Renal colic imaging practice patterns in Ontario: A population-based study

Danielle Jenkins[1], Greg Hosier[1], Marlo Whitehead[2], Jonas Shellenberger[2], Thomas McGregor[1], D. Robert Siemens[1]

[1]Department of Urology, Queen's University, Kingston, ON, Canada; [2]ICES-Queen's, Queen's University, Kingston, ON, Canada

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Corresponding author: Dr. Danielle Jenkins, Department of Urology, Queen's University, Kingston, ON, Canada; danielle.jenkins@queensu.ca

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ABSTRACT

Introduction: Computed tomography (CT) scans are associated with increased cost and exposure to radiation when compared to ultrasound (US) in patients presenting with renal colic. Consequently, a Choosing Wisely recommendation from 2014 states that US should be used over CT in uncomplicated presentations of renal colic in patients under the age of 50. The objective of this study was to describe imaging practice patterns in Ontario among patients presenting with renal colic and the relationship between initial imaging modality, subsequent imaging, and burden of care indicators.

Methods: This is a population-based study of patients who presented with renal colic in Ontario between 2003 and 2019 using administrative data. Patients were assessed according to the first imaging modality they had during their index visit. Descriptive statistics and the Chi-squared test were used to examine differences between these groups. The primary outcome was the need for subsequent imaging. Secondary outcomes included length of renal colic episode, days to surgery, number of emergency department visits, and number of primary care visits during the renal colic

episode. To identify the factors associated with outcomes, both univariate and multivariable logistic regression models were used.
Results: A total of 429 060 patients were included in the final analysis. Of those, 50.5% (216 747) had a CT scan as their initial imaging modality, 20% (84 672) had an US, and 3% (13 643) had both a CT and an US on the same day. Subsequent imaging was obtained in 40.7% of those who had a CT scan as the initial imaging, compared to 43% in those who had an US and 43% who had both an US at CT on the same day. Of those who initially had an US, 38% went on to have at least one CT scan during their renal colic episode, including those who had a CT on the same day as the initial US, while 62% were able to avoid a CT scan altogether. In contrast, 17% had a repeat CT after an initial CT at the time of presentation. The overall use of US increased from 15% to 31% during the study period. The length of the renal colic episode was slightly longer in those who had a CT first compared to US in multivariable models (ARR 1.005, 95% confidence interval [CI] 1.000–1.009); however, the time to surgery was less in those who had a CT first (ARR 0.831, 95% CI 0.807–0.856). Fewer emergency department and family physician visits were seen in those who had an initial CT.
Conclusions: In patients presenting with renal colic in Ontario, approximately half are having a CT done as the initial imaging modality despite US being the recommended imaging modality in uncomplicated renal colic presentations. While US use remains low, its use doubled during this study period, demonstrating an encouraging trend. Those who have an US done first are often able to avoid subsequent CT scans. Efforts should be made to further promote the use of US in those presenting with renal colic rather than CT when clinically indicated.

INTRODUCTION

Patients with nephrolithiasis have been shown to be at risk for increased radiation exposure over the course of their lifetime (1). These patients, who frequently have recurrent presentations, are often subjected to serial CT scans with potentially high cumulative effective doses (2). Given the long-term impact of cumulative radiation dosing, finding ways to lessen this exposure is an important endeavour for providers caring for these patients. This has prompted many to suggest that ultrasound (US) should be used as the imaging modality of choice for patients with renal colic. In 2014, a large, multicenter comparative effectiveness trial reported that initial US was associated with lower cumulative radiation exposure than initial CT, without differences in high-risk diagnosis, serious adverse events, pain scores, return to emergency department visits, or hospitalizations (3).

Several organizations and associations have published statements pertaining to the imaging modality used during renal colic presentations. In 2014, Choosing Wisely recommended

that providers avoid ordering CT scans in otherwise healthy patients age <50 presenting to the emergency department (ED) with symptoms consistent with uncomplicated renal colic (4). Similarly, the Canadian Urology Association (CUA) Guideline for the management of ureteral calculi recommends that US with KUB X-ray be considered the initial modality of choice for acute ureteral stones (5). Furthermore, The European Association of Urology (EAU) Guideline states that US should be used as the primary diagnostic imaging tool given that it is safe (no risk of radiation), reproducible, and inexpensive, however does specify that a non-contrast CT be used to confirm stone diagnosis in patients with acute flank pain (6). In contrast, the American Urology Association (AUA) released clinical effectiveness protocols in the management of ureteral calculi in 2012 which states that a non-contrast CT is the preferred initial imaging study for the index patient (7). In keeping with most of these recommendations, a recent systematic review with multispecialty consensus concluded that CT may be avoided in many common clinical scenarios when uncomplicated renal colic is suspected (8).

