Title

Medical expulsive therapy use in emergency department patients diagnosed with ureteral stones

Journal
The American Journal of Emergency Medicine, 35(8)

ISSN
0735-6757

Authors
Wang, Ralph C
Addo, Newton
Chi, Thomas
et al.

Publication Date
2017-08-01

DOI
10.1016/j.ajem.2017.02.040

Peer reviewed

American Journal of Emergency Medicine 35 (2017) 1069–1074

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contribution

Medical expulsive therapy use in emergency department patients diagnosed with ureteral stones

Ralph C. Wang, MD MAS [a,*], Newton Addo, MAS [a], Thomas Chi, MD [b], Christopher Moore, MD [c], Michael Mallin, MD [d], Stephen Shiboski, PhD [e], Marshall Stoller, MD [b], Rebecca Smith-Bindman, MD [e,f]

[a] Department of Emergency Medicine, University of California, San Francisco, San Francisco, CA, USA
[b] Department of Urology, University of California, San Francisco, San Francisco, CA, USA
[c] Department of Emergency Medicine, Yale University, New Haven, CT, USA
[d] Division of Emergency Medicine, University of Utah, Salt Lake City, UT, USA
[e] Department of Epidemiology and Biostatistics, University of California, San Francisco, CA, USA
[f] Department of Radiology and Biomedical Imaging, University of California, San Francisco, CA, USA

ARTICLE INFO

Article history:
Received 16 January 2017
Received in revised form 24 January 2017
Accepted 25 February 2017

ABSTRACT

Objective: Recent studies have clarified the role of alpha-blockers, such as tamsulosin, for patients diagnosed with ureteral stones < 10 mm not requiring an urgent intervention. Prior studies have reported low rates of use of MET by emergency physicians. We sought to describe patterns of alpha-blocker use and to determine factors associated with utilization in patients diagnosed with ureterolithiasis in the ED.

Methods: We used data from a randomized trial of CT scan vs. ultrasound in participants with suspected urolithiasis enrolled at 15 EDs between October 2011 and February 2013. The use of medical expulsive therapy was identified by the prescription of an alpha-blocker, calcium channel blocker, or steroid at the ED visit. The prevalence of alpha-blocker use in participants with ureteral stones on imaging was calculated, and multivariable models were used to examine risk factors for utilization.

Results: Of the 524 participants who were identified with a ureteral stone on CT scan and discharged from the ED, 375 (71.4%) received an alpha-blocker, and 2 (<1%) received a steroid. There was no significant difference in alpha-blocker use for participants based on stone size or location. However, there was a 3.6-fold difference in alpha-blocker use between the lowest and highest use ED sites. In the multivariable analysis, ED site was independently associated with utilization of alpha-blockers.

Conclusions: Alpha-blockers were prescribed in more than two-thirds of patients with a distal ureteral stone on imaging, a much higher prevalence than previously reported. There was substantial variability in alpha-blocker use based on ED site.

1. Introduction

1.1. Background

Urinary stone disease is a common condition that causes acute, severe pain when stones lodge in the ureter, frequently resulting in an emergency department (ED) visit [1-3]. Medical expulsive therapy (MET), including alpha-blockers, steroids, and calcium channel blockers, has been extensively studied for improving the rate of stone passage in patients who do not require immediate urologic intervention [4-6,22]. Both the American Urologic Association and European Urologic Association have broadly recommended that patients with a new diagnosis of ureteral stone < 10 mm and do not require and urgent urologic intervention "should be offered an appropriate medical therapy to facilitate stone passage" [7]. This recommendation has been refuted by a large multicenter trial of participants with ureteral stones of all locations and sizes up to 10 mm, which did not show a benefit of tamsulosin or nifedipine [8]. Recently, two meta-analyses have clarified the role of MET for patients diagnosed with ureteral stones. Both meta-analyses have found strong evidence that tamsulosin and other alpha-blockers are efficacious and should be prescribed for patients with ureteral stones 5–10 mm in size [9,10].

