

Original Research

A National Study on the Association of Abdominal Ultrasound with CT Utilization and Disposition in the Emergency Department

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Background

Ultrasound and CT imaging have distinct and overlapping roles in the assessment of undifferentiated abdominal pain in the emergency department (ED). CT imaging is the gold standard for many pathologies, ranging from bowel obstruction to aortic pathology whereas ultrasound benefits from less radiation exposure and the ability to employ at bedside. In this pilot study, we utilize nationally representative data to identify associations between ultrasound use in ED patients with a primary complaint of abdominal pain with abdominal CT imaging use and disposition.

Methods

We analyzed retrospective, cross-sectional data on ED patient visits obtained from the National Hospital Ambulatory Medical Care Survey from 2016-2020. This dataset utilizes a weighed multistage, probability sample of ED patient visits involving a four-stage sampling design, including data at county-level geographic regions, hospitals within these regions, emergency service areas in these hospitals, and patient visit records. The study population includes adult patient ED visits with an age of 18 and up presenting with a primary complaint of atraumatic abdominal pain. Descriptive statistics was utilized to describe the sample population. Survey-weighted multivariate logistic regression analysis with calculated odds ratios evaluated for differences between the binary dependent variable of abdominal pain visits with versus without ultrasound use with independent variables of disposition and abdominal CT imaging use while controlling for visit acuity and adjusting for demographic information.

Results

A total of 7563 patient visits met inclusion criteria, representing approximately 60 million patient visits from 2016-2020. In this study population, 18.5% of visits involved ultrasound, whereas 39.8% of visits involved CT imaging use. 14.6% of visits resulted in hospital admission. On weight-adjusted regression analysis, visits involving ultrasound were less likely to require CT imaging and more likely to be admitted, with ORs of 0.49 (95% CI: 0.37, 0.64) and 1.97 (95% CI: 1.44, 2.68), respectively. Visits involving ultrasound were more likely to be associated with an emergency medicine residency program and an emergent acuity level, with ORs of 1.40 (95% CI: 1.01, 1.94) and 1.53 (95% CI: 1.01, 2.31), respectively.

Conclusion

In this national pilot study, abdominal pain visits involving ultrasound were associated with a lower likelihood of CT imaging use and a highly likelihood admission and an emergent acuity level.

INTRODUCTION

Patients presenting to the emergency department (ED) with abdominal pain account for over 10 million ED visits annually and remains the most common presenting complaint in the ED in the United States.¹⁻³ Undifferentiated abdominal pain is associated with a wide differential diagnosis,

with pathologies ranging from benign constipation to life-threatening pathologies that include atypical ACS, bowel perforation and obstruction, mesenteric ischemia and aortic catastrophes.^{2,4} Indeed, mortality can be as high as 10% in the elderly population.⁴ Given such a wide differential, an expeditious clinical assessment in conjunction with imaging of the abdomen, such as CT and ultrasound, can

be essential in diagnosis and exclusion of life-threatening pathologies. Studies on national imaging trends show that both ultrasound and CT imaging continue to increase in utilization in the ED in recent years,⁵⁻⁷ with one study reporting the tripling and doubling of CT and ultrasound use in recent decades, respectively.⁶ Whether exacerbated by legal concerns or increasing patient complexity in an aging and increasing population, these trends undergird a well-acknowledged concern for overutilization of limited health care resources.⁷

Both CT imaging and ultrasound have distinct and overlapping roles in assessment of the ED patient with undifferentiated abdominal pain. CT imaging is the gold standard for many pathologies, ranging from bowel obstruction to aortic pathology.⁸ With the benefit of no radiation and the ability to employ at bedside, ultrasound can also diagnose and supplement CT imaging findings for various pathologies in the appropriate clinical setting, including cholecystitis, diverticulitis, ovarian disease, and urinary retention, as well as life-threatening catastrophes, such as aortic dissection.⁸⁻¹² Generally, these diagnostic capabilities extend to both formal radiology department-performed and emergency provider (EP) performed sonographic studies.¹³⁻¹⁷ In this pilot study, we utilize nationally representative data to study potential associations between ED abdominal pain visits that employ ultrasound with CT imaging use and disposition to provide insight into the potential role of ultrasound on cost-savings and disposition on a national level.

