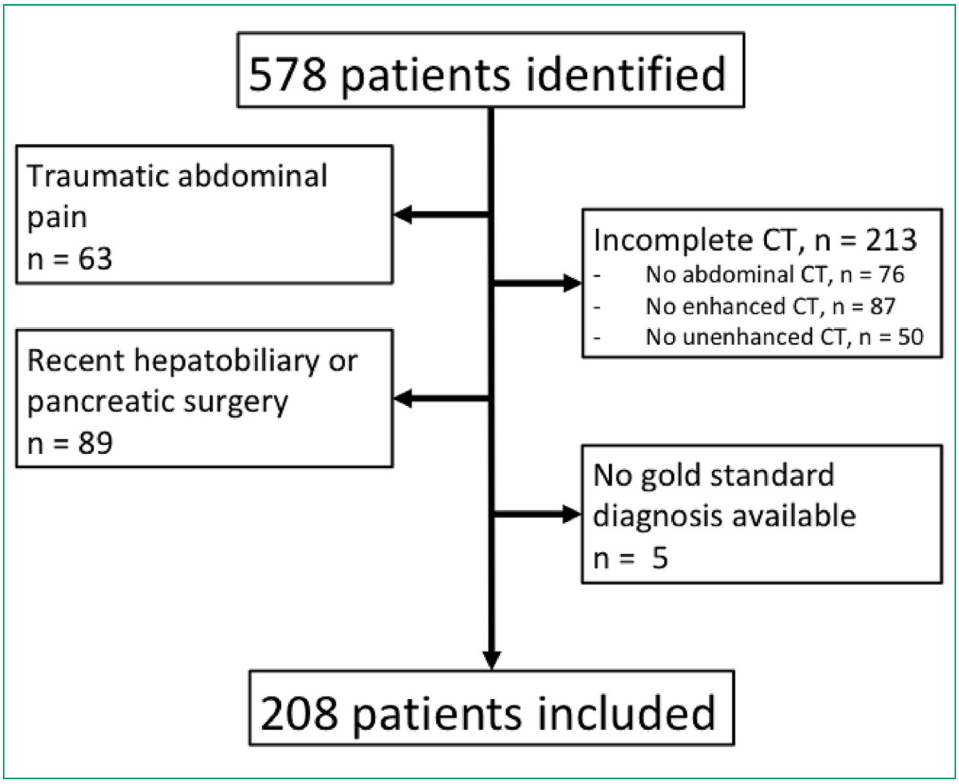

Figure 1. Flowchart of patients inclusion.

contrast material (iomeprol, Iomeron 350®, Bracco Imaging, or iobitridol, Xenetix 350®, Guerbet) was injected through a 20-gauge or larger cannula, with a mechanical power injector at a rate of 2 mL/kg, with portal-venous phase image acquisition performed after a delay of 70 to 80 s. The following parameters were used: voltage, 120 kV; tube current, 120—170 effective mAs; axial resolution, 0.6-mm; slices thickness reconstruction, 1.5-mm; beam collimation, 38.4 mm; gantry rotation time, 0.5 s; table speed, 46-mm/gantry rotation; beam pitch, 1.2. A total of 68 patients had an additional arterial phase acquisition (25 to 35 s after the start of injection), which was performed at the radiologist's discretion when an arterial etiology was suspected. Images were reviewed with Carestream PACS (Carestream Health).

Imaging analysis

Following anonymization, three abdominal radiologists performed a blind, retrospective, independent review all CT examinations: one senior consultant with 10 years of experience in abdominal radiology and two fellows with 4 and 5 years of experience in abdominal radiology respectively. Readers were provided with the location of the abdominal pain, laboratory data [including full blood count, serum C reactive protein (CRP) level, liver function tests, serum lipids, lactate and creatinine levels] and suspected diagnosis initially provided by ED physicians at the time of CT request. Each reader performed two separate interpretationsusing unenhanced CT images only first and then using unenhanced and contrast-enhanced CT images together as a single set.

For each review, CT examinations were provided in random order. The second reading was performed blinded to the results of the first one, after an interval of at least 6 weeks. Following the study by Millet et al., readers were asked to propose a diagnosis chosen from 16 standardized diagnostic categories [13]. Readers had to provide one main diagnosis, and could add one or two alternative diagnoses. Each diagnosis was associated with a confidence level, ranging from 0 to 100%, with increments of 20%. When more than one diagnosis was considered, the total of all confidence levels could not exceed 100%.

