

[ORIGINAL ARTICLE]

The Diagnostic Process for the Evaluation of Acute Abdominal Pain by Resident Trainees in Japan: A Cross-sectional Study

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Abstract:

Objective Acute abdominal pain (AAP) of diverse etiology is a common chief complaint of patients who present to the emergency department (ED). AAP may pose a diagnostic challenge to physicians in training. We aimed to evaluate whether or not resident trainee doctors examine patients presenting with AAP in a Japanese acute-care hospital following Kendall's diagnostic algorithm.

Methods We conducted a retrospective medical chart review from January 2015 to December 2016.

Patients Patients ≥ 50 years old who presented to the ED within 7 days of the onset of AAP who were evaluated by residents at the ED of an acute care hospital were enrolled in this study. Patients transported by ambulance and referred from other hospitals and classified as level 1 or 2 according to the Japanese version of the Canadian Triage and Acuity Scale were excluded. Data, including the clinical history, location and character of pain, and age and gender of patients as well as the level of experience of residents, were abstracted from charts. We evaluated the concordance rate between the actual diagnostic process followed by residents and Kendall's diagnostic algorithm for AAP.

Results We analyzed 466 patients (mean age 67.6 years) in the study who were evaluated and diagnosed by 123 residents. The concordance rate between the diagnostic procedures performed by residents and those suggested by Kendall's diagnostic algorithm was 61.2%. A low concordance rate was observed among patients with peritoneal signs, shock or toxic appearance (25.0%), suggested acute coronary syndromes (ACS) (55.1%), epigastric or right upper-quadrant pain (52.8%), and left upper-quadrant pain (55.6%). Abdominal ultrasonography is one of the recommended examinations for patients with signs of peritoneal irritation, shock or toxic appearance, right lower-quadrant pain, and left upper- or lower-quadrant pain, but the rates were relatively low at 25.0%, 34.4%, 31.8%, and 26.7%, respectively.

Conclusion Abdominal ultrasonography required by Kendall's diagnostic algorithm was not performed appropriately in patients with symptoms and signs of peritonitis, shock or toxic appearance, right lower-quadrant pain, and left upper- or lower-quadrant pain or in female patients by resident trainees. Our findings underscore the importance of providing resident doctors with focused training concerning ultrasonography by attending physicians.

Key words: diagnostic algorithm, abdominal pain, resident, physical examination, concordance rate

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Introduction

Acute abdominal pain (AAP) is one of the most common symptoms among patients who present to the emergency department (ED), accounting for 5-10% of all presenting complaints (1, 2). During the evaluation of patients with AAP, a wide range of underlying diseases need to be considered, which may include everything from benign, self-limiting conditions to life-threatening diseases, including gastrointestinal, urological, gynecological, and vascular disease (3). Furthermore, the signs and symptoms of several diseases that include AAP as the main symptom can be very nonspecific at onset (4). A misdiagnosis or diagnostic delay in the treatment of AAP can lead to poor clinical outcomes. A delay in surgical treatment was one of the major causes of postoperative mortality following emergency abdominal surgery among elderly patients (5). Therefore, it is important for physicians, especially residents in training, to follow a structured process for the diagnosis of patients who present with AAP in order to avoid mistakes in care.

In Japan, residents must undergo a mandatory two-year rotational postgraduate training program in multi-specialty departments, including internal medicine, general surgery, and emergency medicine. Trainees who participate in this program are designated as “junior residents”. After two years of postgraduate training, they opt for specialization and undergo three to six years of additional training before acquiring specialist qualification. Trainees who undergo this specialty training are designated as “senior residents” (6). The diagnostic accuracy of AAP among first- and second-year postgraduate ED residents has been reported to be 66% (7). Such diagnostic errors have been attributed in large part to the tendency of residents to make a diagnosis based on their previous experience of patients with similar symptoms, known as “availability bias” (8). Although it is imperative to review the adequacy of the diagnostic process of trainee doctors and introduce appropriate measures to improve diagnostic skills, there is a paucity of literature on this topic.

