Practice patterns in the emergency care of kidney stone patients: an analysis of the National Hospital Ambulatory Medical Care Survey (NHAMCS)

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Introduction: *The emergency department (ED) is a common setting for evaluation of patients with urolithiasis based on acute symptoms and a propensity for recurrent disease. We sought to characterize practice patterns in the emergency treatment of stone disease, and to identify potential disparities in care based on non-medical factors.*

Materials and methods: *We performed a cross-sectional analysis of ED visits using the National Hospital Ambulatory Medical Care Survey from 2005-2009. Visits with a diagnosis of urolithiasis were identified. The associations between patient, provider and institutional characteristics were analyzed with regard to timing of clinical assessment, use of diagnostic imaging, and use of medical expulsive therapy (MET).*

Results: *The likelihood of a delay in clinical assessment ranged from 30.8%-37.9%. Neither patient nor provider characteristics were associated with a delay in assessment, although urban location (p = 0.004) was more likely, and proprietary ownership was less likely (p = 0.002) to be associated with delay. Factors associated with use of CT included ambulance arrival (p = 0.043), initial ED visit (p = 0.000), and Northeast region (p = 0.030). Patients seen by a resident/intern were more likely to receive MET (p = 0.028). Overall, 10.8% of patients were presenting for follow up treatment, and 7.1% had been seen in the same ED within the last 72 hours.*

Conclusions: *Kidney stones are associated with a high rate of repeated presentations to the ED. Certain non-medical factors did impact details of management. Future efforts should focus on optimizing clinical pathways to improve the efficiency of acute care for kidney stone patients.*

Key Words: kidney stones, nephrolithiasis, practice patterns, emergency care, medical expulsive therapy

Introduction

Kidney stones are a common diagnosis in the United States affecting approximately 10% of the population, and are rising in incidence.[1] Renal colic is a common presenting symptom of kidney stones and frequently leads to emergency department (ED) evaluation. Patients with a history of kidney stone disease are prone to recurrent stone events; additionally, emergency care constitutes a growing proportion of overall health care costs for kidney stone patients.[2,3] Patients with stones are heterogeneous regarding disease characteristics and comorbid conditions, and there are no stringent guidelines for management outside of the American Urological Association/European Association of Urology Guidelines on the Management of Ureteral Calculi which is primarily focused on surgical stratification rather than acute ED care. Thus emergency

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care for this population can be variable in terms of imaging evaluation, medical versus surgical treatment, and patient disposition. While medical factors impact these decisions, the extent to which non-medical factors play a role has not been well studied. Non-medical factors related to patient (e.g. ethnic/racial background, insurance status), provider (e.g. level of training), and institution (e.g. region, urban location, "safety net" status) may influence practice patterns.[4-6] Variations in care of kidney stone patients related to non-medical factors may undermine the quality, efficiency, and fairness of care.

At present, trends and variations in the emergency care of patients with kidney stones are not well understood. In this study, we evaluated a nationally representative sample of ED patients in the United States presenting with kidney stones to characterize trends in management as well as to identify potential treatment disparities.

Materials and methods

We analyzed the National Hospital Ambulatory Medical Care Survey (NHAMCS) dataset, a national probability sample of visits to emergency and outpatient departments of non-institutional general and short stay hospitals in the United States. Federal, military, and Veterans Administration hospitals are excluded. The survey is conducted by the Centers for Disease Control and Prevention's National Center for Health Statistics. U.S. Census Bureau representatives train hospital staff to collect data from a random sample of patient visits during a randomly assigned 4 week period each year. Sampled patient visits are weighted to produce reliable estimates of national ED visits. The NHAMCS uniquely allows for analysis of provider and health care organization characteristics vis-a-vis the content of care and variations in content of care for different patient subgroups.

The study cohort consisted of adult ED patients (≥ 18 years) who presented to the ED between 2005-2009 and were ultimately diagnosed with kidney stone disease (ICD-9 codes: 270.0, 274.11, 592.0, 592.1, 592.9, 788.0 listed as one of three recorded ED diagnoses).