Prior studies have reported low rates of MET use by emergency physicians, ranging from 1.1% to 14% of patients diagnosed with urolithiasis [3,11-13]. These prior studies have concluded that MET is "underutilized by emergency physicians", citing a "problem in knowledge translation", which has implications for quality of patient care and the economic burden of urolithiasis [12-14]. These studies used the National Hospital

* Corresponding author at: Department of Emergency Medicine, 505 Parnassus Avenue, San Francisco, CA 94143, USA.
E-mail address: ralph.wang@ucsf.edu (R.C. Wang).

http://dx.doi.org/10.1016/j.ajem.2017.02.040
0735-6757/

Ambulatory Medical Care Survey (NHAMCS), or the MarketScan Commercial Claims and Encounters Database, a medical and drug insurance claims database, which defined eligibility for MET based on ICD-9 codes for urolithiasis. However, randomized trials of MET determined eligibility based on the presence of a ureteral stone on CT scan [6]. Thus, the prior studies that reported MET "underutilization" are limited in their ability to measure appropriate MET use.

1.2. Importance

One of every 11 Americans suffer from urolithiasis [15]. From 1992 to 2009, ED visits for urinary stone disease nearly doubled, and it is estimated there are now more than a million annual ED visits for suspected USD in the U.S. [3,16]. The use of health care resources for these patients has also increased, rising from $2.1 billion in 2000 to over $5 billion in 2006 [17,18]. MET is an ED intervention that could help with morbidity from kidney stones in certain situations. However, there is a lack of studies to examine patterns of MET use by emergency physicians that include imaging data to allow for the identification of eligible patients.

1.3. Objectives

Using data from a recently completed randomized pragmatic trial, the Study of Ultrasonography versus Computed Tomography for Suspected Nephrolithiasis, we sought to examine patterns of MET prescription in fifteen academic US EDs [19]. Our objective was to determine the current use of MET among patients with ureteral stones on CT, and identify factors associated with the failure to use alpha-blockers in eligible patients. We hypothesize that academic emergency physicians use MET at much higher rates in eligible patients than previously published, but that there is wide practice variation.

2. Methods

2.1. Study design and setting

This was an observational study using data from a recently conducted randomized pragmatic trial, the Study of Ultrasonography versus Computed Tomography for Suspected Nephrolithiasis, (trial registration number: NCT01451931 at clinicaltrials.gov) [19]. This study was conducted at 15 academic EDs across the United States between October 2011 and February 2013. Details of the participating EDs have been reported [20]. Briefly, the participating sites were academic EDs with emergency medicine residencies and emergency ultrasound fellowships across the United States, with representation from a number of settings – urban, rural, university based and safety net hospitals. The sites varied by size, annual census, and patient population served. This randomized trial study was performed with institutional review board approval at each site and informed consent was obtained from all participants. This current study was performed with institutional review board approval at the University of California, San Francisco.

2.2. Participants

Adult participants with suspected kidney stones that required imaging (as determined by an attending emergency physician) who consented to study inclusion were randomly assigned to receive point-of-care ultrasound (POC ultrasound, performed by an ED physician), radiology ultrasound, or CT as their initial imaging test. Patients were excluded from enrollment if they were pregnant, at high risk of a serious non-kidney stone diagnosis, had received a kidney transplant, required dialysis, had a known solitary kidney, or were >285 lbs. if male or 250 lbs. if female. After participants were randomized to an initial imaging test, the subsequent management of participants was up to the discretion of the emergency physicians, including decisions regarding alpha-blocker prescription. We limited this analysis to study participants who were found to have a ureteral stone on CT. Participants who received an intervention at baseline were excluded as they received a urologic intervention prior to receipt of an alpha-blocker prescription in order to mirror eligibility criteria in previous randomized trials of MET.