The diagnostic accuracy has improved with the introduction of an algorithmic approach aimed at reducing the time, effort, and bias in many areas of clinical practice, particularly ophthalmology and arrhythmology (9, 10). By using simple diagnostic algorithms that emphasize the most important points using a structured process, even inexperienced physicians can arrive at an accurate diagnosis, according to a previous report (9). Among several diagnostic algorithms used for the evaluation of AAP (4, 11), Kendall’s algorithm, reported in UpToDate[®], offers the most comprehensive process for the diagnosis of abdominal pain (12, 13). This algorithm initially considers and rules out the most severe and life-threatening disease processes based on the characteristics and localization of abdominal pain by prompting mandatory procedures and examinations. A meticulous diagnostic process follows, based on the localization of pain (12). A

modified version of Kendall’s diagnostic algorithm was adopted in the Japanese clinical practice guideline for AAP. This was published in 2015 as a collaborative guideline by five Japanese medical societies including the Japanese Society for Abdominal Emergency Medicine and the Japan Primary Care Association (14). Considering its popularity and usability, it is appropriate to use Kendall’s diagnostic algorithm as the standard diagnostic process to evaluate the diagnostic ability of residents.

We evaluated whether or not resident trainee doctors examine patients presenting with AAP in a Japanese acute-care hospital following Kendall’s diagnostic algorithm.

Methods and Materials

Study design and setting

This study was approved by the ethics committee of our acute hospital. We conducted a retrospective medical chart review of patients who visited the ED of our hospital with abdominal pain as the main presenting complaint from January 1, 2015, to December 31, 2016. One junior and one senior resident were on duty each night according to their rotation for the initial evaluation of patients who presented to the ED.

Patients

We enrolled patients ≥ 50 years old who presented to the ED within 7 days of the onset of abdominal pain. The evaluation was carried out by junior residents undergoing a mandatory two-year postgraduate training program by rotating through multi-specialty departments, including general internal medicine, general surgery, or emergency medicine, or senior residents who were undergoing three to six years of training before acquiring specialist qualification. We excluded patients transported by ambulance and referred from other hospitals. We also excluded patients classified as level 1 or 2 according to the Japanese version of the Canadian Triage and Acuity Scale (JTAS) (Level 1: presence of shock, percutaneous oxygen saturation (SpO₂) <90%, or altered sensorium; level 2: facial pallor, tachycardia, SpO₂ <92%, a score of 10-13 on the Glasgow Coma Scale) (15, 16), as these patients required immediate care or therapeutic interventions by senior clinicians.

The diagnostic algorithm for the evaluation of AAP

We reviewed the medical charts of enrolled subjects to examine the concordance rate between actual clinical practice carried out by residents and the diagnostic process recommended by Kendall’s algorithm on 9 checkpoints (CPs) classified by the patient condition, characteristics, and location of abdominal pain (Figure) (12). CPs 1 to 5 were based on patient condition and characteristics of abdominal pain; CPs 6 to 9 were based on the location of pain. The location of pain was based on four regions: epigastric and right upper-quadrant pain (RUQP), right lower-quadrant pain

