JACOBS PUBLISHERS

OPEN ACCESS

Jacobs Journal of Medical Diagnosis and Medical Imaging

Research Article

CT Classification of Ureteral Calculi Parameters for Predicting Ureteroscopy Complications

Nathan Edward Hale[1*], Samuel Deem[1], Joshua Lohri[1]

[1]*Charleston Area Medical Center, USA*

**Corresponding author: Dr. Nathan Edward Hale, 3110 MacCorkle Ave SE Charleston, WV 25304, USA, Tel: 304-388-9947;*

Email: nhale@camc.org

Received: 04-29-2015

Accepted: 06-03-2015

Published: 06-16-2015

Abstract

Purpose: The primary objective was to determine if there was a pattern of computed tomography (CT) imaging characteristics that could predict complications and outcomes from ureteroscopy for removal of ureteral calculi.

Materials and Methods: A retrospective analysis of CT scan parameters on two-hundred-fifty subjects that had previously undergone ureteroscopy for treatment of ureteral calculi. Ninety-eight patients met the inclusion criteria and were subsuquently included in final analyses.

Results: Stone size greater than 0.67 centimeters and location in the proximal ureter were found to be statistically significant in predicting complications. When individualizing operative complications with stone characteristics, a stone density of 817 Hounsfield units (HU) or greater, stone size of 0.79 centimeters or greater, and operative time greater than 53 minutes all showed statistical significance for the presence of hematuria. Based on multivariate logistic regression, stones in the proximal 1/3 of the ureter were more likely to get complications than stones located in the middle and lower ureter with a hazard ratio of 4.3.

Conclusion: Pre-operative CT scan parameters can be a valuable asset in predicting intra-operative and post-operative complications. Stone size, location, and density appear to be independent risk factors for predicting operative ureteroscopic complications. CT scan interpretation in the pre-surgical setting is a vital tool in assessing risk and preventing complications related to the treatment of ureterolithiasis using URS.

Introduction

Unenhanced computed tomographic (CT) scan is the imaging of choice for the diagnosis of urolithiasis with reported sensitivity and specificity approaching 100%. [1, 2] The two most important factors that guide clinical management are stone size and its location. [3] Precise interpretation of the CT scan is crucial while counseling the patient and selecting the appropriate treatment strategy. Ureteroscopy (URS) has been used for treatment of ureteral calculi since the late 1970’s. Improvements in equipment and surgeon skill have improved both the safety of URS and its frequency of use. According to the American Urological Association ureteral stone treatment guidelines, the usage of URS is considered a first line treatment for the management of ureteral calculi. URS is useful for scenarios including uncontrollable pain, or when rapid treatment is needed [3].

Various CT parameters have been examined to predict stone free rates following URS. Stone size, location, and degree of hydronephrosis were statistically significant factors in multivariate analysis in predicting stone free rates following URS. [4] Although URS is a versatile and frequently used procedure, currently, data about the relationship between preoperative CT imaging and associated ureteroscopic complications is limited. The primary objective in the present study is to determine if there was a pattern of computed tomography (CT) imaging characteristics that could predict complications and outcomes from URS for removal of ureteral calculi.

Material and Methods

A retrospective study of data from patients who underwent URS was approved by the institutional review board. Inclusion criteria for the study were patients who have been diagnosed with ureteral calculi who have failed a trial of spontaneous passage or who meet criteria for URS for the treatment of ureteral calculi. Patient's data from January 2003 to September 2010 was retrieved from our institution's data warehouse based on ICD 9 code for URS after a CT diagnosis of ureteral calculi. Charts were obtained on 250 patients who had undergone URS for treatment of a ureteral stone. Of these patients, 98 eligible patients who had CT diagnosed ureteral stone within 30 days of URS were included in the final analysis.

Data included CT findings prior to URS regarding stone size, stone density, stone location in ureter, and presence or absence of hydroureter proximal to the stone. Additional data was collected on the need for intraoperative ureteral dilatation, stone composition of the stone fragment, all minor and major complications, time of procedure, and any intraoperative difficulties including placement of ureteral stent. Any acute complications occurring within 30 days of the original procedure were also recorded. Patients were identified with at least one complication and then they were divided into two groups: with and without any complications. Risk factors for any complications were found by comparing variables between these two groups.

