

# Use of Pelvic Computed Tomography and Sonography in Women of Reproductive Age in the Emergency Department

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**Objectives**—The purpose of this study was to review use of pelvic computed tomography (CT) and sonography in the emergency department for women of reproductive age and to identify cases in which sonography might have been adequate.

**Methods**—Computed tomographic and sonographic examinations of the pelvis performed on women up to 55 years of age in our emergency department during a 6-month period were reviewed. Repeated CT and CT with indications for which sonography would not be the first-line imaging modality (eg, diverticulitis and trauma) were excluded. For the sonographic-only assessment, repeated sonography and sonography with indications for which CT would not be the first-line imaging modality (eg, vaginal bleeding) were excluded. Patient referral indications, imaging diagnoses, and discharge diagnoses were compared for the groups with CT only, CT first, sonography first, and sonography only.

**Results**—Of 509 women who underwent CT, 407 (80%) underwent CT only; 54 (11%) underwent CT first; and 48 (9%) underwent pelvic sonography first. The percentages with negative CT findings were 42%, 17%, and 50%, respectively. Overall, 63 (CT only), 38 (CT first), and 12 (sonography first) patients had CT diagnoses of pelvic conditions only (113 of 509 women [22%]). Of the patients with CT and discharge diagnoses of pelvic conditions, 36 of 44 (82%) had CT only or CT first; 58 of 110 (53%) of cases with sonography only showed acute pelvic conditions.

**Conclusions**—Twenty-two percent of pelvic CT examinations performed in women of reproductive age in our emergency department showed only pelvic conditions, suggesting that sonography would have been a reasonable primary imaging test for these patients.

**Key Words**—acute abdominal pain; acute pelvic pain; pelvic sonography; quality assurance

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## Abbreviations

CT, computed tomography

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In the emergency department, computed tomography (CT) is often the primary imaging modality chosen to evaluate the cause of acute abdominal and pelvic pain. Although this choice is appropriate in many situations, there are limited data to support CT as the initial imaging modality in women of reproductive age with abdominal and pelvic pain. In this population, gynecologic etiologies of pain are common and are best diagnosed by sonography. The American College of Radiology Appropriateness Criteria recommend sonography as the primary imaging modality for evaluating acute pelvic pain in women of reproductive age.<sup>1</sup> Computed tomography is recommended in the setting of right lower quadrant pain with concomitant fever and leukocytosis.<sup>2</sup>

For patients who do not meet these criteria, CT might be chosen over sonography because of its increased sensitivity for detection of acute appendiceal, intestinal, and urinary tract abnormalities.

Several studies have indicated that the increased use of CT in the emergency department for evaluation of acute abdominal pain has improved diagnostic confidence among emergency physicians, decreased admission rates for acute nontraumatic abdominal pain, altered surgical management plans, and reduced the rate of negative appendectomies.<sup>3–5</sup> Conversely, Pines<sup>6</sup> reported no substantial improvement in detection rates of appendicitis and admission rates for acute abdominal pain with a doubling of CT use in US emergency departments between 2001 and 2005.

Lower sensitivity for acute intra-abdominal conditions, operator and patient variability, and time-intensive examinations limit the utility of sonography for evaluation of acute abdominal pain in the emergency setting. However, lower cost and lack of ionizing radiation exposure confer potential benefits of sonography over CT. Laméris et al<sup>7</sup> showed that, regardless of the body mass index, age, or location of pain, using sonography as the primary imaging modality followed by CT only in cases of negative or indeterminate sonographic findings resulted in the highest sensitivity for acute abdominal and pelvic conditions and reduced ionizing radiation exposure. Additional studies using diagnostic imaging algorithms with sonography as the initial imaging test revealed similar results.<sup>8,9</sup> Cuevas and Dubinsky<sup>10</sup> weighed the benefits of CT and sonography as initial diagnostic studies for acute pelvic pain in women of reproductive age and postulated that the throughput advantage of CT could be at least partly overcome by having a sonographer available continuously.