2.3. Methods and measurements

Research coordinators used a standardized data collection form to collect detailed demographic, clinical, laboratory, and imaging data during the index ED. Prior to patient enrollment, research coordinators attended a two-day meeting to receive training study protocol, forms, and data collection. Additional weekly online meetings provided more in depth training regarding data collection. Detailed demographic, clinical, laboratory, and imaging data were collected during the index ED visit by trained research coordinators. Patients and physicians were directly interviewed in real time during the index ED visits, including use of alpha-blockers, calcium channel blockers, and steroids. Specific medical expulsive therapy agents in each drug class were captured. These data were recorded on paper forms and faxed to a data-coordinating center, which provided immediate feedback for completeness. Research coordinators were blinded to the study hypothesis.

2.4. Outcome measures

The main outcome measure was the receipt of alpha-blocker prescription at the time of ED discharge. Each participant was identified as having received alpha-blockers (yes vs. no), and the type of alpha-blocker (tamsulosin vs. terazosin vs. doxazosin), calcium channel blockers (yes vs. no), and corticosteroids (yes vs. no) as adjuncts to observation for stone passage. As alpha-blockers are known to have a class effect, we considered any alpha-blocker use as positive for the main outcome.

2.5. Exposures of interest

Based on prior studies, we identified variables associated with participant receipt of MET use, including gender, age, race, educational level, and insurance status, and ED site [3,11,12]. In addition to these variables, we evaluated stone size and location on CT. We combined race categories (Asian, Native American, Pacific Islander) as some categories had <5 observations.

2.6. Statistical analysis

For all analyses we performed 2-sided significance testing and set a type I error rate at 0.05. We first calculated estimates of the prevalence of alpha-blocker use, defining use as a ratio of alpha-blockers prescribed/eligible patients. As the evidence for tamsulosin benefit is primarily in distal ureteral stones (vs. no benefit in proximal or mid-ureteral stones), we described alpha-blocker use according to stone location. Similarly, we examined alpha-blocker use according to stone size, as those with large stones (5–10 mm) receive the most benefit. We conducted univariate analyses to determine the strength of association between these potential predictors and the failure to prescribe alpha-blockers in eligible patients. We also constructed a multivariable logistic regression models to determine the strength of association between predictors of interest and the failure to prescribe alpha-blockers in eligible patients in those participants with distal ureteral stones. We included variables such as gender, age, race, educational level, insurance coverage, stone size, and ED site as potential predictors, as female gender, younger age, and those not employed full time were significantly less likely to receive medical expulsive therapy in prior studies. We considered the ED site #5 as the reference as this site had the lowest prevalence of non-use of alpha-blockers. Uncertainty of the estimated prevalence and measures of associations was summarized using exact binomial 95% confidence intervals. Stata (StataCorp. 2013. *Stata Statistical Software*: *Release 13*. College Station, TX) was used to perform the statistical analysis.

3. Results

Of 1623 subjects receiving CT (including 933 initially randomized to CT, 42 randomized to POCUS, 35 randomized to radiology US, and 613 who received a CT after initial randomization to an ultrasound arm), 564 (34.8%) had a ureteral stone at the index ED visit. 524 were discharged home without a urologic intervention (See Appendix 1). The median age of participants diagnosed with ureterolithiasis was 40, and 68.4% were men (Table 1). Table 1 displays patient demographics, financial characteristics (educational level attained, insurance coverage), and details of the stone location and stone size. 43/524 (8.2%) participants with a distal ureteral stone required urologic intervention within 30 days.