METHODS

DATASET

We analyzed retrospective, cross-sectional data on ED patient visits obtained from the National Hospital Ambulatory Medical Care Survey (NHAMCS) from 2016-2020 conducted by the National Center for Health Statistics (NCHS). This dataset is a multistage, probability sample of ED visits that utilizes a four-stage sampling design that involves random sampling of county-level geographic regions, or primary sampling units (PSUs), then a sample of hospitals within PSUs, then emergency service areas served by each hospital, and lastly patient visit records within each service areas ([Figure 1](#)). Each ED is randomly assigned with a 4-week reporting period. The analysis excluded federal, military, and Veterans Administration hospitals. The final sample for this study included 7563 patient visits statistically representing approximately 60 million visits over 5 years.

The study population includes adult patients aged 18 and up presenting to the ED with a primary complaint of abdominal pain to approximate nontraumatic abdominal pain visits. Probability weights and survey design variables were assigned to each patient visit to determine nationally representative estimates and standard errors. This study was exempt from review by the institutional review board of the authors' institutions.

OUTCOMES AND KEY VARIABLES

This study assessed for differences between patient visits with a chief complaint of abdominal pain with versus without ultrasound use. Abdominal pain in this study was defined as visits with a primary complaint of abdominal pain, irrespective of location. The primary outcomes included binary, independent variables of CT imaging use and hospitalization/admission. CT imaging use was defined as a visit involving CT imaging of the abdomen and pelvis with or without contrast. Ultrasound use was defined as any use of ultrasound, including both formal and bedside EP-performed ultrasound.

Demographic information (age, sex, ethnicity) and acuity of patient as defined by triage categories of non-emergent versus emergent were obtained in order to adjust for demographic differences and acuity. As most prior studies on ultrasound use have been performed in academic centers, and these facilities may have ultrasound-trained faculty, greater sonographic resources, and an educational mission with regards to patient care, the variable of academic versus non-academic ED is included in the analysis.¹⁸⁻²⁰ Visits were considered academic if the associated ED had 25% or more patient visits involving evaluation by a resident physician.

STATISTICAL ANALYSIS

Visit-level data were assigned weights according to NCHS specifications on national population estimates. For example, data on patient visits more representative of the national population as determined by NCHS may be assigned more weight in statistical analysis. The complex sampling design function in Statistical Package for the Social Sciences (SPSS) applied assigned weighting data for each visit and estimated final proportions and data results.

Descriptive statistics with percentage data described the sample population. Survey-weighted multivariate logistic regression analysis evaluated for differences between the binary dependent variable of abdominal pain visits with versus without ultrasound use with independent variables of disposition (admission versus discharge) and CT imaging use while controlling and assessing for patient acuity level (non-emergent vs emergent), status as academic ED, and adjusting for demographic information of sex, age, and ethnicity. Odds ratios (ORs) are presented with 95% confidence intervals (CIs). In this study, $p \leq 0.05$ was considered statistically significant. Statistical analysis was performed with International Business Machines (IBM) SPSS software version 26 (IBM Corp., Armonk, NY, USA).