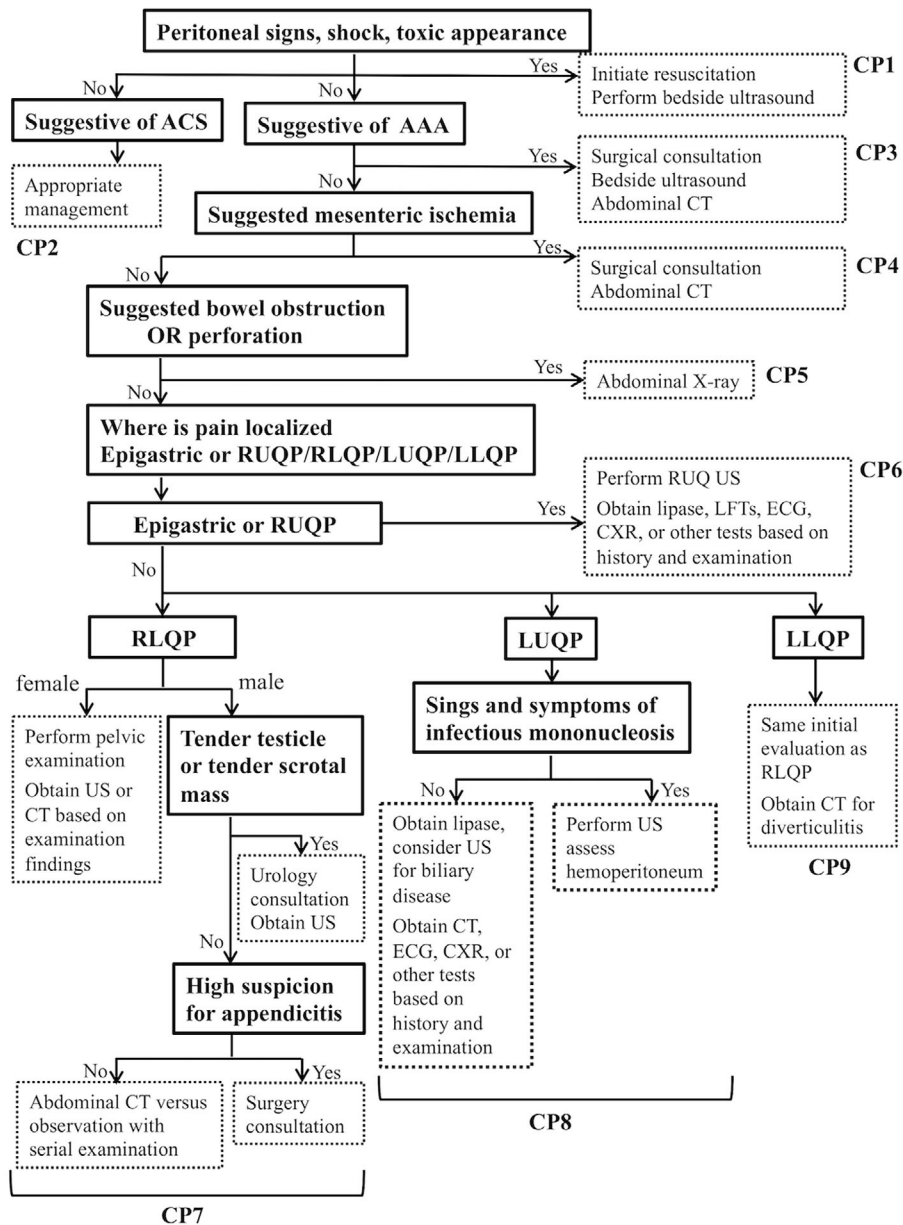


Figure. The diagnostic algorithm for acute abdominal pain proposed by Kendall et al. CP: Checkpoint, RUQP: Right upper quadrant tenderness, RLQP: Right lower quadrant tenderness, LUQP: Left upper quadrant tenderness, LLQP: Left lower quadrant tenderness, Pelvic examination: including gynecology consult, AAA: Aortic abdominal aneurysm, CT: Computed tomography, US: Ultrasonography, ECG: Electrocardiogram, CXR: Chest radiograph, LFTs: Liver function tests

(RLQP), left upper-quadrant pain (LUQP), and left lower-quadrant pain (LLQP). The CPs on Kendall's diagnostic algorithm are as follows:

- CP 1: Patients with symptoms and signs of peritonitis, shock, or toxic appearance. The algorithm recommends initial resuscitation, bedside abdominal ultrasonography (US), or immediate surgical consultation in these patients.
- CP 2: Patients with symptoms and signs of acute coronary syndrome (ACS). ACS was suspected in patients ≥ 50 years old who presented with epigastric pain or discomfort associated with nausea and vomiting, or patients ≥ 80 years old with upper abdominal pain, or pa-

tients with abnormal findings on an electrocardiogram (ECG) suggestive of ACS (17, 18). Kendall's algorithm recommends an ECG, cardiac monitor, supplemental oxygen, and intravenous access in these patients (17, 19, 20).

- CP 3: Patients with symptoms and signs suggesting abdominal aortic aneurysm (AAA). AAA was suspected in patients with pain radiating to the back or a pulsatile abdominal mass with risk factors of AAA, including chronic obstructive pulmonary disease, peripheral vascular disease, hypertension, smoking, or those with a personal or family history of AAA or acute aortic dissection (21). The algorithm recommends bedside ab-

dominal US or computed tomography (CT) of the abdomen.