Despite these recommendations and guidelines, studies have shown that the use of CT during renal colic visits remains high, with some evidence that use is in fact increasing. In the United States of America (USA), Hyams et al. reported that CT utilization had increased from 19.6% in 2000 to 45.5% in 2008 (9). More recently, from 2007 to 2015, a study from USA showed that the use of CT remained stable at 85.8%, while the use of US increased from 2.7 to 6.9% (10). A large retrospective study in the USA found similar rates of CT use in patients presenting to the ED with renal colic at 82.6% (11). In Canada, it was reported that 37% of those under the age of 50 presenting with uncomplicated renal colic received unnecessary CT. Following a quality improvement project, this number improved modestly to 29% (12). Even with the high utilization of CT scans, evidence does not suggest it is associated with improved patient outcomes (3, 13). The objective of our study was to describe imaging practice patterns in Ontario among patients presenting with renal colic and the relationship between initial imaging modality, subsequent imaging, and burden of care indicators. To the best of our knowledge, this is the first large scale population study assessing the impact of initial imaging modality on the need for subsequent imaging and burden of care indicators.

METHODS

Study design

This is a retrospective, population-based cohort study of all patients diagnosed with renal colic in Ontario between 2003 and 2019 using linked administrative databases. Patient cohorts were divided into three groups representing the initial imaging modality obtained during the index visit of the renal colic episode (CT, US, or CT + US). The only exclusion for this dataset was if the patients had a renal colic or urolithiasis diagnosis in the past year in order to ensure an index colic event. This study was approved by the Queen's University Health Sciences and Affiliated

Hospitals Research Ethics Board. All data were fully anonymized before accessing them and requirement for informed consent was waived.

Data source
Linked administrative databases were accessed through the Institute for Clinical Evaluation Sciences (ICES). ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. These databases (National Ambulatory Care Reporting System, Discharge Abstract Database, and Ontario Health Insurance Plan) capture all family practitioner visits, emergency department visits, specialist clinic visits, inpatient stays, and procedures. These databases are routinely used for research purposes and has been previously validated. The datasets were linked using unique encoded identifiers and analyzed at ICES. The codes used in this study have been previously published in a similar dataset, although this analysis was expanded to include all renal colic patients with a renal colic diagnosis between 2003 and 2019. [14] The study team accessed the dataset between August 2021 and February 2022.

Covariates
Covariates used for the adjusted models were determined a priori and conceptualized as patient-related confounding variables such as age, sex, median community income, region of residence, and comorbidities (Charlson index). Furthermore, as an assessment of the severity or complexity of the original colic episode, other covariates included total duration of the renal colic episode, days until surgery, and number of emergency department and primary care visits during their renal colic episode. Given that the time for stone passage varies, the duration of the acute stone event was estimated to be the date of index urolithiasis diagnosis plus 30 days after the last urolithiasis visit or 30 days after any urologic procedure for management for urolithiasis.

Outcomes
The primary outcome was the need for subsequent imaging during the renal colic episode. Secondary outcomes included length of renal colic episode, days to surgery, number of emergency department visits, and number of primary care visits during the renal colic episode.

Statistics
Descriptive statistics (ratios) were used for demographic and baseline characteristics and the Chi-square test was used to compare proportions between groups. To identify the factors associated with the co-primary outcomes, both univariate and multivariable logistic regression models were used. All patient-related and care-related variables included in the original models are noted. A two-sided p-value of <0.05 was considered statistically significant. As per institutional policy, cells with <6 patients were not reported due to privacy concerns. Data were analysed using SAS Stat. 14.3.

RESULTS

A total of 429,060 patients were included in the analysis. Baseline characteristics are described in Table 1. Only 1% of patients had surgery for renal colic in the past 6 years. Approximately half of patients (n=216,747, 50.5%) had a CT during the index visit, while 84,672 (19.7%) had an US, and 13,643 (3.2%) had both an US and a CT on the same day. A kidney, ureter, bladder X-ray (KUB) alone was obtained in 58,688 (14%) of patients. There were 47,941 (11.2%) patients who had no imaging during their index visit. Those that had a CT as a first imaging modality were older median (IQR) 57 (45-69), compared to those that had an US first 42 (30-59). As well, those that had a CT were more likely to be male (mean 56.5 ± SD 15.6) compared to US (44.87 ± 18.81).

In those who initially had a CT, 39.6% underwent subsequent imaging, compared to slightly higher numbers in those who initially had an US (42.2%) and an US and CT on the same day (41.2%). When an US was used as the initial imaging modality, 78.1% of patients were able to avoid a CT during their entire renal colic episode. (Table 2) Interestingly, there was a difference in the initial modality used and need for surgery. For those that had a CT as initial imaging 29% received surgery in follow-up compared to 22% who had an ultrasound and 31% who had both on the same day ($p<0.001$). This likely suggests that those that received CT may have had more typical and perhaps more severe symptoms of renal colic compared to those that did not.