Independent variables included patient characteristics (age, ethnicity/race, gender, residence, mode of arrival, payment source, comorbid conditions, recent ED presentations, triage level, pain scale), provider characteristics (clinician type), and health care setting characteristics (hospital setting, ownership, location, and payer mix, safety net status, and teaching hospital status). Safety net status was based on "safety-net burden" as reported by Gardner RL and colleagues: < 20% Medicaid/uninsured = non-safety net; 20%-50% = secondary safety net; > 50% = safety net.[7] Based on the approach used in a prior study, we defined a teaching hospital as one in which a resident or intern saw more than 50% of the ED patients.[8] Dependent variables included waiting time, delay in clinical assessment, utilization of imaging (CT, x-ray, ultrasound), patient disposition, use of medical expulsive therapy (MET), and repeated presentations. Waiting time was calculated as the difference between time of arrival and time seen by provider. Length of stay was defined as the time from arrival to discharge. Delay in clinical assessment was determined by comparing the triage nurse-determined immediacy with which patient should be seen (categorized into: less than15 minutes, 15-60 minutes, 1-2 hours, and 2-24 hours) with wait time. Patients were deemed to have a delay in clinical assessment if their wait time exceeded the triage nurse-determined immediacy with which patient should be seen. This methodology for determining treatment delays in the ED has been used in prior studies.[5] The involvement of specific consultants (i.e. urologists) is not captured in the dataset. Use of MET was defined as the prescription of at least one of the following medications at ED discharge: tamsulosin, alfuzosin, terazosin, doxazosin, prazosin, nifedipine. Finally, repeat presentations were determined based on whether the patient had been seen in that ED within the last 72 hours for flank pain, or discharged from any hospital within the last 7 days for a complaint of flank pain. The terminal datapoint of the NHAMCS dataset is the final disposition of the patient – it does not track what ultimately becomes of the patient (i.e. do they have a procedure, are they managed with observation only, etc.).

Statistical analysis was performed using STATA software, version 11.1. Demographic and visit characteristics were summarized using descriptive statistics. Continuous variables were summarized as means with their corresponding 95% CI, or medians with corresponding inter-quartile range. Categorical variables are summarized as proportions. Continuous variables that did not follow a normal distribution (wait time and length of stay) were log-transformed prior to the calculation of means. To account for the survey sampling design, we used the svy set of commands from STATA; thus the point estimates presented are weighted estimates. A χ^2 test was used to test proportions for statistical significance, and a t-test was used to test means. To determine whether there was a change in wait time and length of stay during the study years, we performed a test of trend using a simple linear regression. Given the exploratory nature of our analysis and the small number of sampled visits that met our inclusion criteria, a multivariable analysis was not performed. Statistical significance was defined as a p value < 0.05.

TABLE 1. **Patient, provider, and health care setting characteristics of study population**

Sample size		1590 visits
National estimate		5848, 115 visits
Patient characteristics		
Age (%)	18-40	49.3 [45.8-52.9]
	41-65	42.9 [39.4-46.4]
	> 65	7.8 [6.4-9.6]
Sex (%)	Male	56.6 [53.7-59.4]
	Female	43.4 [40.6-46.3]
Race/ethnicity (%)	Non-Hispanic white	78.7 [74.7-82.1]
	Non-Hispanic black/ African American	6.3 [4.8-8.3]
	Hispanic	12.2 [9.8-15.1]
	Other	2.8 [1.7-4.5]
Residence (%)	Private	98.6 [97.7-99.2]
	Nursing home	0.1 [0.0-0.4]
	Other	1.3 [0.7-2.2]
Mode of arrival (%)	Ambulance	9.4 [7.4-11.8]
	Non-ambulance	90.6 [88.2-92.6]
Payment source (%)	Private insurance	57.5 [53.1-61.8]
	Medicare	11.0 [9.2-13.1]
	Medicaid	10.5 [8.5-12.8]
	Uninsured	17.9 [14.9-21.3]
Episode of care (%)	Initial ED visit	89.2 [86.1-91.7]
	Follow up ED visit	10.8 [8.3-13.9]
Previous care (%)	Seen in present ED in last 72 hours	7.1 [5.6-9.1]
	Discharged from any hospital within 1 week	3.2 [2.1-4.8]
Provider characteristics		
Type of provider (%)	ED attending	94.6 [92.6-96.1]
	ED resident/intern	9.5 [7.1-12.6]
	NP/PA*	9.2 [7.3-11.6]
Health care setting		
Hospital region (%)	Northeast	18.0 [14.3-22.5]
	Midwest	23.2 [18.5-28.7]
	South	38.3 [32.7-44.3]
	West	20.5 [16.1-25.7]
"Safety net" status (%)	Non-safety net	48.3 [43.5-53]
	Secondary safety net	43.3 [39.1-47.6]
	Safety net	8.4 [6.2-11.3]
Teaching hospital (%)	Teaching	5.7 [4.1-7.8]
	Non-teaching	94.3 [92.2-95.9]
Urban (%)	MSA	83.6 [73.0-90.6]
	Non-MSA	16.4 [9.4-27.0]
Ownership (%)	Voluntary nonprofit	76.0 [71.0-80.5]
	Government, nonfederal	11.7 [8.6-15.6]
	Proprietary	12.3 [8.7-17.2]