In our emergency department, sonographers are available 24 hours a day, 7 days a week, and studies are performed promptly after the order is placed. However, it has been our anecdotal experience that CT is often being used in women of reproductive age who could have been imaged with sonography instead. We thought it was important to document whether this procedure was occurring to better care for our patients. Therefore, the purpose of this study was to review the use of pelvic CT and sonography in the emergency department for women of reproductive age and to identify cases in which sonography alone might have been adequate.

## Materials and Methods

This retrospective study was conducted with approval from the Institutional Review Board with waiver of informed

consent and was compliant with the Health Insurance Portability and Accountability Act.

Computed tomographic and sonographic examinations of the abdomen, pelvis, or both performed on female patients up to 55 years of age in our emergency department during a 6-month period (August 1, 2009–January 31, 2010) were catalogued. If the patient had CT and underwent abdominal or pelvic sonography within 24 hours of the CT examination, the sonography report was also reviewed.

During the study period, 814 women underwent 876 abdominal or pelvic CT examinations in our emergency department. Sixty-two second and third CT examinations from 58 women were excluded. Three hundred seven initial CT examinations from 305 women were excluded for indications for which sonography would not necessarily be the first-line imaging modality; these indications included trauma/orthopedic ( $n = 112$ ), diverticulitis ( $n = 10$ ), pancreatitis ( $n = 12$ ), nephroureterolithiasis ( $n = 32$ ), inflammatory bowel disease ( $n = 35$ ), recent major abdominal or pelvic surgery ( $n = 76$ ), known history of total abdominal hysterectomy and bilateral salpingo-oophorectomy ( $n = 9$ ), known metastatic cancer ( $n = 6$ ), clinical instability ( $n = 6$ ), known complicated appendicitis ( $n = 2$ ), perirectal/perianal abscess ( $n = 2$ ), periumbilical cellulitis ( $n = 1$ ), and superior mesenteric artery syndrome ( $n = 2$ ). Thus, the final CT cohort comprised 509 CT examinations from 509 women (mean age  $\pm$  SD,  $36 \pm 11$  years; range, 16–55 years).

As a comparison group, we also assessed women who had only pelvic sonography but not CT at an emergency visit during the same study period. During the study period, this group included 173 women who underwent 176 pelvic sonographic examinations. Three second sonographic examinations were excluded. Sixty-three sonographic examinations from 63 patients were excluded for indications for which CT would not be considered an appropriate imaging modality; these indications included vaginal bleeding ( $n = 29$ ), recent pregnancy or abortion ( $n = 21$ ), intrauterine device ( $n = 12$ ), and recent intrauterine insemination ( $n = 1$ ). Thus the sonography-only cohort included 110 women (mean age,  $29 \pm 9$  years; range, 15–55 years).

Patient age, indications for imaging, timing of studies, imaging findings, and radiologists' recommendations were recorded. The patient's referral indication and imaging diagnosis were compared for the groups with CT only, CT before pelvic sonography, and CT after pelvic sonography. Patients who underwent right upper quadrant or renal sonography before or after CT but

did not undergo pelvic sonography were included in the CT-only group for analysis.

Our main analysis was a comparison of the 3 CT groups. The sonography-only group was used as a comparison for descriptive purposes. Single-factor analysis of variance was used to compare the age distributions for each of the 3 CT groups. With a  $\chi^2$  test, CT indications and findings were compared for the CT-only, CT-first, and sonography-first groups overall and by individual indications and findings. For patients with pelvic conditions on CT, discharge diagnoses were compared for the 3 groups. A 2-tailed *P* value was calculated for each CT indication, major CT finding, and discharge diagnosis. MATLAB version 7.11 software (The MathWorks, Natick, MA) was used for statistical analysis. *P* < .05 was used for significance.

## Results

Of 509 women, 80% underwent CT only; 11% underwent CT followed by pelvic sonography; and 9% underwent pelvic sonography followed by CT. Women in the sonog-

raphy-first group (mean age, 32 ± 11 years; range, 16–55 years) were slightly younger (*P* = .03) than those having CT first (mean age, 33 ± 10 years; range, 18–54 years) and those having CT only (mean age, 36 ± 11 years; range, 18–55 years).

The most common indication for CT was abdominal pain (296 of 509 [58%]). Of these 296 patients with pain as the only indication, 76% had CT only; 13% had CT first; and 11% had sonography first (Table 1). Patients with gastrointestinal symptoms were significantly more likely to undergo CT only. No other statistically significant difference was detected between the 3 groups based on CT indication (Table 1).