When this data was examined over time, there was increase in CT utilization that increased from 49.1% between 2003 and 2008 to 56.6% between 2015 and 2019. Interestingly, the use of US doubled over the same periods from 14.7% to 31.0%, perhaps demonstrating an encouraging trend. Those who had no imaging during their index visit decreased from 13.4% to 8.5%. (Table 3)

In the adjusted model, compared to US, those who initially had a CT had a shorter time to surgery (adjusted risk ratio (ARR) 0.882, CI 0.859-0.906), fewer ED visits (ARR 0.896, CI 0.883-0.910), and fewer visits to the primary care provider (ARR 0.959, CI 0.949-0.969). (Table 4)

DISCUSSION

In this study, we found that over half of patients presenting with renal colic in Ontario are having a CT performed during their index renal colic visit. An increase in CT utilization over time was observed, however this also corresponded to a 2-fold increase in US use and instead a decrease in patients receiving no imaging. Finally, while US as the initial imaging modality did lead to decreased CT utilization, this was associated with an impact on other health care outcomes.

The high use of CT as the initial imaging modality is consistent with previous studies that have reported high use of CT despite recommendations from guidelines. Understanding provider reluctance to use US as the initial imaging modality in uncomplicated renal colic is an important

step in improving adherence to guidelines. A survey of emergency physician knowledge, attitudes, and behaviours regarding the Choosing Wisely recommendation found that concern for a serious diagnosis was the most frequently reported reason for performing at CT for recurrent, uncomplicated renal colic (15). This highlights a fear of missing an alternative diagnosis that may be found with CT. However, studies have shown that patients assessed with an US at initial presentation have no statistically significant differences in high-risk diagnosis. Instead, a low-dose unenhanced CT in the ED detects an alternative diagnosis in 6% of patients with suspected uncomplicated renal colic, with only half of those subsequently requiring hospitalizations (16).

It is important to note the limitations of US, and how these may factor into the decision-making process for providers. Specifically, US can be difficult in patients with obesity, offers poor visualization of the mid ureter, and has a limited ability to detect stones <5mm (17). Additionally, access to US after hours varies greatly from one institution to another. Many hospitals do not have access to an US technician overnight therefore limiting access to imaging during these hours to a CT. Patients who presented overnight may have had a CT when an US would have been preferred, if available.

It is worth highlighting that this study does not capture the use of point-of-care ultrasound (POCUS). This bedside imaging modality is used by a growing number of primary physicians, particularly those working in emergency departments. If performed and no concerning findings are seen, particularly in patients with a reassuring clinical presentation, subsequent imaging may be omitted. This may, in part, explain the 11% of patients who had no formal imaging done during their index visit.

Some of these findings may be confounded with the patient's presentation. For example, patients who have a more concerning clinical presentation are more likely to get a CT and are more likely to require urgent intervention. If a large proportion of patients presented with severe symptoms, this could justify the high use of CT, and explain the shorter time to surgery in this cohort. Indeed, there was a difference in the initial imaging modality documeted and the need for eventual surgery. For those that had a CT as initial imaging 29% received surgery in follow-up compared to 22% who had an ultrasound and 31% who had both on the same day. This suggests that those that received CT may have had more typical and perhaps more severe symptoms of renal colic compared to those that did not and explaining some of the differential results.

This study highlights the need for increased education for physicians, primarily those working in emergency departments and family physicians, to emphasize to use of US as the initial imaging modality in uncomplicated renal colic presentations. These patients are at risk for repeat presentations which is associated with high ionized radiation exposure over a lifetime. Once a patient is referred to a urologist, or there are any complicating factors, we recognize that a CT is largely the preferred imaging of choice.

One of the main strengths of this study is the large population representing routine care of patients presenting with renal colic in Ontario using a rich data source of inpatient and outpatient

care. However, no clinically relevant information of the renal colic presentation is available which limits the ability to assess the clinical context in which the imaging was ordered, and how this might impact practice patterns. Our definition of the acute colic episode, 30 days beyond the last clinical visit for colic or stone surgery, was arbitrary and perhaps a longer look forward at imaging after this timeframe may have led to more imaging events. Additional limitations include those associated with retrospective, observational studies. Furthermore, as previously discussed, the fact that this data set does not capture the use of point-of-care ultrasound (POCUS) used by emergency physicians which, when performed, may influence the use of subsequent imaging. It is also possible that unmeasured confounders are present in the models of health care utilization.