*NP/PA = nurse practitioner/physician assistant; ED = emergency department.

Results

A total of 1590 sampled ED visits met our inclusion criteria. These visits represent an estimated 5.8 million U.S. ED visits between 2005 and 2009 during which kidney stone disorder was diagnosed. Patient, provider and health care setting characteristics are presented in Table 1. Overall, 10.8% (8.3-13.9) of patients had repeat ED visits for kidney stone disorders, and 7.1% (5.6-9.1) had been seen in the same ED within the last 72 hours.

The annual rate of ED visits for kidney stone disease did not vary significantly during the study period (data not presented). There was no change in time to be seen by a provider, time to discharge, or delay in clinical assessment during the study period, Table 2. The overall likelihood of a delay in clinical assessment was 30.8%-37.9% from 2005-2009; no significant trend in delay was identified.

Table 3a and 3b demonstrates univariate analysis of wait times and frequency of delay in assessment. Neither patient nor provider characteristics were associated with a delay. Regarding health care setting, urban location was associated with a longer time to initial assessment (33.4 minutes versus 19.2 minutes), time to discharge (229.1 minutes versus 159.0 minutes), and delay in assessment (37.4% versus 21.0%; p = 0.004) compared with non-urban location. Proprietary ownership (for-profit) was less likely associated with a delay in assessment compared with voluntary non-profit and government non-federal hospitals (20.8% versus 35.9% and 41.7%, respectively; p = 0.002).

Table 4a and 4b demonstrates univariate analysis of predictors of MET use and use of specific radiographic modalities. Patients seen by a resident or intern (i.e. in a teaching hospital setting) were more likely to receive MET (9.6% versus 4.8%; p = 0.028), as were those not seen in the ED in the last 72 hours (6.1 versus 0.8%; p = 0.001). There were several factors associated with use of CT, including ambulance arrival (81.1 versus 68.6%; p = 0.43), initial versus follow up ED visit (71.8% versus 39.9%; p = 0.000), and Northeast versus West region (75.7% versus 58.7%; p = 0.030). We were not able to assess the utilization of CT imaging on prior visits, so offer no comparison on the rationale for this association.

Discussion

Our analysis did not identify socioeconomic disparities in the emergency management of kidney stone patients; these findings are encouraging regarding the fairness and consistency of care for these patients. However, we did find some interesting trends in management, as well as variations in care that may identify areas for improvement. One notable finding was the high rate of patients seeking follow up care in the ED after prior evaluation (10.8%) or within that ED within 72 hours (7.1%). The lack of association with demographic findings suggests that access to care may not be a driving factor in these unanticipated repeat visits. However, these higher than expected rates underscore the need for optimization of care at the initial evaluation of a stone event (e.g. better coordination of follow up treatments, increased use of MET, etc.)