The standard of reference to determine the actual disease of the patient was the final diagnosis as defined above. Diagnostic accuracies were computed for each reader and each reading, separately, by comparing the final diagnosis with the suggested diagnoses. Diagnosis was considered accurate when the main diagnosis proposed by the readers (the one with the highest level of confidence) corresponded to the diagnosis made using the standard of reference. Confidence levels were compared between readers and readings. For each reader, a radar chart showing the number of correct diagnoses according to the 16 categorical diagnoses was plotted for both readings.

A subgroup analysis was conducted after exclusion of patients with a final diagnosis of nonspecific abdominal pain (NSAP). Another subgroup analysis was performed for patients who required emergent or urgent intervention (including surgical, endoscopic or interventional radiology procedures) after CT.

Table 1 Characteristics of 208 patients.

Gender	
Men	90/208 (43.3%)
Women	118/208 (56.7%)
Age (years) mean ± SD [range]	85.4 ± 4.9 [75–101.4]
Abdominal pain location	
Diffuse	156/208 (75.0%)
Right hypochondium	11/208 (5.3%)
Epigastric	8/208 (3.8%)
Left hypochondrium	1/208 (0.5%)
Right flank	1/208 (0.5%)
Umbilical	3/208 (1.4%)
Left flank	5/208 (2.4%)
Right iliac fossa	14/208 (6.6%)
Suprapubic	2/208 (0.9%)
Left iliac fossa	16/208 (7.7%)
Patients with abnormal laboratory blood tests	
CRP > 5 mg/L	107/208 (51.4%)
Leukocytosis > 10/μL	125/208 (60.1%)
Hemoglobin < 10 g/L	16/208 (7.7%)
ALAT > 50 UI	28/208 (13.5%)
ASAT > 50 UI	30/208 (14.4%)
Creatininemia > 96 μmol/L	53/208 (25.5%)
Lactatemia > 2 mmol/L	26/208 (12.5%)
Lipasemia > 150 UI	8/208 (3.8%)
Patients outcome	
Interventional treatments	58/208 (27.9%)
Surgery	42/208 (20.2%)
Interventional radiology	16/208 (7.8%)
Early death (< 7 days)	7/208 (3.4%)

CRP: C reactive protein; ALAT: alanine aminotransferase; ASAT: aspartate aminotransferase.

For those patients with an available working diagnosis proposed by the ED physician at the time of CT acquisition ($n = 177$, 85.1%), the rate of change of diagnosis, defined as the proportion of cases in which the CT-scan correctly altered the diagnosis suspected by the physician, was analyzed and compared between readers for unenhanced and contrast-enhanced CT.

Statistical analysis

Quantitative values were expressed as mean ± standard deviation (SD) and compared using the Student *t*-test. Qualitative values were expressed in percentage and compared using a Chi^2 test or Fisher's exact test when attended observations were under 5. Paired variables were compared using the McNemar test. Intra-observer and inter-observer agreements were calculated using the kappa statistics and the interclass correlation coefficient (ICC). Kappa coefficients between 0.00 and 0.20; 0.21 and 0.40; 0.41 and 0.60; 0.61 and 0.80; and 0.81 and 1.00, indicated slight, fair, moderate, substantial, and almost perfect agreement [15]. Diagnostic accuracies were expressed as percentages. The statistical significance for all tests was set at $P < 0.05$. The SPSS version 20.0 (SPSS, IBM) was used for statistical analyses.

Results

Patients and final diagnoses

Final diagnoses of all patients are summarized in Table 2. The most frequent diagnoses were mechanical bowel obstruction (44/208; 21.2%), nonspecific abdominal pain (41/208; 19.7%), and acute biliary disease (44/208, 17.8%). Eight patients (8/208; 3.9%) had a non-abdominal cause of abdominal pain secondary to pneumonia ($n = 5$ patients), pulmonary embolism ($n = 2$ patients), and spondylitis ($n = 1$ patient). Seven patients died within seven days after their admission in the ED, and death was related to small bowel obstruction ($n = 5$ patients), acute diverticulitis ($n = 1$ patient), and acute mesenteric ischemia ($n = 1$ patient) (Figs. 2–4).

Diagnostic accuracy

Comparison of diagnoses proposed by readers and final diagnoses are detailed in Table 2.