Forty-two percent of the patients in the CT-only group, 17% in the CT-first group, and 50% in the sonography-first group (40% overall) had negative CT examination findings (Table 2). An adnexal cyst was the primary finding on CT in 9%, 35%, and 6% of patients in the CT-only, CT-first, and sonography-first groups, respectively. Two patients with ovarian torsion and 8 with a tubo-ovarian abscess or hydrosalpinx underwent CT only or CT first.

**Table 1.** Indications for CT

Indication	CT Only (n = 407)	CT First (n = 54)	Sonography First (n = 48)	<i>P</i> (<.0001)
Abdominal pain	224	38	34	.02
Location not specified	39	4	2	
Right lower quadrant	61	18	9	
Left lower quadrant	22	5	11	
Right upper quadrant	4	0	0	
Left upper quadrant	2	0	0	
Right abdomen	11	1	3	
Left abdomen	5	0	4	
Right flank	15	1	0	
Left flank	11	1	0	
Bilateral flank	4	0	0	
Flank, side not specified	5	0	0	
Lower abdomen	9	2	0	
Epigastric	5	0	0	
Periumbilical	5	0	0	
Abdomen and pelvis	0	0	2	
Back	4	0	0	
Right groin	1	0	0	
Left groin	0	0	1	
Multiple sites	21	6	2	
Abdominal pain and fever and/or leukocytosis	27	5	2	.59
Gastrointestinal symptoms	110	9	3	.003
Pain and vaginal bleeding	1	0	1	.14
Urinary symptoms, nephrolithiasis	20	2	1	.64
Sonographic finding	0	0	4	NA
Kidney-ureter-bladder radiographic or outside CT finding	4	0	0	.60
Miscellaneous	21	0	3	.21

NA indicates not applicable.

Overall, 63 (CT only), 38 (CT first; Figures 1 and 2), and 12 (sonography first) patients had CT diagnoses of pelvic conditions only (113 of 509 women [22%]).

Of the 101 women with pelvic conditions only who underwent CT only or CT first, discharge diagnoses included pelvic conditions (36%), nonspecific pain (43%), gastroenteritis or urinary tract infection (10%), and mis-

cellaneous (12%; Table 3). Of these patients with discharge diagnoses of pelvic conditions, 64% had sonography after CT ( $P = .009$ ). In total, 44 patients had discharge diagnoses of pelvic conditions. Of these 44 patients, 30% had CT only; 52% had CT first, and 18% had sonography first (Table 3).

Of 509 women, 142 (28%) had appendicitis, acute intestinal conditions, or urinary tract conditions (Table 2).

**Table 2.** Major CT Findings

Finding	CT Only (n = 407)	CT First (n = 54)	Sonography First (n = 48)	P ( $<.0001$ )
No clinically important finding	170	9	24	$<.0001$
Pelvic finding				
Adnexal cyst, primary finding	36 <sup>a</sup>	19 <sup>b</sup>	3 <sup>c</sup>	$<.0001$
Complex pelvic cyst or mass	1	2	1	.01
Acute adnexal or uterine condition <sup>d</sup>	16	14	4	$<.0001$
Free pelvic fluid only	10	3	4	.06
Appendicitis	40	2	3	.26
Acute intestinal condition	53	0	2	.004
Pyelonephritis or nephrolithiasis	36	3	3	.62
Epiploic appendagitis/omental infarction	3	1	0	.55
Miscellaneous	42	1	4	.13