In our study, we sought to identify risk factors for prolonged wait time of kidney stone patients. Prior studies of emergency care have demonstrated disparities in wait time based on race and insurance status.[4-6] This issue is relevant as prolonged wait time can significantly impact the quality of care and patient satisfaction.[9-11] As patients with renal colic frequently

TABLE 2. **Average wait times and frequency of delays according to year**

Year	Time to be seen by provider* (minutes)	Time to discharge** (minutes)	Proportion with delay in clinical assessment*** (%)
2005	33.4 [27.5-40.5]	213.6 [193.1-236.2]	30.8 [24.7-37.8]
2006	27.9 [23.6-33.1]	214.2 [199.1-230.4]	37.9 [29.9-46.7]
2007	26.9 [22.6-32.1]	200.4 [182.9-219.6]	34.3 [28.0-41.2]
2008	33.9 [29.2-39.3]	224.8 [208.1-243.0]	34.8 [27.6-42.7]
2009	30.3 [21.9-42.0]	225.1 [195.0-259.9]	35.0 [26.9-45.8]

*Time to be seen by provider did not change significantly during study period (p = 0.960)
**Time to discharge did not change significantly during study period (p = 0.394)
***Delay in clinical assessment did not change significantly during study period (p = 0.790)

TABLE 3a. **Average wait times and frequency of delays according to patient characteristics***

Patient characteristics		Time to be seen by provider (minutes)	Time to discharge (minutes)	Proportion with delay in clinical assessment (%)
Age (years)	18-40	31.9 [27.4-37.1]	208.4 [192.8-225.2]	35.9 [30.7-41.5]
	41-65	30.1 [25.8-35.2]	222.6 [210.9-234.9]	34.0 [28.8-39.6]
	> 65	24.9 [19.9-31.1]	224.5 [183.0-275.5]	30.6 [21.3-41.7]
Sex	Male	28.1 [24.5-32.3]	205.3 [194.0-217.2]	33.7 [29.8-37.8]
	Female	33.8 [29.2-39.2]	230.0 [215.0-246.0]	35.9 [30.3-42.0]
Race/ethnicity	Non-Hispanic white	28.7 [24.5-33.7]	206.9 [193.1-221.7]	33.8 [29.5-38.4]
	Non-Hispanic black/ African American	37.7 [28.8-49.6]	232.0 [204.1-263.8]	35.4 [24.4-48.2]
	Hispanic	38.6 [28.7-52.1]	253.5 [225.6-284.7]	37.5 [29.0-46.9]
	Other	33.8 [24.4-47.0]	250.7 [219.6-286.2]	23.0 [10.6-42.8]
Residence	Private	30.5 [27.0-34.4]	213.8 [202.6-225.5]	34.5 [30.8-38.3]
	Nursing home	26.6 [3.7-183.3]	312.5 [138.8-703.5]	28.3 [2.4-86.4]
	Other	36.2 [20.0-65.3]	217.9 [179.7-264.2]	41.3 [18.0-69.2]
Mode of arrival	Ambulance	21.3 [16.3-27.8]	226.7 [201.1-255.5]	35.3 [23.3-49.5]
	Non-ambulance	31.4 [28.3-34.9]	210.8 [200.4-221.8]	33.8 [29.4-38.5]
Payment source	Private insurance	29.3 [26.1-33.0]	217.2 [204.2-231.0]	32.2 [27.5-37.3]
	Medicare	29.1 [22.4-37.9]	203.2 [179.2-230.3]	31.1 [20.7-43.8]
	Medicaid	32.0 [25.3-40.3]	209.1 [187.2-233.6]	35.4 [25.7-46.3]
	Uninsured	34.3 [28.0-41.9]	207.3 [190.5-225.6]	39.5 [32.3-47.2]
Episode of care	Initial ED visit	30.7 [25.3-37.3]	215.4 [197.9-234.4]	37.4 [32.5-42.7]
	Follow up ED visit	34.8 [25.2-48.0]	240.7 [207.6-279.2]	40.0 [27.4-54.2]
Previous care	Seen in present ED in last 72 hours	29.3 [23.2-37.6]	211.2 [182.2-244.9]	27.1 [16.1-41.9]
	Not seen in ED in present last 72 hours	31.8 [28.0-36.0]	216.5 [204.5-229.3]	37.7 [33.4-42.2]
	Discharged from any hospital within 1 week	39.8 [28.2-56.3]	215.8 [171.9-271.0]	57.2 [34.5-77.1]
	Not discharged from any hospital within 1 week	33.0 [28.8-37.8]	211.8 [198.8-225.7]	38.2 [33.5-43.1]