All readers gave a main diagnosis for each CT examination. A second diagnosis was given in 41/208 (19.7%), 95/208 (45.7%) and 63 (30.3%) patients for reader 1, 2 and 3, respectively with unenhanced CT images and in 49 (23.6%), 58 (27.9%) and 26 (12.5%) patients with unenhanced and both unenhanced and contrast-enhanced CT images, respectively. A third diagnosis was proposed in 8 (3.8%), 6 (2.9%) and 4 (1.9%) patients, and only when readings were limited to unenhanced CT images. The number of alternate diagnoses was significantly lower when readings included contrast-enhanced CT acquisitions (45.7% vs. 63.0%; $P < 0.001$). Radar charts for the diagnostic accuracy of each reader are presented in Fig. 5.

When considering only the main proposed diagnosis, the diagnostic accuracy ranged from 63.9% (95% CI: 62.9–66.9%) to 68.3% (95% CI: 66.3–70.3%) for unenhanced CT images only, and from 68.3 (95% CI: 66.3%–70.3%) to 71.2% (95% CI: 69.2–73.2%) using both unenhanced and contrast-enhanced CT images. Contrast-enhanced CT images did not significantly improve the diagnostic accuracy for neither senior nor junior radiologists except for reader 2 (71.2% versus 75.3%; $P = 0.035$) (Table 3). When a second diagnosis was also considered, diagnostic accuracy did not significantly improve, except for reader 1 with unenhanced CT only (75.3% vs. 63.8%; $P = 0.020$).

Forty-one patients had a final diagnosis of NSAP (41/208; 21%). After exclusion of these patients, diagnostic accuracy did not significantly improve by adding contrast-enhanced CT images (mean accuracy = 61.7% to 68.5%, $P = 0.313$ with unenhanced CT images only and mean = 64.1% to 75.4% with both unenhanced and contrast-enhanced CT, $P = 0.082$).

Diagnostic accuracy of all readers was greater for patients who required immediate intervention after CT than in those requiring conservative medical management or no treatment ($P = 0.001$–0.060). Contrast-enhanced CT images did not significantly improve the diagnostic accuracy when compared to unenhanced CT images (Table 4).

Table 2 Proportion of correct diagnoses with unenhanced and contrast-enhanced CT in 208 patients.

	n (%)	Reader 1			Reader 2			Reader 3		
		UCT	ECT	*P*-value[a]	UCT	ECT	*P*-value[a]	UCT	ECT	*P*-value[a]
Final diagnosis										
Mechanical bowel obstruction	44 (21)	39 (88)	38 (85)	> 0.999	39 (88)	40 (91)	> 0.999	37 (82)	34 (77)	0.590
Nonspecific abdominal pain	41 (19.5)	25 (61)	23 (56)	0.822	19 (46)	21 (51)	0.827	31 (77)	34 (83)	0.586
Acute biliary disease	37 (18)	29 (78)	34 (92)	0.189	31 (84)	31 (84)	> 0.999	25 (68)	27 (73)	0.799
Fecal impaction	17 (8)	12 (71)	12 (71)	> 0.999	11 (64)	9 (53)	0.728	6 (35)	7 (42)	> 0.999
Acute diverticulitis	16 (8)	10 (64)	8 (50)	0.722	5 (32)	6 (38)	> 0.999	5 (32)	4 (25)	> 0.999
Acute appendicitis	10 (5)	9 (90)	8 (80)	> 0.999	7 (70)	8 (80)	> 0.999	10 (100)	8 (80)	0.474
Colitis	10 (5)	5 (50)	3 (30)	0.649	8 (80)	10 (100)	0.757	9 (90)	9 (90)	> 0.999
Non-abdominal disease	8 (4)	1 (13)	2 (25)	> 0.999	1 (13)	4 (50)	0.282	1 (13)	2 (25)	> 0.999
Bowel ischemia	5 (2.5)	1 (20)	3 (60)	0.524	0 (0)	2 (40)	0.444	0 (0)	1 (20)	> 0.999
Acute pancreatitis	4 (1.5)	4 (100)	4 (100)	> 0.999	4 (100)	4 (100)	> 0.999	3 (75)	4 (100)	> 0.999
Other acute intra-abdominal disease	3 (1.5)	0 (0)	2 (67)	0.400	1 (33)	2 (67)	> 0.999	1 (33)	2 (67)	> 0.999
Peptic ulcer	3 (1.5)	2 (67)	2 (67)	> 0.999	2 (67)	2 (67)	> 0.999	1 (33)	3 (100)	0.400
Urinary obstruction	3 (1.5)	3 (100)	3 (100)	> 0.999	1 (33)	2 (67)	> 0.999	3 (100)	3 (100)	> 0.999
Acute aortic disease	2 (1)	1 (50)	2 (100)	> 0.999	2 (100)	2 (100)	> 0.999	1 (50)	2 (100)	> 0.999
Pyelonephritis	2 (1)	0 (0)	2 (100)	0.333	2 (100)	2 (100)	> 0.999	0 (0)	0 (0)	> 0.999
Paralytic ileus	1 (0.5)	1 (100)	1 (100)	> 0.999	1 (100)	1 (100)	> 0.999	1 (100)	1 (100)	> 0.999
Acute gynecological disease	1 (0.5)	0 (0)	0 (0)	> 0.999	0 (0)	0 (0)	> 0.999	0 (0)	0 (0)	> 0.999
Inflammatory peritoneal disease	1 (0.5)	0 (0)	1 (100)	> 0.999	0 (0)	1 (100)	> 0.999	0 (0)	0 (0)	> 0.999
Total	208	142 (68)	148 (71)	0.593	134 (64)	147 (71)	0.208	134 (64)	141 (67)	0.534