CONCLUSIONS

In patients presenting with renal colic, approximately half are having a CT done as the initial imaging modality despite evidence that US is safe and effective in patients presenting with uncomplicated renal colic presentations. While US use remains relatively low, its utilization doubled during this study period, demonstrating an encouraging trend. Those who have an US done first are often able to avoid subsequent CT scans, however, impacts on other health care resources and outcomes were noted. Efforts should be made to encourage the use of evidence-based practice with the use of US in those presenting with renal colic rather than CT when clinically indicated.

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FIGURES AND TABLES

Table 1. Baseline characteristics of patients with renal colic in Ontario between 2003 and 2019	
	All patients
	N=429 060
Age at index renal colic	
0–18	7432 (2%)
19–39	113 936 (27%)
40–59	192 036 (45%)
60–79	101 479 (24%)
80+	14 177 (3%)
Sex	
Female	166 074 (39%)
Male	262 986 (61%)
Neighbourhood income quintile	1369 (0%)
1 (low)	82 731 (19%)
2	86 536 (20%)
3	86 552 (20%)
4	88 566 (21%)
5 (high)	83 306 (19%)
Charlson Index	
0	398 992 (93%)
1–2	22 244 (5%)
3+	7824 (2%)
Enrolled with a family practice	312 582 (73%)
History of stone surgery 1–6 years pre index	4352 (1%)
# days in renal colic episode	
<60	348 846 (81%)
60+	80 214 (19%)
# ED visits during acute renal colic episode	
0	305 199 (71%)
1	87 978 (21%)
2	23 772 (6%)
>2	12 111 (3%)
# PCP visits during acute renal colic episode	
0	206 462 (48%)
1	127 361 (30%)
2	55 891 (13%)

>2	41 346 (10%)
Had surgery (within 180 days of index renal colic episode)	135 767 (32%)
Time to surgery from index visit	
No surgery	293 293 (68%)
<30	106 841 (25%)
30+	28 926 (7%)

ED: emergency department; PCP: primary care physician.

Table 2. Subsequent imaging during renal colic episode by initial imaging modality

	CT	**US**	**US & CT on the same day**
	n=216 747	**n=84 672**	**n=13 643**
# subsequent CT			
0	194 650 (90%)	66 095 (78%)	12 186 (89%)
1	19 722 (9%)	16 931 (20%)	1302 (10%)
2	2027 (1%)	1465 (2%)	129 (1%)
>2	348 (0.2%)	181 (0.2%)	26 (0.2%)
# subsequent US			
0	179 538 (83%)	69 281 (82%)	10 880 (80%)
1	32 200 (15%)	12 701 (15%)	2345 (17%)
2	4224 (2%)	2020 (2%)	335 (3%)
>2	785 (0.4%)	670 (0.8%)	83 (0.6%)
# subsequent AXR			
0	162 290 (75%)	68 896 (82%)	10 266 (75%)
1	35 001 (16%)	10 764 (13%)	2278 (17%)
2	11 805 (6%)	2945 (4%)	695 (5%)
>2	7651 (4%)	2067 (2%)	404 (3%)
# subsequent imaging test			
0	130 822 (60%)	48 964 (58%)	7931 (58%)
1	46 823 (22%)	19 823 (23%)	3235 (24%)
2	22 000 (10%)	8860 (11%)	1410 (10%)
>2	17 102 (8%)	7025 (8%)	1067 (8%)
Index imaging without subsequent imaging	130 822 (60%)	48 964 (58%)	7931 (58%)

Index imaging with subsequent imaging	85 925 (40%)	35 708 (42%)	5712 (4%)

AXR: abdominal X-ray; CT: computed tomography; US: ultrasound.

Table 3. Index imaging for renal colic presentation per era			
	2003–2008	**2009–2014**	**2015–2019**
	n=146 310	**n=150 847**	**n=131 903**
Index imaging included CT	71 820 (49%)	83 870 (56%)	74 700 (57%)
Index imaging included US	21 565 (15%)	35 848 (24%)	40 902 (31%)
No index imaging	19 637 (13%)	17 146 (11%)	11 158 (8%)
Other imaging (AXR, IVP)	54 853 (23%)	13 983 (9%)	5143 (4%)

AXR: abdominal X-ray; CT: computed tomography; IVP: intravenous pyelogram; US: ultrasound

Table 4. Adjusted models of burden of care indicators for renal colic			
	Comparison	**ARR (95% CI)**	**p**
Length of renal colic episode	CT vs. US	1.01 (1.00–1.01)	<0.0001
Days to surgery	CT vs. US	0.88 (0.86–0.91)	<0.0001
# ED visits between index date and end of renal colic episode	CT vs. US	0.90 (0.88–0.91)	<0.0001
# PCP visits between index date and end of renal colic episode	CT vs. US	0.96 (0.95–0.97)	<0.0001

Adjusted for age, sex, median community income, region of residence, Charlson comorbidity.
ARR: adjusted risk ratio; CT: computed tomography; ED: emergency department; PCP: primary care provider