RESULTS

CHARACTERISTICS OF STUDY SUBJECTS

A total of 7563 patient visits met inclusion criteria. Under survey-adjusted weights, this national sample represented approximately 60 million patient visits (95% CI: 53,204,699, 66,785,300) from 2016-2020, or about 12 mil-

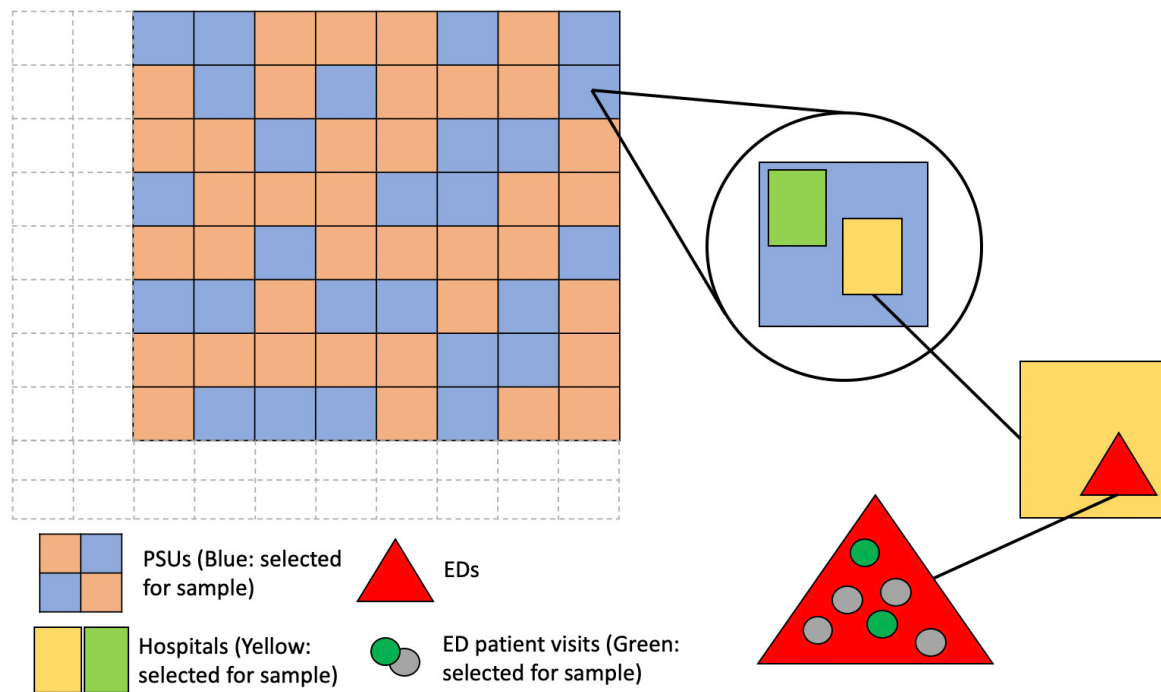


Figure 1. Four-stage Multistage Sampling

Illustration of multistage, probability sample of emergency department (ED) visits that utilizes a four-stage sampling design, including geographically defined primary sampling units (PSUs), hospitals, emergency service areas, and patient visit records.

lion visits with abdominal pain as primary complaint annually. In this study, 18.5% of visits involved ultrasound, and 39.8% of visits involved CT imaging. About 14.6% of visits resulted in hospital admission with 32.2% of visits classified as occurring in an ED with an EM residency program. About 7.5% of visits involved an acuity level triaged as emergent.

FACTORS ASSOCIATED WITH ULTRASOUND UTILIZATION

On regression analysis, abdominal pain visits involving ultrasound were independently less likely to require CT imaging and independently more likely to be admitted, with ORs of 0.49 (95% CI: 0.37, 0.64) and 1.97 (95% CI: 1.44, 2.68), respectively. Abdominal pain visits involving ultrasound were also more likely to be associated with an emergency medicine residency program and an emergent acuity level, with ORs of 1.40 (95% CI: 1.01, 1.94) and 1.53 (95% CI: 1.01, 2.31), respectively. The regression analysis controlled for demographic variables of age category, sex, and race/ethnicity (Table 1).