*Unless otherwise noted, there were no significant differences between patient, provider and health care setting characteristics regarding average wait time and frequency of delay ($p > 0.05$).
ED = emergency department.

have severe pain, delays in ED evaluation may be particularly important. Socioeconomic factors and insurance status are not associated with wait times in our study, possibly because of the high acuity of patients with renal colic. Indeed, biases may be less likely to manifest when patients present with severe pain. A similar explanation was discussed in a recent study of resource utilization in the management of trauma patients, who present with high acuity and for whom no systematic biases were seen.[12]

We did find that urban hospital location was associated with longer wait times and increased likelihood of delay in assessment. These findings likely reflect general trends in urban EDs that tend to have higher throughput and resource demand. Proprietary (for-profit) hospitals were associated with a decreased likelihood of delay in assessment, which may be based in part on financial incentives for rapid diagnosis and management, as well as lower patient volumes seen at these institutions. Interestingly, 30%-38% of patients

TABLE 3b. **Average wait times and frequency of delays according to provider characteristics and healthcare setting***

Provider characteristics		Time to be seen by provider (minutes)	Time to discharge (minutes)	Proportion with delay in clinical assessment (%)
Type of provider	ED attending	27.9 [15.2-51.2]	202.3 [170.7-239.6]	33.0 [29.5-36.7]
	ED resident/intern	29.6 [26.2-33.4]	213.0 [201.7-224.9]	42.3 [32.1-53.2]
	NP/PA	30.3 [26.9-34.3]	214.4 [202.8-226.7]	43.1 [32.9-53.8]
Health care setting				
Hospital region	Northeast	28.0 [22.7-34.6]	242.7 [215.4-273.3]	36.2 [25.8-48.2]
	Midwest	30.7 [25.0-37.8]	221.2 [203.9-239.9]	33.3 [26.8-40.5]
	South	28.9 [23.0-36.1]	202.7 [181.9-225.7]	31.0 [25.9-36.7]
	West	35.9 [28.0-46.0]	213.1 [200.8-226.2]	41.7 [34.0-49.9]
"Safety net" status	Non-safety net	28.2 [23.7-33.6]	212.7 [196.4-230.4]	32.2 [27.0-37.9]
	Secondary safety net	33.4 [28.8-38.8]	219.1 [206.0-233.0]	36.0 [30.6-41.6]
	Safety net	28.9 [21.8-38.4]	214.6 [194.1-237.2]	41.8 [27.6-57.4]
Teaching hospital status	Teaching	30.0 [26.6-33.9]	215.4 [204.0-227.3]	34.9 [22.3-50.1]
	Non-teaching	39.0 [24.7-61.5]	219.8 [191.2-252.7]	34.6 [30.9-38.6]
Urban**	MSA	33.4 [30.0-37.3]	229.1 [219.6-239.0]	37.4 [34.0-40.9]
	Non-MSA	19.2 [13.3-27.6]	159.0 [136.5-185.1]	21.0 [13.3-31.5]
Ownership***	Voluntary nonprofit	30.6 [27.0-34.6]	220.0 [207.6-233.0]	35.9 [31.7-40.3]
	Government, nonfederal	35.0 [27.6-44.3]	209.7 [186.5-235.9]	41.7 [32.8-51.3]
	Proprietary	[21.5-33.0]	196.1 [175.7-218.9]	20.8 [14.1-29.5]

*Unless otherwise noted, there were no significant differences between patient, provider and health care setting characteristics regarding average wait time and frequency of delay ($p > 0.05$).
**Urban location was associated with a longer time to initial assessment, total ER time, and delay in assessment ($p = 0.004$).
***Non-proprietary ownership was associated with a delay in assessment ($p = 0.002$).
NP/PA = nurse practitioner/physician assistant; ED = emergency department; MSA = metropolitan statistical area.

had a delay in assessment; this percentage is quite high and may be indicative of ED overcrowding, increased staffing needs, or other as yet unidentified processes.