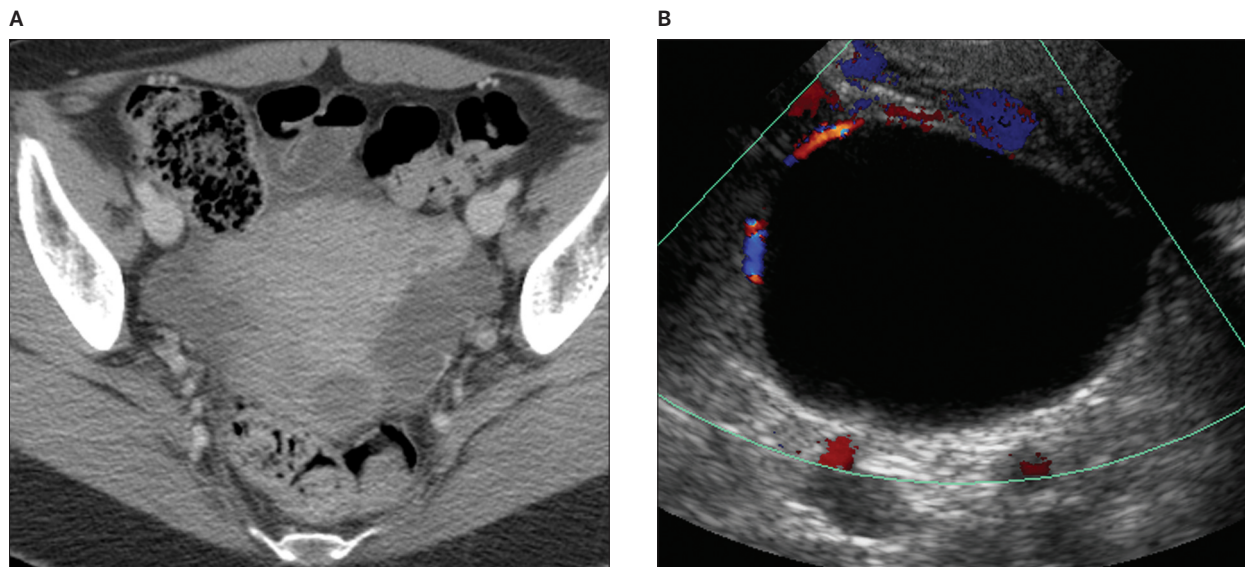
<sup>a</sup>Fifteen patients had an adnexal cyst as a secondary finding (cyst not included in this table).

<sup>b</sup>One patient had an adnexal cyst, and 2 patients had an ovarian dermoid as a secondary finding.

<sup>c</sup>Two patients had an adnexal cyst, and 1 patient had an ovarian dermoid as a secondary finding.

<sup>d</sup>Ovarian torsion, enlarged ovary, tubo-ovarian abscess, hydrosalpinx, endometritis, active pelvic/endometrial bleeding, degenerating fibroid, nonspecific adnexal cyst, and abnormal adnexal or uterine appearance.

**Figure 1.** Images from a 46-year-old woman with lower abdominal pain and nausea. **A**, Axial CT of the pelvis shows adnexal cysts and free pelvic fluid. Gynecologic consultation after CT noted a history of tubal occlusion and “exquisite tenderness to palpation of the uterus and bilateral adnexae . . . (and) cervical motion tenderness.” The patient was afebrile with a normal white blood cell count and urinalysis results. **B**, Transvaginal pelvic sonography performed after CT shows adnexal cysts with internal avascular echogenic debris. The histologic diagnosis was chronic salpingitis and endometriosis. Sonography would have been sufficient in this patient.