3.1. Main results

Missing data was identified in 5 participants (<1%) who refused to answer the question regarding whether they had insurance coverage. Of the 524 participants, 374 (71.4%) were prescribed an alpha-blocker, and of these 366 (97.9%) were given tamsulosin, with the remainder receiving terazosin or doxazosin. Steroids were prescribed in 2 patients, and calcium channel blockers were prescribed in 0 patients (overall 0.4% of 524 participants). Table 2 displays patterns of alpha-blocker use by stone size. The most common location of ureteral stone was distal – 249/524 (47.5)%. Of the distal ureteral stones, 202/249 (81.1%) measured 0-5 mm, and 44/249 (28.6%) measured from 5 to 10 mm. Alpha-blockers were prescribed in approximately 70% of those with distal ureteral stones. There was no difference between alpha-blocker use in those with distal vs. non-distal stones. Similarly, >70% of those with smaller stones as well as larger stones received alpha-blockers. 6 of 12 participants with stones >10 mm received alpha-blockers; of the 6 participants with stones >10 mm who received an alpha-blocker, 4 received a urologic consultation in the ED.

Table 1
Characteristics of participants with ureteral stone on CT scan.

	Overall (N = 524)
Male	358 (68.3)
Age (IQR)	40 (30–51)
Race	
White	253 (48.2)
African American	81 (15.6)
Asian	39 (7.4)
Native American	10 (1.9)
Pacific Islander	2 (0.4)
More than one	13 (2.6)
Hispanic	125 (23.8)
Refused	1 (0.2)
Educational level	
Elementary	85 (16.2)
High school	144 (27.4)
College	128 (24.4)
Graduate School	167 (31.8)
Insurance coverage	361 (68.8)
Pain level (IQR)	9 (8–10)
History of prior stone	230 (43.9)
Stone location	
Proximal	59 (11.3)
Mid-ureter	216 (41.2)
Distal	249 (47.5)
Stone size	
0–5 mm	358 (68.3)
6–10 mm	154 (29.3)
>10 mm	12 (2.3)
Urologic consultation in ED	
No	364 (69.5)
Yes	113 (21.6)
Unknown	47 (9.0)
Urologic intervention	
Within 30 days	43 (8.2)
Within 180 days	65 (12.4)

Table 2
Alpha-blocker use by stone size and location

	Distal ureteral[b] (N = 249)	Proximal and mid-ureteral[c] (N = 275)	p-Value
0–5 mm	143/202 (70.8%)	106/156 (68.2%)	0.59
5–10 mm	34/44 (77.3%)	85/110 (77.3%)	1.0
>10 mm[a]	2/3 (66.7%)	4/9 (44.4%)	0.1

[a] Medical expulsive therapy not indicated for ureteral stones >10 mm.
[b] Tamsulosin effective in distal ureteral stones.
[c] Tamsulosin not effective in proximal or mid-ureteral stones.

Table 3 displays the results of a multivariable analysis to identify predictors of alpha-blocker underutilization in patients with distal ureteral stones. ED site was the strongest predictor of underutilization of alpha-blockers, with ED sites numbered 14, 7 and 15 having odds ratios of 11.8, 20.3, and 57.2 as compared to the reference site (5). Utilization was also less likely in those who reported a high school education compared to those who had attained a graduate school education (OR 3.7, 95% CI 1.1–12.9). This association was significantly associated with underutilization despite adjustment for gender, race, age, insurance coverage, stone size, and ED site. However, we do not believe that physicians fail to use alpha-blockers in those with lower educational levels attained, but rather due to the correlation between educational levels and ED site (chi-square test = 137, $p < 0.001$).

We displayed alpha-blocker use in eligible patients stratified by stone size and ED site in Fig. 1. Alpha-blocker use varied among the 15 ED sites considerably, ranging from 25.0% to 90.9%, ($p < 0.001$). This represents more than a 3-fold difference between the use of alpha-blockers between the site with the lowest rate of alpha-blocker prescription and that of the highest. Especially notable is alpha-blocker use in for those with large stones, who are the most likely to benefit. Two sites did not provide alpha-blockers, whereas 7 sites provided alpha-blockers in 100% of participants.