We also sought to identify predictors of use of imaging in the evaluation of kidney stone patients. Indeed, various modalities may be appropriate (i.e. CT, ultrasound, plain radiography) though with notable differences in cost, associated radiation dose, and diagnostic yield. While rising utilization of CT in the ED has been well described, there has not been investigation of predictors of imaging utilization for kidney stones in particular.[13-15] In our study, we found that certain geographic and logistical factors were associated with higher utilization of CT. Patients in the Northeast were more likely to have a CT evaluation than those in the West, though reasons for this are speculative. Ambulance arrival was associated with a higher likelihood of CT, likely based on a higher acuity of presentation by this mode of transport. We have previously reported that CT is the most common imaging modality in the emergency evaluation of suspected stone disease.[15]

Another important aspect of emergency care for stone disease is use of MET for patients undergoing a trial of passage. MET confers a significantly increased likelihood of spontaneous passage and avoiding surgical therapy in selected patients.[16-18] However, recent studies have demonstrated slow diffusion of MET in the emergency setting. Hollingsworth and colleagues examined utilization of MET in the ED from 2000-2006 using NHAMCS; while they reported an increase in MET utilization during the study period, a very low overall prevalence of use was observed (1.1%).[19] In this study, we found that trainee involvement (i.e. academic setting) was associated with higher utilization of MET; it may be that academic institutions have more familiarity with recent literature regarding the utility of MET. Absence of a recent ED visit was also associated with higher utilization of MET; it may be that MET is protective for reducing re-presentation rates for patients

TABLE 4a. **Medical expulsive therapy and radiographic evaluation among patients with kidney stone disease by patient characteristics***

Patient characteristics		**MET**		**Radiology**	
			X ray	**Ultrasound**	**CT imaging**
Age (years)	18-40	4.5% [2.8-7.1]	19.0 [14.6-24.3]	5.7 [2.8-11.1]	67.5 [61.4-73.1]
	41-65	6.7 [4.6-9.7]	18.3 [14.8-22.4]	3.9 [2.4-6.3]	71.0 [66.7-74.9]
	> 65	2.2 [0.7-6.8]	26.3 [17.8-37.2]	4.1 [1.5-11.0]	63.6 [52.6-73.4]
Sex	Male	6.4 [4.5-9.1]	19.6 [15.7-24.2]	4.5 [2.6-7.7]	70.0 [65.3-74.4]
	Female	3.7 [2.2-6.3]	18.8 [14.6-23.9]	5.2 [2.9-9.1]	66.9 [61.6-71.9]
Race/ethnicity	Non-Hispanic white	5.4 [3.6-8.1]	19.3 [15.2-24.2]	5.2 [2.6-10.0]	68.4 [63.1-73.3]
	Non-Hispanic black/ African American	5.4 [1.7-15.9]	29.3 [18.9-42.6]	5.5 [2.1-13.3]	79.0 [64.4-88.7]
	Hispanic	5.6 [2.6-11.7]	19.3 [13.1-27.5]	4.9 [2.2-10.6]	62.1 [52.2-71.0]
	Other	7.6 [2.2-23.3]	20.2 [16.7-24.2]	5.3 [3.1-0.0]	61.2 [38.8-79.7]
Residence	Private	5.1 [3.7-6.9]	19.0 [15.5-23.0]	5.0 [2.9-8.5]	69.2 [65.1-73.0]
	Nursing home	0.0	0.0	0.0	100.0
	Other	0.0	33.0 [13.4-61.2]	5.0 [2.9-8.4]	51.4 [25.1-76.9]
Mode of arrival**	Ambulance	3.6 [0.7-16.2]	20.2 [11.4-33.1]	1.7 [0.4-7.9]	81.1 [69.6-89.0]
	Non-ambulance	1.2 [0.6-2.6]	19.6 [16.2-23.5]	3.6 [2.4-5.4]	68.6 [64.3-72.6]
Payment source	Private insurance	1.0 [0.4-2.6]	19.1 [15.1-23.8]	2.7 [1.6-4.5]	73.2 [68.0-77.8]
	Medicare	1.0 [0.1-7.1]	29.3 [20.6-39.9]	3.4 [1.1-9.6]	61.6 [50.3-71.8]
	Medicaid	0.7 [0.1-4.4]	22.7 [14.2-34.3]	5.6 [2.3-12.6]	68.5 [58.6-76.9]
	Uninsured	3.9 [1.3-11.2]	15.1 [10.3-21.6]	2.9 [1.4-6.2]	68.6 [60.8-75.5]
Episode of care***	Initial ED visit	7.4 [5.2-10.4]	17.6 [13.2-23.0]	5.5 [2.3-12.4]	71.8 [64.9-77.8]
	Follow up ED visit	5.9 [2.1-15.1]	17.3 [10.1-27.9]	3.6 [1.5-8.4]	39.9 [29.7-51.1]
Previous care****	Seen in present ED in last 72 hours	0.8 [0.2-3.1]	20.5 [12.2-32.3]	5.2 [1.9-13.5]	39.5 [29.5-50.5]
	Not seen in present ED in last 72 hours	6.1 [4.4-8.3]	19.7 [16.1-23.8]	5.1 [2.9-8.8]	71.1 [66.0-75.7]
	Discharged from any hospital within 1 week	5.6 [1.3-21.3]	19.1 [5.7-47.8]	0.0	39.6 [21.0-61.8]
	Not discharged within 1 week	5.6 [3.9-7.9]	21.1 [16.8-26.1]	5.7 [2.9-10.9]	68.1 [62.9-72.8]