DISCUSSION

The results of this pilot study on a nationally representative patient sample shows that there is a significant, independent association of ED ultrasound use with decreased CT utilization and increased admission in ED visits with a primary complaint abdominal pain (Table 1). Although causation cannot be assumed given the cross-sectional nature of this study, in the appropriate clinical setting, employing ultrasound may allow a provider to rule in or rule out diag-

noses and facilitate disposition without requiring CT imaging. For example, patients presenting with upper and lower abdominal pain may have a ruptured ovarian cyst or cholelithiasis, respectively, and may be diagnosed and dispositioned in the appropriate clinical settings.^{9,10,13,14} These examples and the results of this study highlight the potential role of ultrasound in cost-savings, reduced radiation exposure, and expedient patient disposition. Furthermore, ultrasound use was found to be have a greater association with academic EDs, which may be related to the presence of ultrasound-trained faculty, greater sonographic resources, and an additional educational focus in patient care¹⁸⁻²⁰

Ultrasound use was also independently and positively associated with abdominal pain visits triaged as emergent and visits resulting in admission (Table 1). This association may be related to the ability to effectively employ ultrasound at the bedside in sick undifferentiated patients who are too unstable for CT imaging. For example, bedside-ultrasound can assess for aortic dissection with a sensitivity and specificity of 67-79% and 99-100%, respectively, while also simultaneously assessing for the presence of an abdominal aortic aneurysm, and causes of hypotension if present.^{8,21} Ultrasound can also rule in clinically significant arterial occlusion with a specificity (95% vs 96%) compared to CT angiography, although with a lower sensitivity of 88% vs 95%.²² In these examples, ultrasound may facilitate admission or disposition to the operating room prior to CT imaging in the appropriate clinical setting.

The primary strength of this study is the large, representative sampling on the national level that includes non-academic centers. This strength results in a greater gener-

Table 1. Logistic regression results displaying associations between emergency department abdominal pain visits with versus without ultrasound use.

	OR (95% CI)	p-value
CT utilization		
Yes	0.49 (0.37, 0.64)	< 0.001
No	Reference	
Admission		
Yes	1.97 (1.44, 2.68)	< 0.001
No	Reference	
Academic		
Yes	1.40 (1.01, 1.94)	< 0.05
No	Reference	
Emergent acuity		
Yes	1.53 (1.01, 2.31)	< 0.05
No	Reference	
Sex		
Male	0.48 (0.36, 0.65)	< 0.001
Female	Reference	
Age		
45+	0.54 (0.43, 0.67)	< 0.001
18-44	Reference	
Race/ethnicity		
Non-white	0.82 (0.72, 0.93)	< 0.005
White	Reference	

OR, odds ratio; CI, confidence interval

alizability of the study findings. However, there are several limitations that restrict applicability and generalizability of this pilot study. This investigation utilizes retrospective cross-sectional survey data; thus, causation cannot be inferred and the conclusions are inherently vulnerable to reporting and processing errors as well as non-response bias.

Furthermore, the data occurs at the visit-level, which introduces bias by not accounting for repeated visits of the same patient. The inclusion of patient visits with a chief complaint of abdominal pain is nonspecific and limits generalizability and validity of the study findings. Lastly, this study does not differentiate between “formal” or radiology department-performed ultrasound and appropriately-trained, EP-performed bedside ultrasound. However, several studies have indicated similar efficacy and sensitivity/specificity in both, particularly in the settings of biliary and pelvic pathology, which may maintain the general implications of this study.^{8-10,14,16,17}

Future studies can employ prospective methodologies, including randomized-controlled and cohort studies, to better evaluate the role of ED ultrasound in facilitating disposition and potential cost-savings in the setting of more specific, regional abdominal pain complaints and etiologies. Further investigations can also compare diagnostic efficacy and disposition speed between use of formal ultrasound and ED-performed bedside ultrasound. Additionally, as ultrasound has potential in reducing CT imaging utilization, future studies should assess for “bounce-back” data when ultrasound is utilized without CT imaging for abdominal pain, as many diagnoses, such as bowel obstruction and aortic dissection, can be easily missed.⁸

CONCLUSION

In this national pilot study, abdominal pain visits involving ultrasound were associated with lower likelihood of CT use and a higher likelihood admission and an emergent acuity level. This pilot study highlights avenues for future study on the role of ED ultrasound in cost-savings, care of critically ill patients, and ED disposition.