3.2. Limitations

This is a secondary analysis of data obtained from a randomized trial, the Study of Ultrasonography vs. Computed Tomography for Suspected Nephrolithiasis, and thus some limitations exist for assessing data on therapy. One limitation that should be noted is the time of data collection, which ended in 2013. We feel that more recent data would be desirable, mainly to reflect current practice. Also, a second limitation in this study is likely decreased generalizability to community emergency medicine practice, as the parent trial was conducted at academic emergency departments, chosen for their experience with point-of-care ultrasound to be included in the parent randomized trial. While we cannot comment on community emergency medicine practice, this is a 15-center study, with representation from a number of settings – urban, rural, university based and safety net hospitals, and is likely to reflect academic emergency medicine practice. Additionally, we did not collect data regarding allergies to medications, or other contra-indications to MET. Despite these limitations, we feel that this data source is superior to other administrative data sources in many respects. The data from this trial was prospectively collected from 15 ED across the United States, and contained information regarding CT findings, including stone size and location. Other data sources, such as NHAMCS, are more generalizable to community emergency medicine settings, but the most recent NHAMCS survey available is from 2013 as well. Also, our methodology is likely more valid than prior methods that have used NHAMCS or insurance claims data, as we are able to

Table 3
Adjusted odds ratios of predictors of alpha-blocker underutilization among participants with distal ureteral stones (N = 249)

	Overall N = 249	Alpha-blockers N = 179	No alpha-blockers N = 70	AOR (95%CI)
Female	174 (70.0)	127 (71.0)	47 (67.4)	1.3 (0.4–1.6)
Age	40.9 (12.8)	41.2 (12.9)	40.0 (12.6)	1.0 (0.97–1.02)
Race				
White	123 (49.4)	91(50.3)	32 (45.7)	Ref
African American	37 (14.9)	27 (13.4)	10 (14.3)	0.4 (0.1–1.1)
Other	33 (13.3)	26 (13.6)	7 (10.0)	0.5 (0.2–1.6)
Hispanic	56 (22.5)	35 (23.5)	21 (30.0)	0.9 (0.3–2.3)
Educational level				
Graduate School	90 (31.8)	75 (41.9)	15 (21.4)	Ref
College	57 (24.6)	37 (22.7)	20 (28.6)	2.4 (0.9–6.3)
High school	65 (27.4)	47 (26.1)	18 (25.7)	1.7 (0.6–4.3)
Elementary	37 (16.2)	20 (11.2)	17 (24.3)	3.8 (1.2–12.1)
Insurance coverage	170 (69.1)	128 (71.9)	42 (61.8)	1.3 (0.5–3.2)
Stone size				
0–5 mm	202 (68.4)	143 (66.7)	59 (72.7)	Ref
5–10 mm	44 (29.3)	34 (31.7)	10 (23.3)	0.6 (0.2–1.5)
>10 mm	3 (2.3)	2 (1.6)	1 (4.0)	3.0 (0.1–42.3)
ED site[a]				
5	43	40 (93.0)	3 (7.0)	Ref
1	7	6 (85.7)	1 (14.3)	2.7 (0.2–32.3)
2	12	7 (58.3)	5 (41.7)	7.7 (1.3–46.9)
3	20	11 (55.0)	9 (45.0)	27.9 (4.6–169.7)
4	33	25 (75.8)	8 (24.2)	4.6 (1.0–21.3)
6	12	8 (66.7)	4 (33.3)	6.5 (1.1–36.4)
7	16	7 (43.8)	9 (56.3)	20.3 (3.8–107.7)
8	16	13 (81.2)	5 (18.8)	3.9 (0.6–25.2)
9	13	11 (84.6)	2 (15.4)	2.8 (0.4–20.0)
10	14	11 (78.6)	3 (21.4)	4.6 (0.7–28.5)
11	6	5 (83.3)	1 (16.7)	3.0 (0.2–38.3)
12	19	16 (84.2)	3 (15.8)	3.0 (0.4–20.7)
13	15	12 (80.0)	3 (20.0)	2.9 (0.5–17.5)
14	6	4 (66.7)	2 (33.3)	11.8 (1.4–102.5)
15	17	3 (17.7)	14 (82.4)	57.2 (8.6–379.4)

[a] Row percentages provided to display prevalence of alpha-blocker use at each site.

identify those participants with ureteral stones on CT, as well as specify stone location and size. Thus, we can comment on the appropriate use of MET in specific subgroups of patients, whereas prior studies are limited in this respect.