*Unless otherwise noted, there were no differences between patient, provider, or health care setting characteristics regarding use of MET or various imaging modalities ($p > 0.05$)
**Ambulance arrival is associated with use of CT ($p = 0.43$).
***Initial ED visit is associated with use of CT ($p = 0.000$).
****Being seen in the ED in the last 72 hours, or being discharged from the hospital in the last 7 days, is associated with not having a CT scan ($p = 0.001$).
ED = emergency department.

with flank pain. An alternate explanation, which cannot be disproved by the NHAMCS dataset, is that patients were already prescribed MET from their initial visit and so did not require a second prescription for the medication. Interestingly, our data demonstrate a continued slow increase in utilization of MET, albeit at low levels, reflecting continued modification of clinical practice patterns.

There are several limitations of our study that deserve mention. As an administrative dataset, NHAMCS is susceptible to coding inaccuracies, erroneous and absent data, leading to under and overestimation of certain results; however, there are rigorous quality control procedures in place to minimize this risk.[20] Detailed clinical information is absent (e.g. stone size) from NHAMCS, prohibiting a more nuanced analysis

TABLE 4b. **Medical expulsive therapy and radiographic evaluation among patients with kidney stone disease by provider characteristics and health care setting***

		MET	X ray	Radiology Ultrasound	CT imaging
Provider characteristics					
Type of provider**	ED attending	5.2 [3.8-7.2]	19.2 [15.7-23.3]	4.9 [2.8-8.4]	68.8 [64.7-72.7]
	ED resident/intern	9.6 [5.4-16.5]	21.6 [14.5-30.8]	8.9 [4.0-18.9]	65.4 [54.0-75.3]
	NP/PA	7.0 [2.8-16.3]	12.0 [7.0-19.9]	5.5 [2.1-13.5]	65.9 [55.6-75.0]
Health care setting					
Hospital region***	Northeast	7.6 [4.3-13.0]	20.8 [13.7-30.2]	4.5 [2.4-8.3]	75.7 [69.5-81]
	Midwest	5.8 [2.6-12.5]	16.6 [11.7-22.9]	4.6 [2.5-8.2]	72.2 [66.4-77.4]
	South	4.0 [2.7-6.0]	22.5 [16.3-30.2]	4.8 [1.4-15.7]	68.6 [59.4-76.5]
	West	4.8 [2.3-9.6]	14.9 [9.2-23.3]	5.4 [2.7-10.3]	58.7 [50.4-66.6]
"Safety net" status	Non-safety net	5.8 [4.1-8.2]	21.5 [16.1-28.1]	6.1 [2.8-13.1]	68.8 [63.1-74.0]
	Secondary safety net	5.0 [3.1-8.0]	16.8 [12.9-21.7]	3.3 [1.9-5.8]	68.4 [62.9-73.4]
	Safety net	3.4 [0.8-13.2]	18.7 [12.3-27.4]	4.8 [2.2-10.2]	69.3 [58.3-78.5]
Teaching hospital status	Teaching	10.5 [4.8-21.7]	9.7 [4.9-18.4]	6.6 [1.8-21.2]	65.6 [50.7-77.9]
	Non-teaching	4.9 [3.5-6.9]	19.8 [16.3-23.9]	4.7 [2.7-8.1]	68.9 [64.6-72.9]
Urban****	MSA	5.9 [4.3-8.0]	18.6 [15.3-22.4]	3.8 [2.6-5.4]	71.2 [67.2-75.0]
	Non-MSA	2.0 [0.7-5.9]	22.6 [12.5-37.4]	10.1 [2.7-31.3]	55.9 [45.5-65.8]
Ownership	Voluntary nonprofit	5.8 [4.3-7.8]	18.8 [15.4-22.8]	4.0 [2.5-6.4]	69.7 [65.1-73.9]
	Government, nonfederal	6.6 [2.6-15.4]	19.7 [12.5-29.7]	4.7 [2.3-9.4]	61.6 [51.6-70.6]