- CP 4: Patients with symptoms and signs suggesting acute intestinal ischemia. Acute intestinal ischemia was suspected in patients with extremely severe abdominal pain making them unable to sit still and with risk factors including atherosclerotic disease, low cardiac output, atrial fibrillation, severe valvular heart disease, a recent history of myocardial infarction, intra-abdominal malignancy, or a history of mesenteric ischemia. The algorithm recommends contrast-enhanced abdominal CT in these patients.
- CP 5: Patients with symptoms and signs suggesting bowel obstruction or perforation. Bowel obstruction and perforation are suspected in patients with diffuse abdominal pain accompanied by distension, repetitive vomiting, or abdominal wall rigidity with the absence of bowel sounds (22). The algorithm recommends conventional abdominal radiography in the management of these patients.
- CP 6: Patients with epigastric pain or RUQP. The algorithm recommends bedside abdominal US, serum chemistry (including liver function tests and lipase levels), ECG, and chest radiography.
- CP 7: Patients with RLQP. The algorithm recommends different approaches according to gender. A pelvic examination is recommended in women who present with RLQP. However, in Japan, a pelvic examination is conventionally performed by gynecologists following a consultation by the ED residents. Abdominal US is recommended in women who present with pelvic pain. If the pelvic examination is normal, an abdominal CT scan is recommended. Men with pain, tenderness, or enlargement of the testicles are recommended to receive a urology consultation and testicular US. In the absence of testicular or urological problems, acute appendicitis is considered based on the modified Alvarado scores (23). Patients with a modified Alvarado score of ≥ 3 are suspected to have acute appendicitis and recommended to undergo surgical consultation. In such cases, abdominal CT or US is performed, as diagnostic imaging is usually required before surgical consultation. If the score is < 3 , acute diverticulitis or abdominal abscess is suspected with a recommendation for close observation or a further evaluation by abdominal CT.
- CP 8: Patients with LUQP. Kendall's algorithm recommends abdominal US to exclude infectious mononucleosis (IM) if a fever, sore throat, or cervical lymphadenopathy is present (24, 25). In patients with none of these findings, abdominal US, CT, ECG, and serum lipase testing are recommended.
- CP 9: Patients with LLQP. The recommendations are the same as those for CP 7.

Data analyses

The data were derived from the hospital health charts re-

corded in the ED. We collected patient data, including the age, gender, clinical history, medical history, symptoms, and signs indicating the presence of shock, peritonitis, ACS, AAA, mesenteric ischemia, bowel obstruction or perforation, location of abdominal pain, and years of experience of residents who evaluated the patients. Continuous variables were expressed as the mean \pm standard deviation (SD), and categorical variables were expressed as the number and percentage. We analyzed the concordance rate between Kendall's diagnostic algorithm and the actual diagnostic process followed by both junior and senior residents. In this study, we defined "concordance" as when the resident doctors performed the practice recommended in the diagnostic algorithm. The "concordance rate" was defined as the number of "concordance" patients divided by the total number of patients in each CP. We surveyed the concordance rates for each CP defined by location if the patients experienced any abdominal pain at more than one location.

Subsequently, we analyzed the implementation rate of examinations, which recommended by the diagnostic algorithm, that was actually performed by resident doctors for each CP. At that time, it was evaluated whether the residents major in gastroenterology or not.

Finally, we performed univariate and multivariate logistic regression analyses to calculate the adjusted odds ratio (AOR) of the concordance between Kendall's diagnostic algorithm and the actual diagnostic process of residents as an objective variable, using the sex of patients, whether patients were < 65 or ≥ 65 years old, whether the residents treating the patients were junior or senior residents, and whether or not residents were majoring in gastroenterology as explanatory variables.

All calculations were performed using EZR (Easy R) (Saitama Medical Center, Jichi Medical University, Saitama, Japan) version 1.35, which is an easy-to-use basic-statistics graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria) (26). More precisely, it is a modified version of R commander designed to add statistical functions.

Results

Characteristics of the patients

We enrolled 466 patients in this study, including 261 (56.0%) men. The mean age of the patients was 67.6 ± 10.3 years old. These patients were initially examined by either one of the 101 junior residents or one of the 22 senior residents. Eleven senior residents majored in gastroenterology as their specialty.

Regarding CPs for the patient's condition and characteristics of abdominal pain, 24 patients (5.2%) belonged to CP 1 at least 1 peritoneal sign, 49 (10.5%) to CP 2 with symptoms and signs suggesting ACS, 6 (1.3%) to CP 3 with features suggestive of AAA, 1 (0.2%) to CP 4 with features suggestive of acute intestinal ischemia, and 5 (1.1%) to CP

Table 1. Patient Characteristics and Details of Residents who Evaluated Them.