4. Discussion

We conducted a multicenter study using prospectively collected data to describe MET use in ED patients with urolithiasis. We found

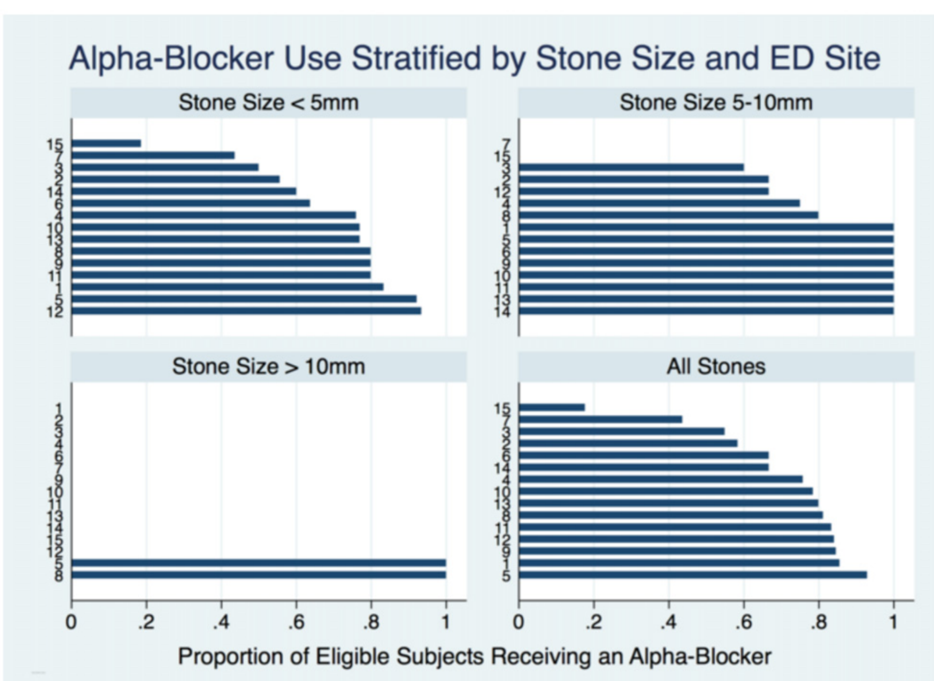


Fig. 1. Proportion of eligible subjects who received an alpha-blocker, stratified by ED site and stone size (<5 mm, 5–10 mm, and >10 mm).

that in this diverse cohort of patients presenting to academic emergency departments, MET was prescribed in approximately 70% of those with a ureteral stone on CT scan, a significantly higher rate than previously reported [3,11,12]. When a MET agent was prescribed, it was almost exclusively an alpha-blocking medication, tamsulosin. We found that the pattern of emergency physicians alpha-blocker use reflects American Urologic Association guidelines (which recommends those with a ureteral stone < 10 mm receive MET), as > 70% of those with distal, mid-ureteral, and proximal ureteral stones < 10 mm in size received an alpha-blocker. Some participants with ureteral stones >10 mm received tamsulosin; in the majority of these cases, a urologist was consulted, suggesting that the decision to provide MET was made jointly.