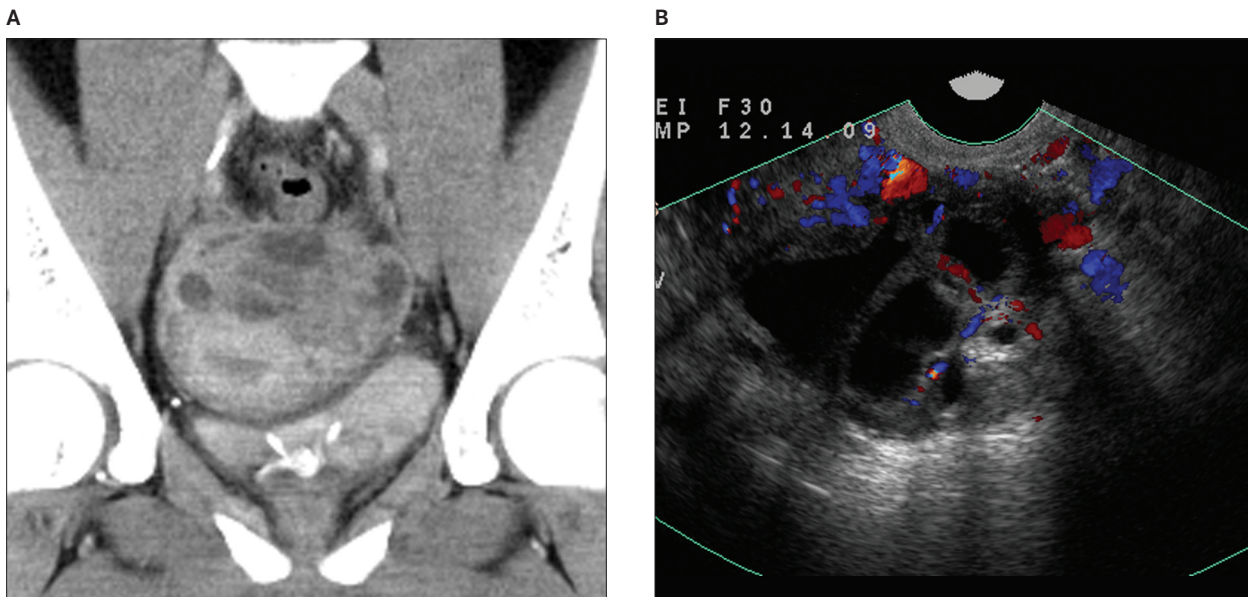


Of 407 patients who underwent CT only, 10% had appendicitis; 13% had acute intestinal conditions; and 9% had acute urinary tract conditions (32% overall). Of 45 patients with appendiceal conditions, 89% had CT only; 4% had CT first; and 7% had sonography first. Of the patients with appendicitis who underwent sonography first, 2 had confident diagnoses by sonography.

Of 54 patients who had sonography after CT, in 18 cases (33%), pelvic sonography was recommended by the radiologist on the basis of the CT findings. Of 48 patients who underwent CT after sonography, CT was recommended by the radiologist in 3 cases (6%). Of 407 patients who underwent CT only, 10 recommendations for urgent pelvic sonography and 25 recommendations for nonurgent pelvic sonography were provided by the radiologist.

The most common indication for pelvic sonography in the sonography-only cohort was pain (80%; Table 4). Of these 88 women with pain, 28% had a reported history of gynecologic conditions on the sonography order. Additional indications included abnormal pelvic examination findings (9%), pain with gastrointestinal symptoms or fever (4%), outside hospital imaging findings in the pelvis (3%), symptoms after recent ovarian stimulation (3%), and symptoms after recent drainage of tubo-ovarian abscess (1%; Table 4). Of 110 sonographic examinations, 25% were negative; 36% had adnexal cysts; 7% had free pelvic fluid only; 4% had ovarian torsion; and 2% had hydrosalpinx (Table 5). Overall, 53% had acute pelvic conditions (Table 5).

**Figure 2.** Images from a 30-year-old female with 4 months of lower abdominal pain. **A**, Coronal CT of the pelvis shows a complex left adnexal cyst. **B**, Transvaginal pelvic sonography performed after CT shows a left-sided thick-walled fluid-filled hyperemic tube with vascular walls. A further history obtained by gynecologic consultation revealed a history of right salpingectomy, remote gonococcal infection, and severe endometriosis. Cervical discharge was noted on physical examination. Sonography would have been sufficient in this patient with pelvic inflammatory disease who was trying to become pregnant.



**Table 3.** Discharge Diagnoses for Patients With Pelvic Findings on CT

Discharge Diagnosis	CT Only (n = 63)	CT First (n = 38)	Sonography First (n = 12)	P (.0036)
Pain	31	12	2	.048
Adnexal/uterine condition	13	23	8	<.0001
Urinary tract infection	4	1	0	.50
Gastroenteritis	5	0	1	.20
Miscellaneous	10	2	1	.25

## Discussion

Of all CT examinations performed in women of reproductive age without clinically important prior abdominal or surgical histories in our emergency department during a 6-month period, 40% revealed no acute findings; 28% showed acute appendicitis, intestinal conditions, or urinary tract conditions; and 22% showed only pelvic conditions. The 40% negative CT rate seems high, but no published standard is available. In contrast, of the group with sonography only, 25% of pelvic sonographic examinations had negative findings, and 53% showed acute pelvic conditions.