Patients	All (n=466)
Age, mean±SD, years	67.6±10.3
Male, n (%)	261 (56.0)
Hospitalization, n (%)	79 (16.7)
Checkpoints (CPs) on the diagnostic algorithm, n (%)	
CP 1. Shock, Peritoneal sings, Toxic appearance	24 (5.2)
CP 2. Suggested ACS	49 (10.5)
CP 3. Suggested AAA	6 (1.3)
CP 4. Suggested Mesenteric ischemia	1 (0.2)
CP 5. Suggested bowel obstruction, perforation	5 (1.1)
CP 6. Epigastric or RUQP	106 (22.7)
CP 7. RLQP	96 (20.6)
CP 8. LUQP	63 (13.5)
CP 9. LLQP	116 (24.9)
Residents	All (n=123)
PGY, mean±SD, years	1.7±1.3
Male, n (%)	82 (66.7)
Junior residents, n (%)	101 (82.1)
Senior residents, n (%)	22 (17.9)
Majoring in Gastroenterology, n (%)	11 (8.9)

ACS: Acute coronary syndrome, AAA: Abdominal aortic aneurysm, RUQP: Right upper quadrant pain, LUQP: Left upper quadrant pain, RLQP: Right lower quadrant pain, LLQP: Left lower quadrant pain, PGY: Post-graduate year

5 with features suggestive of bowel obstruction or perforation (Table 1).

Regarding the location of pain, 106 (22.7%) belonged to CP 6 with features suggestive of epigastric or RUQP, 96 (20.6%) to CP 7, 63 (13.5 %) to CP 8, and 116 (24.9%) to CP 9 (Table 1).

Concordance rate for each CP of the diagnostic algorithm

The concordance rate between Kendall's diagnostic algorithm and the actual diagnostic process followed by residents was 61.2% among the overall patient cohort. Although there was only one patient in the CP 4 (signs and symptoms suggesting acute intestinal ischemia) and five in the CP 5 (bowel obstruction or perforation) category, the concordance rates for both categories were 100%. The concordance rates for CP 7, CP 9, and CP 3 (signs and symptoms suggesting AAA) were 72.9%, 72.4%, and 66.7%, respectively, but those for CP 1, CP 2, CP 6, and CP 8 were low at 25.0%, 55.1%, 52.8%, and 55.6%, respectively. Although the concordance rates were higher among residents majoring in gastroenterology than among non-gastroenterology residents for most CPs, there was no significant difference (Table 2).

In terms of the implementation rate of examinations recommended by the diagnostic algorithm, the rates of electrocardiography recommended for epigastralgia and upper abdominal pain in CP6 and CP8 were especially low at 17.9% and 14.8%, respectively. The rates of abdominal ultrasonography were 25.0%, 41.5%, 34.4%, 31.8%, and 26.7% for CP1, CP6, CP7, CP8, and CP9, respectively. The imple-

mentation rates were low for lower abdominal pain categories, such as CP7 and CP9 (Table 3).

The multivariate analysis showed significantly lower concordance rates among women than men in CPs 7 and 9 [adjusted odds ratio (AOR) 0.12, 95% confidence interval [CI] 0.04-0.39; AOR 0.09, 95% CI 0.03-0.27]. In CP8, the concordance rate was significantly lower in patients ≥65 years old than in those <65 years old (Table 4).

Discussion

The present study revealed that overall, the utilization rate of abdominal US by residents as an imaging modality was only 33.1%. This finding explains the significantly low concordance rates among patients belonging to CP 1, CP 7, CP 8, and CP 9. Compliance with abdominal US was poor among patients belonging to CP 1, who presented with peritoneal signs. Although ECG and chest radiography, also recommended for CPs 6 and 8, had some influence on the concordance rates among patients with epigastric or RUQP or LUQP, abdominal US is highly recommended, considering the high prevalence of biliary tract diseases among elderly patients and infectious mononucleosis (3, 27). Furthermore, the lower concordance rate among women than men might have been due to this low implementation rate of abdominal US, as all women belonging to CP 7 and CP 9, with RLQP and LLQP, are recommended to undergo abdominal CT or US, in contrast to men, who are recommended to undergo abdominal CT or US only in cases with modified Alvarado scores of ≥3 (12).