This study provides an updated understanding of alpha-blocker use by emergency physicians. Prior studies using ICD9 codes to identify eligible patients reported infrequent use of alpha-blockers for kidney stone. According to a national survey of kidney stone management in 2000, alpha-blockers were absent from a list of the 20 most frequently prescribed medications for urolithiasis [21]. In a national survey of claims data from 2000 to 2006, the overall prevalence for MET use was 2.5% [11]. A subsequent study using data from the National Hospital Ambulatory Medical Care Survey found that alpha-blockers were used in 14% of participants in the years 2007–2009 [3]. Our study, which defined eligibility for MET based on stone location and size on CT scan, suggests that alpha-blocker use is now widespread in academic emergency departments. It is unclear as to which factors explain this difference in the reported prevalence from prior studies, and this study. The results of this study, while unlikely to represent community practice, is likely to be internally valid, as we are able to accurately identify those who are actually eligible for MET based on criteria which mirror those of clinical trials.

We identified independent predictors of alpha-blocker use in eligible patients. The strongest predictor of underutilization is ED site, with substantial variation between the lowest and highest-using sites. This likely reflects the local practice of each ED faculty's practice patterns and beliefs regarding alpha-blocker efficacy. Especially striking is the pattern of alpha-blocker use in 5-10 mm distal ureteral stones (the subgroup of participants who would benefit the most from tamsulosin) in which we found that 2 sites did not prescribe any alpha-blocker, and 7 sites prescribed alpha-blockers in 100% of subjects. Based on recent clinical trial and meta-analysis data, we believe that patients with large ureteral stones should receive tamsulosin, unless the patient has a contraindication, such as pregnancy, an allergic reaction to alpha-blockers, previous alpha-blocker or beta-blocker use, postural hypotension, or need for immediate intervention. We believe that while most academic emergency physician practices frequently use MET, continuing education and awareness of the role of MET for a common ED problem would result in improved standardization and quality of care.

In summary, we report current patterns of alpha-blocker use by emergency physicians at 15 academic emergency department sites across the United States. The main agent that emergency physicians prescribed was tamsulosin, as opposed to other alpha-blockers, calcium channel blockers, or steroids. We found that alpha-blockers are frequently prescribed for patients diagnosed with ureteral stones on CT scan, which are indicated in large ureteral stones.

Funding/Support

This study was supported by funding from the Agency of Healthcare Research and Quality AHRQ Grant # K08 HS02181 (RCW) and a Multidisciplinary K12 Urologic Research Career Development Program, Grant # K12-DK-07-006 (TC).

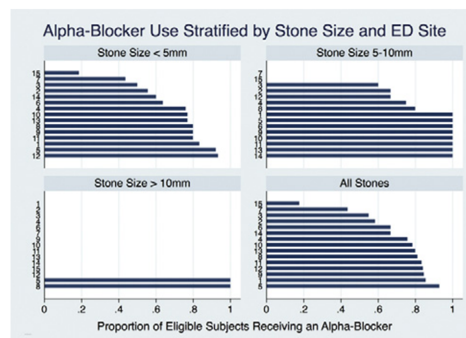
Conflict of interest

The authors declare no conflicts of interest.

Author contributions

Contributors: RCW conceived the work, collected data, performed data cleaning and statistical analysis, and drafted and critically revised the manuscript. NA participated in data analysis and manuscript revision. TC helped with study conception, design, participated in data collection and manuscript revision. MM participated in data collection, cleaning, analysis and manuscript revision. CM helped with study conception, design, participated in data collection and manuscript revision. SS helped to perform statistical analysis and manuscript revision. RSB helped with study conception, design, participated in data analysis and manuscript revision. All authors had full access to the data, take responsibility for the integrity of the data and have approved the manuscript. The data were collected, results analyzed, and the manuscript prepared without influence from funding agencies. RCW takes responsibility for the manuscript as a whole.