CT: computed tomography; UCT: unenhanced CT examination; ECT: enhanced CT examination. Reader 3 was the most experienced reader.

[a] Fisher's exact test.

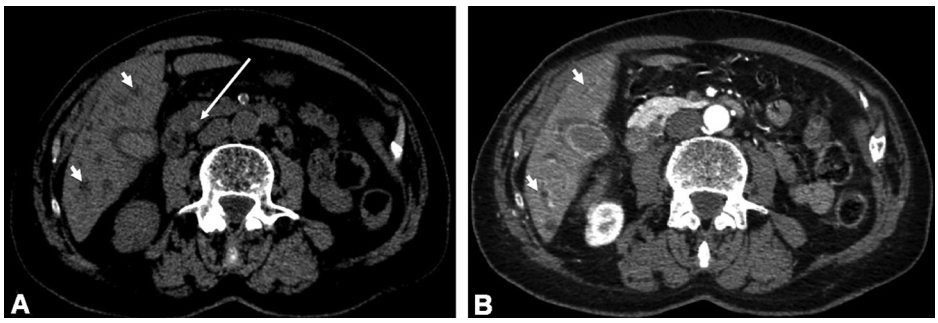

Figure 2. Cholangitis secondary to a common bile duct stone in a 93-year-old man admitted with acute, diffuse abdominal pain and jaundice. The patient had moderately elevated leucocyte count (12,500/mL)and liver function tests results consistent with obstruction. The emergency department physician suspected acute cholecystis. A. Unenhanced computed tomography (CT) image in the axial plane shows hyperattenuating stone in the common bile duct (long arrow) and upstream bile duct dilatation (short arrows). B. Contrast-enhanced CT image obtained during the late arterial phase shows bile duct dilatation (short arrows) but the stone is not visible. The patient received antibiotics and underwent endoscopic sphincterotomy 48 hours after admission, which confirmed the diagnosis.

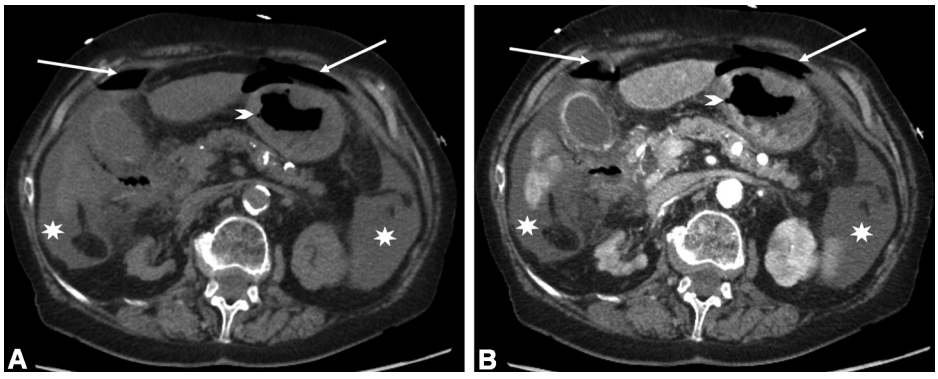

Figure 3. Perforated gastric ulcer in an 88-year-old woman admitted for acute, diffuse abdominal pain and vomiting. She had for only abnormality a mild inflammatory syndrome. The emergency department physician suspected bowel obstruction. A. Unenhanced computed tomography (CT) image in the axial plane shows pneumoperitoneum (large arrows) and non-hemorrhagic ascites (asterisk) and gas bubble associated with wall thickening (arrowhead) of the stomach wall. B. Contrast-enhanced CT image during the portal-venous phase shows similar findings. The patient underwent surgery in the 12 first hours associated with intravenous antibiotic therapy. Patient was alive 4 months after the admission.