Table 2. Concordance Rate between the Diagnostic Algorithm and the Diagnostic Process Followed by Residents.

	Concordance, n (%)			p value
	All residents	Non-Gastroenterology residents	Gastroenterology residents	
All patients	285 / 466 (61.2)	223 / 369 (60.4)	65 / 97 (67.0)	0.236
CPs on the diagnostic algorithm				
CP 1	6 / 24 (25.0)	4 / 19 (21.1)	2 / 5 (40.0)	0.384
CP 2	27 / 49 (55.1)	21 / 42 (50.0)	6 / 7 (85.7)	0.079
CP 3	4 / 6 (66.7)	4 / 5 (80.0)	0 / 1 (0.0)	0.121
CP 4	1 / 1 (100)	1 / 1 (100)	0 / 0 (0.0)	NA
CP 5	5 / 5 (100)	4 / 4 (100)	1 / 1 (100)	NA
CP 6	56 / 106 (52.8)	41 / 81 (50.6)	15 / 25 (60.0)	0.411
CP 7	70 / 96 (72.9)	57 / 81 (70.4)	13 / 15 (86.7)	0.192
CP 8	35 / 63 (55.6)	27 / 47 (57.5)	8 / 16 (50.0)	0.605
CP 9	84 / 116 (72.4)	64 / 89 (71.9)	20 / 27 (74.1)	0.826

CP: Check point, CP 1: Shock, peritoneal signs, toxic appearance, CP 2: Suggested Acute coronary syndrome (ACS), CP 3: Suggested Abdominal aortic aneurysm (AAA), CP 4: Suggested mesenteric ischemia, CP 5: Suggested bowel obstruction, perforation, CP 6: Epigastric or Right upper quadrant pain (RUQP), CP 7: Right lower quadrant pain (RLQP), CP 8: Left upper quadrant pain (LUQP), CP 9: Left lower quadrant pain (LLQP)

Table 3. Implementation Rate of Each Examination by Residents Doctors.

	Recommendation on the diagnostic algorithm	Implementation rate, n (%)			p value
		All	Non-Gastroenterology residents	Gastroenterology residents	
CP1	Abdominal US	6 / 24 (25.0)	4 / 19 (21.1)	2 / 5 (40.0)	0.384
CP2	Appropriate management, ECG	26 / 48 (54.2)	20 / 41 (48.8)	6 / 7 (85.7)	0.07
CP3	Abdominal US	2 / 6 (33.3)	0 / 1 (0.0)	0 / 1 (0.0)	0.439
	Abdominal CT	3 / 6 (50.0)	3 / 5 (60.0)	0 / 1 (0.0)	0.273
CP4	Abdominal CT	1 / 1 (100)			
CP5	Abdominal X-ray	5 / 5 (100)	4 / 4 (100)	1 / 1 (100)	1
CP6	Abdominal US	44 / 106 (41.5)	31 / 81 (38.3)	13 / 25 (52.0)	0.223
	LFTs	33 / 106 (33.3)	27 / 81 (33.3)	6 / 25 (24.0)	0.378
	ECG	19 / 106 (17.9)	18 / 81 (22.2)	1 / 25 (4.0)	0.038
	Chest X-ray	4 / 106 (5.8)	4 / 81 (4.9)	0 / 25 (0.0)	0.257
	Abdominal CT	34 / 106 (32.1)	24 / 81 (29.6)	10 / 25 (40.0)	0.332
CP7	Abdominal US	33 / 96 (34.4)	27 / 81 (33.3)	6 / 15 (40.0)	0.618
	Abdominal CT	30 / 96 (31.3)	23 / 81 (28.4)	7 / 15 (46.7)	0.161
	Observation with serial examination	35 / 96 (36.5)	30 / 81 (37.0)	5 / 15 (33.3)	0.784
	Surgical consultation	4 / 4 (100)	3 / 3 (100)	1 / 1 (100)	1
CP8	Abdominal US	20 / 63 (31.8)	13 / 47 (27.7)	7 / 16 (43.8)	0.232
	Abdominal CT	20 / 63 (31.8)	16 / 47 (34.0)	4 / 16 (25.0)	0.502
	ECG	9 / 61 (14.8)	7 / 45 (15.6)	2 / 16 (12.5)	0.767
	Chest X-ray	3 / 61 (4.9)	3 / 45 (6.7)	0 / 16 (0.0)	0.29
CP9	Abdominal US	31 / 116 (26.7)	23 / 89 (25.8)	8 / 27 (29.6)	0.697
	Abdominal CT	33 / 116 (28.5)	19 / 63 (30.2)	14 / 53 (26.4)	0.656
	Observation with serial examination	52 / 116 (44.8)	40 / 89 (44.9)	12 / 27 (44.4)	0.964
	Surgical consultation	1 / 1 (100.0)	1 / 1 (100)	NA	