Appendix 1. Patient flow diagram



References

[1] Teichman JMH. Clinical practice. Acute renal colic from ureteral calculus. N Engl J Med Feb 12 2004;350(7):684–93.
[2] Brown J. Diagnostic and treatment patterns for renal colic in US emergency departments. Int Urol Nephrol Jan 1 2006;38(1):87–92.
[3] Fwu C-W, Eggers PW, Kimmel PL, Kusek JW, Kirkali Z. Emergency department visits, use of imaging, and drugs for urolithiasis have increased in the United States. Kidney Int Apr 2013;83(3):479–86.
[4] Hollingsworth JM, Rogers MAM, Kaufman SR, et al. Medical therapy to facilitate urinary stone passage: a meta-analysis. Lancet Sep 30 2006;368(9542):1171–9.
[5] Singh A, Alter HJ, Littlepage A. A systematic review of medical therapy to facilitate passage of ureteral calculi. Ann Emerg Med Nov 1 2007;50(5):552–63.
[6] Campschroer T, Zhu Y, Duijvesz D. Alpha-blockers as medical expulsive therapy for ureteral stones. Cochrane Database Syst Rev 2014.
[7] Preminger GM, Tiselius H-G, Assimos DG, et al. 2007 guideline for the management of ureteral calculi. J Urol Dec 1 2007;178(6):2418–34.
[8] Pickard R, Starr K, MacLennan G, Lam T, Thomas R. Medical expulsive therapy in adults with ureteric colic: a multicentre, randomised, placebo-controlled trial. Lancet 2015.
[9] Wang RC, Smith-Bindman R, Whitaker E, et al. Effect of tamsulosin on stone passage for ureteral stones: a systematic review and meta-analysis. Ann Emerg Med 2016.
[10] Hollingsworth JM, Canales BK, Rogers MA, et al. Alpha blockers for treatment of ureteric stones: systematic review and meta-analysis. BMJ Dec 01 2016;355:i6112.
[11] Hollingsworth JM, Wolf JS, Faerber GJ, Roberts WW, Dunn RL, Hollenbeck BK. Understanding the barriers to the dissemination of medical expulsive therapy. J Urol Oct 16 2010.
[12] Hollingsworth JM, Davis MM, West BT, Wolf JS, Hollenbeck BK. Trends in medical expulsive therapy use for urinary stone disease in U.S. emergency departments. Urology Dec 1 2009;74(6):1206–9.
[13] Picozzi SC, Marenghi C, Casellato S, Ricci C, Gaeta M, Carmignani L. Management of ureteral calculi and medical expulsive therapy in emergency departments. J Emerg Trauma Shock Jan 2011;4(1):70–6.
[14] Bensalah K, Pearle M, Lotan Y. Cost-effectiveness of medical expulsive therapy using alpha-blockers for the treatment of distal ureteral stones. Eur Urol Feb 1 2008;53(2):411–8.
[15] Scales CD, Smith AC, Hanley JM, Saigal CS, Project UDiA. Prevalence of kidney stones in the United States. Eur Urol Jul 2012;62(1):160–5.
[16] Foster G, Stocks C, Borofsky MS. STATISTICAL BRIEF #139; Jul 27 2012 1–10.

[17] Pearle MS, Calhoun EA, Curhan GC, Project UDoA. Urologic diseases in America project: urolithiasis. J Urol Mar 1 2005;173(3):848–57.
[18] Litwin MSSC. Economic impact of urologic disease [internet]. Urologic Diseases in America. Washington D.C.: U.S. Department of Health and Human Services; 2012. p. 463–96.
[19] Smith-Bindman R, Aubin C, Bailitz J, et al. Ultrasonography versus computed tomography for suspected nephrolithiasis. N Engl J Med Sep 18 2014;371(12):1100–10.
[20] Valencia V, Moghadassi M, Kriesel DR, Cummings S, Smith-Bindman R. Study of tomography of nephrolithiasis evaluation (STONE): methodology, approach and rationale. Contemp Clin Trials May 2014;38(1):92–101.
[21] Brown J. Diagnostic and treatment patterns for renal colic in US emergency departments. Int Urol Nephrol 2006;38(1):87–92.
[22] Furyk JS, Chu K, Banks C, et al. Distal ureteric stones and tamsulosin: a double-blind, placebo-controlled, randomized, multicenter trial. Ann Emerg Med Jul 13 2015.