Level of confidence

The mean confidence level for first and second diagnoses ranged from 82% to 88% and 33% to 37% respectively, with unenhanced CT images only, and from 88% to 95% and 37% to 44% with both unenhanced and contrast-enhanced CT ($P = 0.938$). Contrast-enhanced CT did not significantly improve the confidence level for the main proposed diagnosis ($P = 0.938$). Yet, the mean confidence level was significantly greater when the proposed diagnosis by readers was the correct one (85% to 92% vs. 75% to 83% for false diagnoses; $P < 0.001$), except for reader 3 with unenhanced and contrast-enhanced CT (95% vs. 92%; $P = 0.278$). These results were similar when considering both the first and the second diagnosis.

Inter-reader agreements

Intra-reader agreement for diagnosis between unenhanced and contrast-enhanced CT was moderate to substantial, with kappa ranging between 0.513 and 0.711. Inter-reader agreement was substantial with kappa ranging between 0.745 and 0.789 for unenhanced CT, and between 0.745 and 0.799 for contrast-enhanced CT. These results were similar between the two juniors, as well as between each junior and the senior radiologist.

Interclass correlations for the diagnosis were substantial to almost perfect and ranged from 0.741 to 0.808 for unenhanced CT and from 0.733 to 0.829 for contrast-enhanced CT. Kappa values for inter-reader agreement between readers ranged between 0.741 and 0.808 for unenhanced CT images, and between 0.733 and 0.829 for contrast-enhanced CT images.

Change of diagnosis

Radiologists correctly changed the diagnosis suspected by the emergency physician in 59.1% of patients with unenhanced CT images only (range: 58.1% to 60.0%) and in 61.2% of patients with both unenhanced and contrast-enhanced CT (range: 57.6% to 65.5%). The addition of contrast-enhanced CT did not significantly improve the rate of change in diagnosis ($P = 0.746$).

Physician's diagnostic suspicions were most frequently correct in patients with mechanical bowel obstruction (38/44; 87%), appendicitis (6/7; 85%), bowel ischemia (3/5;

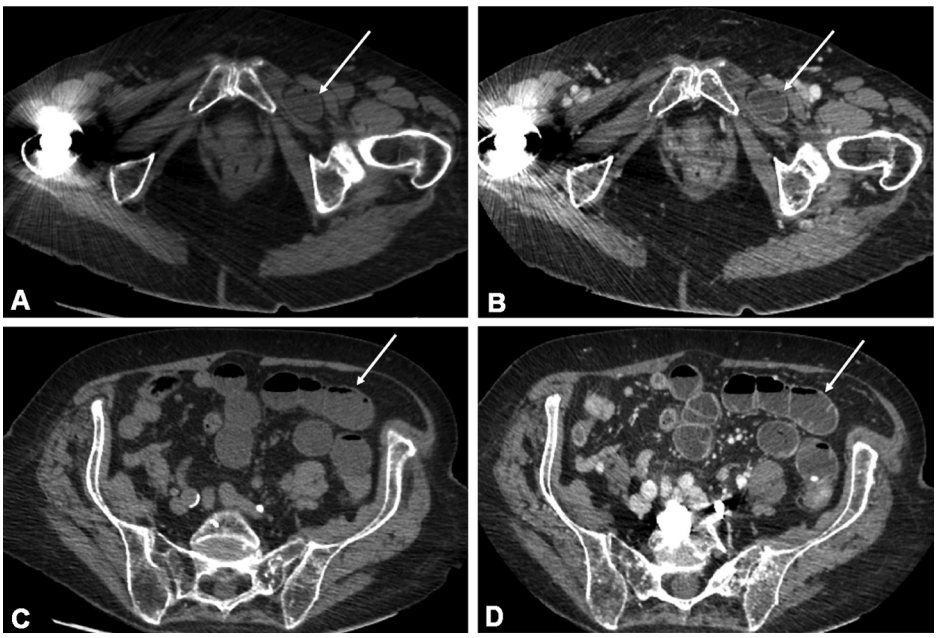

Figure 4. Small bowel obstruction in an 82-year-old woman admitted for acute, diffuse abdominal pain and rectal bleeding. Laboratory test results were normal. A. Unenhanced computed tomography (CT) image in the axial plane showed an obturator hernia with strangulated small bowel loop without associated free fluid or spontaneously hyperattenuating bowel wall (arrow). B. Contrast-enhanced CT image during the portal-venous phase shows the same findings and normal degrees of bowel wall enhancement. C. Unenhanced CT also shows upstream small bowel dilatation without spontaneously hyperattenuating bowel wall (arrow). D. Contrast-enhanced CT image during the portal-venous phase shows similar findings and normal bowel wall enhancement. The patient underwent laparoscopic surgery without bowel resection 6 hours after admission.