CP: Check point, CP 1: Shock, peritoneal signs, toxic appearance, CP 2: Suggested Acute coronary syndrome (ACS), CP 3: Suggested Abdominal aortic aneurysm (AAA), CP 4: Suggested mesenteric ischemia, CP 5: Suggested bowel obstruction, perforation, CP 6: Epigastric or Right upper quadrant pain (RUQP), CP 7: Right lower quadrant pain (RLQP), CP 8: Left upper quadrant pain (LUQP), CP 9: Left lower quadrant pain (LLQP), US: Ultrasound, CT: Computed tomography, ECG: Electrocardiogram, LFTs: Liver function tests

Several reasons have been reported for the low utilization of abdominal US, including “not enough time”, “lack of hospital credentialing”, “inadequate radiology staffing”, and “fear of litigation” (28). Residents in the present study had

Table 4. Adjusted Odds Ratios for Concordance between the Diagnostic Algorithm and the Diagnostic Process Followed by Residents on Multivariate Logistic Regression Analysis.

	AOR (95% CI)					
	CP 1	CP 2	CP 6	CP 7	CP 8	CP 9
Patient age (vs.<65)	0.40 (0.06 - 2.57)	0.37 (0.06 - 2.42)	0.67 (0.31 - 1.49)	1.86 (0.65 - 5.32)	0.10 (0.03 - 0.35)	1.94 (0.76 - 4.96)
Patient gender (vs. male)	0.54 (0.31 - 3.39)	0.90 (0.27 - 3.07)	0.52 (0.23 - 1.18)	0.12 (0.04 - 0.39)	0.96 (0.29 - 3.20)	0.09 (0.03 - 0.27)
Senior resident (vs. Junior)	1.31 (1.14 - 14.9)	2.85 (0.68 - 12.0)	1.48 (0.42 - 5.24)	0.55 (0.15 - 1.94)	2.71 (0.62 - 11.9)	1.21 (0.38 - 3.91)
Majoring in Gastroenterology	6.28 (0.42 - 95.1)	3.29 (0.28 - 38.4)	1.18 (0.27 - 5.04)	6.16 (0.87 - 43.5)	0.44 (0.09 - 2.28)	1.04 (0.26 - 4.16)

CP: Check point, CP 1: Shock, peritoneal signs, toxic appearance, CP 2: Suggested Acute coronary syndrome (ACS), CP 3: Suggested Abdominal aortic aneurysm (AAA), CP 4: Suggested mesenteric ischemia, CP 5: Suggested bowel obstruction, perforation, CP 6: Epigastric or Right upper quadrant pain (RUQP), CP 7: Right lower quadrant pain (RLQP), CP 8: Left upper quadrant pain (LUQP), CP 9: Left lower quadrant pain (LLQP), AOR: Adjusted odds ratio, CI: Confidence interval

to perform abdominal US independently because no radiologist was assigned to our ED. This may have been one of the reasons for the low utilization rate of US. Point-of-care ultrasound (POCUS), a recently introduced training program for US, is becoming popular worldwide (29). POCUS follows an easy and systematic methodology for training doctors to perform US. This program could refine decision-making on further workup and treatment by narrowing down the differential diagnoses based on history and physical examination (30). Adoption of the POCUS training program by attending doctors who are in charge of training residents may improve concordance rates with CPs.