	Proprietary	0.5 [0.1-3.1]	21.5 [12.5-34.2]	9.8 [3.4-24.9]	69.4 [58.3-78.7]

*Unless otherwise noted, there were no differences between patient, provider, or health care setting characteristics regarding use of MET or various imaging modalities ($p > 0.05$).
**Being evaluated by a resident/intern (i.e. being evaluated in a teaching hospital) is associated with receiving MET ($p = 0.28$).
***Patients in the Northeast are more likely than patients in the West of having CT imaging ($p = 0.03$).
****Urban setting is associated with use of CT ($p = 0.004$).
MSA = metropolitan statistical area

of practice patterns for smaller versus larger stone burdens. However, this dataset enables analysis of a large, nationally representative sample of patients, exchanging statistical power and broad applicability for the merits of more granular data. It is not possible to link across patient visits, so we are unable to determine clinical pathways (imaging, use of MET, etc.) that were taken on each emergency visit. The census of the emergency department at the time of presentation, which could conceivably affect treatment pathways, was also not available.

Analysis of MET use may be limited in our study because these medications may also be prescribed for hypertension or BPH; however, by requiring a primary diagnosis of "kidney stone" within a patient encounter, the likelihood of an ancillary purpose for prescribing one of the stated agents is low. Finally, the unit of analysis in NHAMCS is patient encounter, thus individual patients cannot be followed across visits, and recurrent presentations by an individual have the potential to bias the data. The sampling method used by NHAMCS, however, makes it less likely that recurrent presentations by the same patient will be captured.[21]

Conclusions

Socioeconomic factors do not appear to drive disparities in health care delivery for patients suffering from acute kidney stone events. However, kidney stones are associated with high rates of repeated visits to the ED. In our review of the NHAMCS dataset, over 10% of patients experienced an unplanned repeat visit for a stone event. Our analysis, then, is hypothesis-generating as it suggests that future efforts directed toward the improvement of emergency care for acute stone events may be best focused on coordination of care to minimize the likelihood of repeated ED visitations.

Further investigation, with the use of data more granular than that available in NHAMCS, will enable the better characterization of patients at risk for repeated presentation to the ED with flank pain. In addition, although MET does continue to diffuse into clinical practice, efforts directed toward speeding this process may also have a beneficial effect on the management of patients suffering from an acute stone event. ☐

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