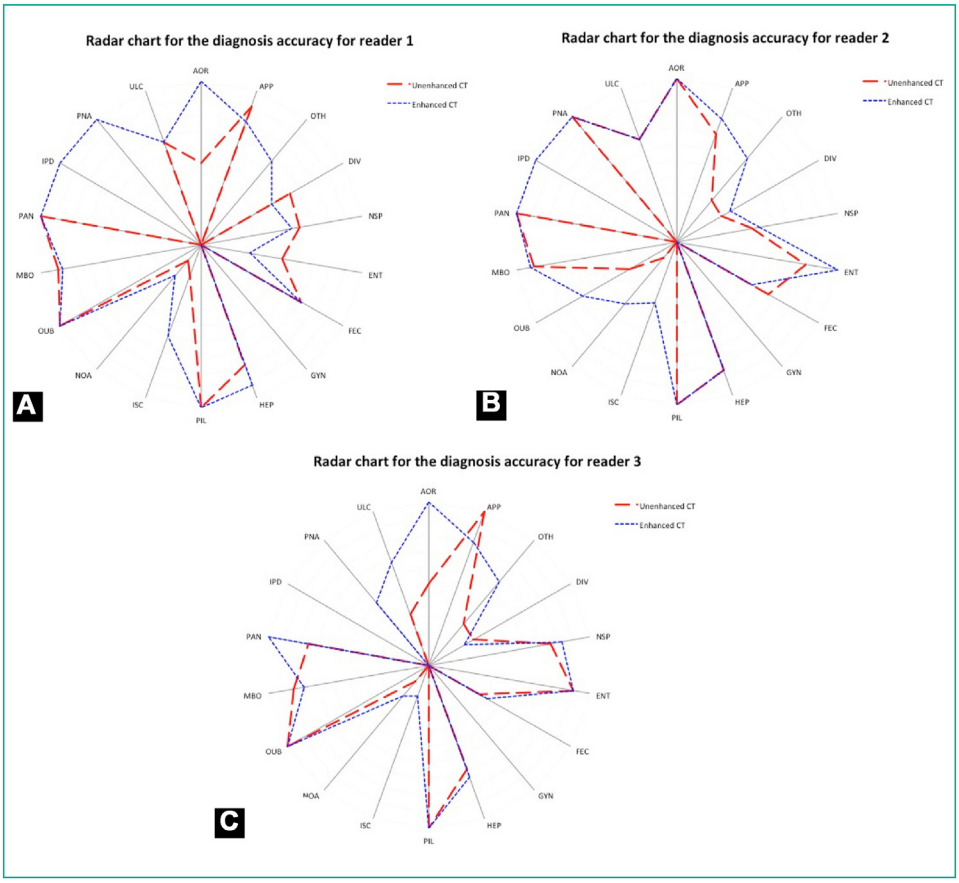

Figure 5. Graphs show radar charts for the diagnosis of each diagnosis with unenhanced and contrast-enhanced computed tomography (CT) examination for reader 1 (A), 2 (B) and 3 (C).

Table 3 Number of correct and false diagnoses with associated levels of confidence.