Patients with abdominal pain were significantly more likely to undergo CT only (Table 1). Eighty-two percent of patients with discharge diagnoses of pelvic conditions underwent CT only or CT first. These results suggest that CT is overused as the primary imaging modality in cases of abdominal and pelvic pain in women of reproductive age in our emergency department.

**Table 4.** Sonographic Indications for Patients With Pelvic Sonography Only

Indication	n
Pain (abdominal, pelvic, adnexal)	63
Pain and abnormal gynecologic history	25
Abnormal pelvic examination findings (cervical motion tenderness, discharge, palpable abnormality)	10
Symptomatic status after ovarian stimulation	3
Outside hospital/prior imaging finding	3
Pain or cervical motion tenderness with nausea, vomiting, or fever	5
Recently drained tubo-ovarian abscess	1

**Table 5.** Sonographic Findings for Patients With Pelvic Sonography Only

Finding	n
Complex adnexal cyst (including hemorrhagic cysts)	25
Ovarian cyst, not otherwise specified	6
Physiologic cyst	2
Ruptured hemorrhagic cyst	7
Avascular endometrial contents	6
Endometrial polyp	2
Adnexal mass	2
Fibroid uterus	12
Ovarian hyperstimulation syndrome	3
Hydrosalpinx	2
Torsion	4
Free fluid only	8
Bladder abnormality	1
Polycystic ovarian syndrome	1
Negative	29

In only 3 of 48 patients (6%) who underwent sonography before CT was CT recommended by the radiologist. Because 94% of the CT examinations performed after sonography were ordered on the basis of the clinical assessment and not the sonographic results, this finding suggests that referring clinicians think that CT is frequently needed to facilitate triage of patients in the acute setting. Conversely, in 18 of 54 cases (33%) in which sonography was performed after CT, sonography was recommended by the radiologist on the basis of the CT findings despite evidence to suggest that sonography adds little diagnostic information in the acute setting when pelvic conditions are detected by CT.<sup>11</sup> Indications for pelvic sonography after CT have been reported, which may be applicable in acute and nonacute settings.<sup>12</sup>

Both Abujudeh et al<sup>3</sup> and Sala et al<sup>13</sup> showed that CT improves diagnostic accuracy for patients with nonspecific abdominal pain in the emergency setting. Sala et al<sup>13</sup> showed that “early abdominal CT in patients with acute abdominal pain improves diagnostic certainty, but does not reduce the length of hospital stay and 6-month mortality.” In their study, only 6 of 198 patients with nonspecific abdominal pain had a pelvic condition as the final diagnosis. Although our exclusion criteria differed from theirs, in our population, the rate of detection of pelvic conditions by CT was much higher, suggesting overuse of CT in our emergency department. Increased reporting of CT characteristics of pelvic processes suggests that this situation is also the trend elsewhere.<sup>14</sup> Thirty-two percent of patients who underwent CT only had appendicitis, acute intestinal conditions, or acute urinary tract conditions, suggesting that in about one-third of cases, CT was appropriately chosen as the initial diagnostic imaging test.

Our study had limitations. We evaluated imaging reports but not the imaging studies themselves. The actual time delays that might have occurred during imaging were not assessed. The most common indication for CT and sonography was pain without any additional clinical indicators. It is unclear from this study whether performing a clinical pelvic examination, complete blood count, or urinalysis before ordering an imaging test would help further stratify patients into categories of likely pelvic versus likely urinary or intestinal conditions. Additional circumstances that may have led to the decision to perform CT rather than sonography were not available for review, such as patient or referring physician requests.

Our study showed that 40% of emergency abdominopelvic CT examinations performed on women of reproductive age had negative findings, and 22% revealed only pelvic conditions, suggesting that increasing our use of

sonography as a primary rather than secondary imaging test for these patients is a reasonable approach. Prior studies have shown the diagnostic accuracy and adequate sensitivity of this algorithm.<sup>7–9</sup> Adopting this approach in our emergency department will require a change in practice among emergency physicians as well as adequate confidence among radiologists to perform and interpret right lower quadrant and pelvic sonography. This proposed change in practice has the potential to reduce ionizing radiation exposure for women of reproductive age.

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