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REFERENCES

1. Cairns C, Kang K. *National Hospital Ambulatory Medical Care Survey: 2020 Emergency Department Summary Tables*. National Center for Health Statistics (U.S.); 2022. [doi:10.15620/cdc:121911](https://doi.org/10.15620/cdc:121911)
2. Kamin RA, Nowicki TA, Courtney DS, Powers RD. Pearls and pitfalls in the emergency department evaluation of abdominal pain. *Emerg Med Clin North Am*. 2003;21(1):61-vi. [doi:10.1016/s0733-8627\(02\)00080-9](https://doi.org/10.1016/s0733-8627(02)00080-9)
3. Hooker EA, Mallow PJ, Oglesby MM. Characteristics and Trends of Emergency Department Visits in the United States (2010-2014). *J Emerg Med*. 2019;56(3):344-351. [doi:10.1016/j.jemermed.2018.12.025](https://doi.org/10.1016/j.jemermed.2018.12.025)
4. Spangler R, Van Pham T, Khoujah D, Martinez JP. Abdominal emergencies in the geriatric patient. *Int J Emerg Med*. 2014;7:43. [doi:10.1186/s12245-014-0043-2](https://doi.org/10.1186/s12245-014-0043-2)
5. Chou SC, Nagurney JM, Schuur JD, Weiner SG. Advanced imaging and trends in hospitalizations from the emergency department. *PLoS One*. 2020;15(9):e0239059. [doi:10.1371/journal.pone.0239059](https://doi.org/10.1371/journal.pone.0239059)
6. Tung M, Sharma R, Hinson JS, Nothelle S, Pannikottu J, Segal JB. Factors associated with imaging overuse in the emergency department: A systematic review. *Am J Emerg Med*. 2018;36(2):301-309. [doi:10.1016/j.ajem.2017.10.049](https://doi.org/10.1016/j.ajem.2017.10.049)
7. Bellolio MF, Heien HC, Sangaralingham LR, et al. Increased Computed Tomography Utilization in the Emergency Department and Its Association with Hospital Admission. *West J Emerg Med*. 2017;18(5):835-845. [doi:10.5811/westjem.2017.5.34152](https://doi.org/10.5811/westjem.2017.5.34152)
8. Kameda T, Taniguchi N. Overview of point-of-care abdominal ultrasound in emergency and critical care. *J Intensive Care*. 2016;4:53. [doi:10.1186/s40560-016-0175-y](https://doi.org/10.1186/s40560-016-0175-y)
9. Morgan BB, Kao A, Trent SA, et al. Effect of Emergency Physician-Performed Point-of-Care Ultrasound and Radiology Department-Performed Ultrasound Examinations on the Emergency Department Length of Stay Among Pregnant Women at Less Than 20 Weeks' Gestation. *J Ultrasound Med*. 2018;37(11):2497-2505. [doi:10.1002/jum.14607](https://doi.org/10.1002/jum.14607)
10. Wilson SP, Connolly K, Lahham S, et al. Point-of-care ultrasound versus radiology department pelvic ultrasound on emergency department length of stay. *World J Emerg Med*. 2016;7(3):178-182. [doi:10.5847/wjem.j.1920-8642.2016.03.003](https://doi.org/10.5847/wjem.j.1920-8642.2016.03.003)
11. Cohen A, Li T, Stankard B, Nelson M. A Prospective Evaluation of Point-of-Care Ultrasonographic Diagnosis of Diverticulitis in the Emergency Department. *Ann Emerg Med*. 2020;76(6):757-766. [doi:10.1016/j.annemergmed.2020.05.017](https://doi.org/10.1016/j.annemergmed.2020.05.017)
12. Nixon G, Blattner K, Muirhead J, Kerse N. Rural point-of-care ultrasound of the kidney and bladder: quality and effect on patient management. *J Prim Health Care*. 2018;10(4):324-330. [doi:10.1071/HC18034](https://doi.org/10.1071/HC18034)
13. Wertz JR, Lopez JM, Olson D, Thompson WM. Comparing the Diagnostic Accuracy of Ultrasound and CT in Evaluating Acute Cholecystitis. *AJR Am J Roentgenol*. 2018;211(2):W92-W97. [doi:10.2214/AJR.17.18884](https://doi.org/10.2214/AJR.17.18884)
14. Adhikari S, Morrison D, Lyon M, Zeger W, Krueger A. Utility of point-of-care biliary ultrasound in the evaluation of emergency patients with isolated acute non-traumatic epigastric pain. *Intern Emerg Med*. 2014;9(5):583-587. [doi:10.1007/s11739-014-1047-x](https://doi.org/10.1007/s11739-014-1047-x)
15. Gunther KH, Smith J, Boura J, Sherman A, Siegel D. The Use of Bedside Ultrasound for Gallstone Disease Care within a Community-based Emergency Department: A Confirmation Bias. *Spartan Med Res J*. 2021;6(1):18182. [doi:10.51894/001c.18182](https://doi.org/10.51894/001c.18182)
16. Peters JR. Can bedside emergency ultrasonography enhance clinical decisionmaking in emergency department patients presenting with symptoms of biliary colic? *Ann Emerg Med*. 2013;62(6):629-630. [doi:10.1016/j.annemergmed.2013.05.002](https://doi.org/10.1016/j.annemergmed.2013.05.002)
17. Ross M, Brown M, McLaughlin K, et al. Emergency physician-performed ultrasound to diagnose cholelithiasis: a systematic review. *Acad Emerg Med*. 2011;18(3):227-235. [doi:10.1111/j.1553-2712.2011.01012.x](https://doi.org/10.1111/j.1553-2712.2011.01012.x)
18. Reznick MA, Scheulen JJ, Harbertson CA, Kotkowski KA, Kelen GD, Volturo GA. Contributions of Academic Emergency Medicine Programs to U.S. Health Care: Summary of the AAAEM-AACEM Benchmarking Data. *Acad Emerg Med*. 2018;25(4):444-452. [doi:10.1111/acem.13337](https://doi.org/10.1111/acem.13337)