Reader	True diagnosis considering the first only	LC (mean ± SD) (%)	False diagnosis considering the first only	LC (mean ± SD) (%)	*P*-value[a]	True diagnosis considering the first or the second	LC (mean ± SD) (%)	False diagnosis considering the first or the second	LC (mean ± SD) (%)	*P*-value[a]
1										
Unenhanced CT	142/208 (68%)	86 ± 17	66/208 (32%)	75 ± 16	< 0.001	147 (71%)	83 ± 19	61 (29%)	60 ± 26	< 0.001
Contrast-enhanced CT	148 (71%)	85 ± 17	60 (29%)	75 ± 15	< 0.001	162 (78%)	86 ± 21	46 (22%)	66 ± 25	< 0.001
P-value	0.360[b]	0.008[b]		0.264[b]		0.020[c]	0.016[b]		< 0.001[b]	
2										
Unenhanced CT	134 (64%)	88 ± 17	74 (36%)	75 ± 18	< 0.001	155 (75%)	81 ± 24	53 (25%)	56 ± 27	< 0.001
Contrast-enhanced CT	147 (71%)	92 ± 16	61 (29%)	83 ± 20	< 0.001	155 (75%)	90 ± 20	53 (25%)	64 ± 30	< 0.001
P-value[b]	0.035[b]	0.024[b]		0.026[b]		1.000[c]	< 0.001[b]		< 0.001[b]	
3										
Unenhanced CT	134 (64%)	93 ± 16	74 (36%)	80 ± 23	< 0.001	147 (71%)	88 ± 23	61 (29%)	67 ± 28	< 0.001
Contrast-enhanced CT	141 (67%)	95 ± 14	67 (33%)	92 ± 16	0.278	142 (68%)	95 ± 14	66 (32%)	82 ± 25	< 0.001
P-value	0.248[b]	0.122[b]		< 0.001[b]		0.442[c]	< 0.001[b]		< 0.001[b]	

CT: computed tomography. The intended diagnosis was considered accurate if the diagnosis with the maximum confidence level was the same as the standard of reference diagnosis.

[a] Student *t*-test comparing the level of confidence (LC) between true and false diagnosis.

[b] Student *t*-test comparing the level of confidence (LC) for the diagnosis between unenhanced and contrast-enhanced CT for each reader, for true and false diagnoses.

[c] McNemar test comparing the number of true positive diagnoses between unenhanced and contrast-enhanced for each reader.

Table 4 Proportion of correct diagnoses according to the need for immediate interventional treatment (interventional radiology, surgery or endoscopic treatment) after CT or not.

	Unenhanced CT			Contrast-enhanced CT			*P*-value[a]
	Reader 1	Reader 2	Reader 3	Reader 1	Reader 2	Reader 3	
Interventional treatment (*n* = 58)							0.211
Correct	49 (84%)	43 (74%)	46 (83%)	52 (90%)	50 (86%)	45 (78%)	
False	9 (16%)	15 (26%)	12 (17%)	6 (10%)	8 (56%)	13 (12%)	
No interventional treatment (*n* = 150)							0.218
Correct	92 (62%)	91 (61%)	88 (59%)	96 (64%)	97 (65%)	95 (78%)	
False	58 (38%)	59 (39%)	62 (41%)	54 (36%)	53 (35%)	54 (36%)	
P-value[a]	**0.001**	0.068	**0.005**	**< 0.001**	**0.002**	0.060	

CT: computed tomography; IV−: unenhanced CT; IV+: contrast-enhanced CT. Bold indicates significant *P*-values.
[a] Chi^2 test.

60%), and diverticulitis (8/16; 53%). Diagnosis performances of readers were lower for hepatobiliary diseases (14/37; 38%), acute aortic disease (0/2; 0%) and fecal impaction (0/17; 0%). In all patients with non-abdominal disease (8/208; 3.8%), physicians provided an erroneous diagnosis whereas CT provided a correct diagnosis.

Discussion

The present study included patients over 75 years admitted to the ED with non-traumatic acute abdominal pain, and showed that the diagnostic accuracy of CT was not significantly improved by the use of an enhanced phase. Unenhanced CT alone led to a change in the initial diagnosis proposed by ED physicians in up to 60% of patients. Moreover, the addition of contrast-enhanced CT did not improve intra and inter-reader agreements or confidence levels. This suggests that unenhanced CT images alone could be a valuable triage modality for elderly patients admitted to ED for non-traumatic abdominal pain.

If contrast-enhanced CT is consensually recommended as a first-line investigation in the context of abdominal pain, our results support the use of alternative strategies in elderly, such as unenhanced CT for all patients, with the use of intravenous iodinated contrast material left at the discretion of the radiologist, or when specific diagnosis that require intravenous iodinated contrast material are suspected (e.g., acute mesenteric ischemia). This strategy is faster — no need to perform and to wait for blood test results — and would decrease the risk of iodine-induced side effects [16].

The accuracy of unenhanced CT examination and the limited added value of intravenous contrast injection are consistent with the results of the recent large prospective study by Millet et al. evaluating the diagnostic value of a systematic unenhanced CT in elderly patients with abdominal pain [13]. These researchers reported a diagnostic accuracy of unenhanced CT up to 80%, with a change in management in 37% of patients [13]. These authors also found that the addition of a contrast-enhanced CT improved the diagnosis in a few patients only [13].