Outside of the poor utilization rate of US, we noted other factors that decreased concordance rates. First, utilization rates of US, abdominal CT, ECG, and chest radiography, which are recommended among patients belonging to CP 8 with LUQP, were only 31.8%, 31.8%, 14.8%, 4.9%, respectively. In contrast, abdominal radiography, which is not recommended in CP 8, had a much higher utilization rate of 47.6%. Abdominal radiography is recommended only for patients belonging to CP 5 suspected of having bowel obstruction or perforation (22); it is thus imperative for attending physicians to train residents in the more appropriate use of abdominal radiography. Second, the concordance rate for CP 2 with suspicion of ACS was lower than that for almost other CPs, although non-significantly, because of the low utilization rate of ECG than that of expected. While the prevalence of ACS and ischemic heart disease is lower in Japan than in western countries (31), diagnostic errors regarding ACS can be fatal (32). It is therefore crucial to train residents to perform ECG on patients belonging to CP 2 to encourage the use of ECG to exclude ACS. Third, inadequate skills in performing physical examinations may have contributed to a decreasing concordance rate. Although there were six patients who belonged to CP 3, which suggested the possibility of AAA, a pulsatile abdominal mass was not identified in any patient. The sensitivity of a physical examination for the diagnosis of AAA has been reported to be high at 72% for AAAs ≥ 4.0 cm and 82% for AAAs ≥ 5.0

cm (33). None of the patients' records contained any information on abdominal palpation. This may imply that residents do not routinely describe the findings on abdominal palpation in medical charts, suggesting that a measurement bias may have influenced our findings. The Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery reported the estimated risk of rupture of AAAs according to size: 3-15% for a diameter of 5.0-5.9 cm, 10-20% for 6.0-6.9 cm, 20-40% for 7.0-7.9 cm, and 30-50% for ≥ 8.0 cm (34). Therefore, it is also imperative for attending doctors to direct residents to record the findings on a physical examination of the abdomen, especially the presence of a pulsatile mass among patients belonging to CP 3.

The concordance rates among patients belonging to CPs 7 and 9 with RLQP and LLQP were higher than those for patients belonging to other CPs, at 72.9% and 72.4%, respectively. This finding may have been influenced by the recommendation for abdominal CT in these categories of patients (12). CT is one of the most useful diagnostic imaging tools, especially in the evaluation of emergency patients. In the United States, CT utilization in the ED increased by 330% from 1996 to 2007. Furthermore, the rate of performing CT on patients presenting with abdominal pain increased nearly 10-fold during the same period. CT is performed for nearly 30% of patients presenting with abdominal pain (35). With the recent increase in the utilization of CT, it is important to note that Japan has the highest number of CT scanners among the Organisation for Economic Cooperation and Development (OECD) countries, with 101 scanners per 100,000 population (Australia is a distant second with 44) (36). The widespread availability of CT may thus explain the high concordance rate in patients belonging to CPs 7 and 9.

In addition, the concordance rates for CP 4, with the possibility of acute intestinal ischemia, and CP 5, with the possibility of bowel obstruction or perforation, were 100%. However, there was only one patient in CP 4 and five in CP 5, making the interpretation of concordance rates unreliable. Patients belonging to CPs 4 and 5 tended to be excluded

from this study, because of severe nature of the disease and the intense pain which was observed to reach JTAS level 2, which is one of the exclusion criteria (37). A larger sample size is needed in the future in order to validate such high concordance rates.

Acute mesenteric ischemia is a rare disease, with an incidence of 5.3 per 100,000 population per year (38). The difference in concordance rates between junior and senior residents was not significant, although a higher concordance rate was observed among senior residents than among juniors. Although the diagnostic abilities may differ according to the duration of training, further research is required to validate this difference.

Several limitations associated with the present study warrant mention. First, the age of the subjects according to the diagnostic algorithm we used was ≥ 50 years old; our findings therefore cannot be extrapolated to younger patients (12). Second, this is a retrospective review of medical charts written by residents. Measurement bias is therefore possible, considering the possible failure to record practices and processes in a precise manner. Third, there are some parameters that are not included in Kendall's diagnostic algorithm, including the severity and duration of abdominal pain. These parameters may have influenced the diagnostic process, which may have led to an imprecise interpretation of the results of the study. Finally, the diagnostic accuracy of Kendall's diagnostic algorithm has not been verified, making it impossible to examine the relationship between the use of the algorithm and diagnostic accuracy.

Conclusion

In conclusion, abdominal US was not utilized adequately by residents among patients with symptoms and signs of peritonitis, shock or toxic appearance, or RLQP or LLQP and women as required by Kendall's diagnostic algorithm. Our findings underscore the importance of providing resident doctors with focused training concerning US by attending physicians.

The authors state that they have no Conflict of Interest (COI).

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