19. Reznick MA, Michael SS, Harbertson CA, Scheulen JJ, Augustine JJ. Clinical operations of academic versus non-academic emergency departments: a descriptive comparison of two large emergency department operations surveys. *BMC Emerg Med*. 2019;19(1):72. [doi:10.1186/s12873-019-0285-7](https://doi.org/10.1186/s12873-019-0285-7)

20. Huang D, Wanchu R, Cho M, Leon L, Ganti L. Emergency department point-of-care ultrasound diagnosis of active bleeding into the intraluminal thrombus of an abdominal aortic aneurysm. *Radiol Case Rep*. 2023;18(6):2116-2120. [doi:10.1016/j.radcr.2023.03.002](https://doi.org/10.1016/j.radcr.2023.03.002)

21. Huang D, Wanchu R, Cho M, Leon L, Ganti L. Emergency department point-of-care ultrasound diagnosis of active bleeding into the intraluminal thrombus of an abdominal aortic aneurysm. *Radiol Case Rep*. 2023;18(6):2116-2120. [doi:10.1016/j.radcr.2023.03.002](https://doi.org/10.1016/j.radcr.2023.03.002)

22. Huang D, Ruzicka J, León L, Ganti L. Acute Upper Extremity Arterial Occlusion Diagnosed on POCUS in the Emergency Department. *POCUS J*. 2023;8(1):25-29. [doi:10.24908/pocus.v8i1.15902](https://doi.org/10.24908/pocus.v8i1.15902)