In our study, the diagnostic accuracy of CT ranged from 63.9 to 81.3%. It ranged from 81—95% in previous studies [13,14,17]. This could be explained by the retrospective design of the current study, leading to inclusion bias. It could also be related to the relatively large group of patients with nonspecific abdominal pain in the present study or the large panel of different abdominal diseases we found [13,17]. These patients were discharged without any organic disease that could explain the pain and did not return to the emergency department. For these patients, readers often suggested a diagnosis that differed from ''nonspecific abdominal pain, but without improvement in the confidence level or the diagnostic accuracy after intravenous contrast injection. When considering the two first diagnoses, the diagnosis accuracy increased up to 81%. This finding confirms that unenhanced CT could be used as triage in order to improve patient care, but also that a clinical exam performed by an experienced physician cannot be avoid. Finally, the distribution of diseases greatly varied among studies. For instance, in our study 'other acute abdominal disease''' or ''acute biliary disease'' were present in 1.5% and 17.7% of patients, respectively whereas they were present in 17.7%, and 9.7% of patients, respectively in the study by Millet et al. [13].

For acute abdominal pain, most centers use a CT protocol with a single portal-venous phase acquisition, to limit the radiation dose, assuming that the value of unenhanced images is limited. Our results suggest that this may not be the case in elderly patients. First, the use of contrast material increases the total radiation dose from 20 to 50%, but more importantly, exposes patients to an increased risk of iodine-related renal toxicity, which is potentially severe in the elderly, even if it has never been proven to be an independent factor of increased mortality [16,18,19]. Furthermore, unenhanced CT has been proven to be useful in the setting of many acute abdominal emergencies [20—25]. Our results suggest a more extensive analysis of unenhanced CT images in elder patients. Intravenous administration of iodinated contrast material remains of utmost importance and should not been delayed when needed. We do not advocate the use of unenhanced CT only. This is especially true when vascular anomalies need to be detected, or when bowel wall enhancement needs to be analyzed [23,24].

Overall, our results show that unenhanced CT is a valid tool in elderly patients, both for diagnosis purposes, and to help triage patients, in line with Millet et al. [13].

A major strength of the current study is the assessment of intra and inter-reader agreement between three readers with different levels of experience. Agreement between readers for the diagnosis was substantial when based on unenhanced CT alone. This is important because, aside from its diagnostic value, reproducibility of imaging findings is crucial in these patients. As in the present study, several others have reported good inter-reader agreement of unenhanced CT performed for acute abdominal disease, with kappa values over 0.7 in many indications and up to 0.92 in patients with acute appendicitis [22,26].

One major limitation of our study was its retrospective design. However, the final diagnosis was well documented in all patients. Although patient inclusion was consecutive, several patients were excluded because they did not undergo unenhanced CT resulting in a lower number of patients when compared to other studies [13,17]. Then, the time saved by using unenhanced CT only could not be evaluated. In addition, readers were provided with the initial clinical and biological results, together with the suspected diagnosis of the emergency department physician, which could have led to an interpretation bias. Yet, this was intentional, as we felt it was important that our study should reflect everyday clinical practice. Moreover, readers were aware of the possible negative influence of this information. Because the rate of diagnostic change after CT was around 60%, we can assume that this bias was minimal. Moreover, and as stated above, this rate was similar to that of other studies (42 to 60%) [13,14,17].

In conclusion, unenhanced CT alone is accurate and associated with a high inter-reader agreement of acute abdominal pain in patients older than 75 years presenting to the ED. Unenhanced CT-examination could be a valuable tool for triaging in this population. Contrast-enhanced CT did not prove to be superior, advocating for a more extensive use of unenhanced CT for the initial management of these patients.

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Authors contribution

Maxime Barat: study concept and design, acquisition of the data, analysis and interpretation of the data, drafting of the manuscript.

Anita Paisant: acquisition of the data, critical revision of the manuscript.

Paul Calame, Mathieu Lagadec, Magaly Zappa: acquisition of the data.

Yvonne Purcell: critical revision of the manuscript.

Sonja Curac: study concept and design, acquisition of the data.

Valérie Vilgrain: study concept and design, analysis and interpretation of the data, critical revision of the manuscript, statistical expertise.

Maxime Ronot: study concept and design, analysis and interpretation of the data, drafting of the manuscript, critical revision of the manuscript for important intellectual content, statistical expertise.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.diii.2019.05.004.

Disclosure of interest

The authors declare that they have no competing interest.

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