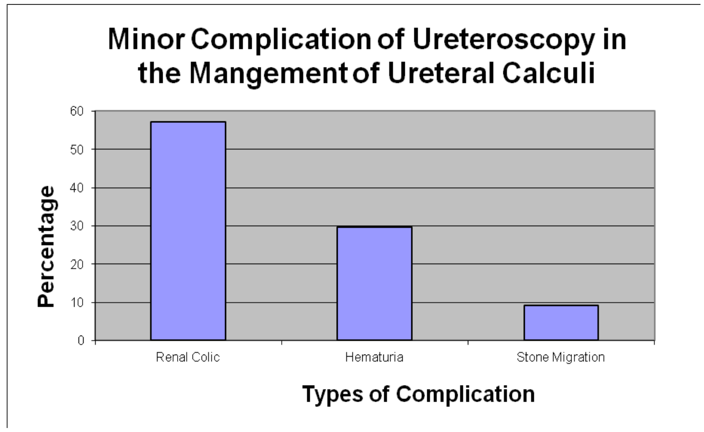
Descriptive statistics was done. Continuous data was compared between two groups by two sample t-test and categorical data was compared by chi-square or fisher's exact test as appropriate. Multivariate logistic regression was done to find predictors of any complication.

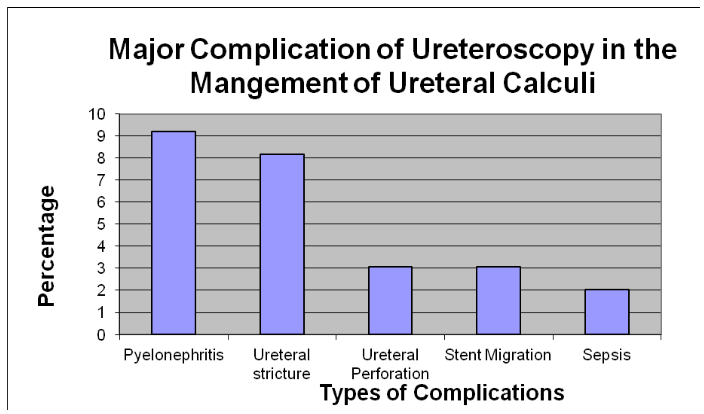
Results

Ninety eight (98) patients had URS done within 30 days of CT scan. The mean age was 49 years (Range= 11 to 87). In all, 45.6 % of patients were male. Some of the major co-morbidities at admission included diabetes (13%), Coronary artery disease (10%), hyperlipidemia (17%) and hypertension (41%).

Each patient was classified into different complication categories as described in Figure 1a & 1b. We divided the patient's complications into major and minor complications. The most frequent complications were defined as minor complications with the two most common being renal colic (57%) and hematuria (28%). Major complications including pyelonephritis, ureteral stricture; ureteral perforation etc. comprised less than 10% of the complications. There were 76 (77.55%) patients who had at least one of the above listed complications.

Figure 1a &1b: Types and rates of ureteroscopy complications for the management of ureteral calculus





We compared the 76 patients with at least one complication with rest of the 22 patients with neither of any complication. The two groups were statistically similar with respect to their age, gender, weight, height and co-morbidities except hypertension (Table 1). There were significantly higher (46.05%) hypertensive patients in complications group than non-complication group (22.73%) (p= 0.0500).

CT classification of ureteral calculi parameters between the two groups were compared (Table 2). Stone size was found to be significantly higher in patients with complications (p=0.0195) and stone location in the upper 1/3 of the ureter was statically significant with respect to predicting complications (p=0.0102). Need for intra-operative ureteral dilatation, operative time and placement of ureteral stent were found to be marginally significant with P-values less than 0.1.

Table 1: Demographics of patient who underwent ureteroscopy for the treatment of a ureteral calculus

	Patients with complications (N=76)	Patients without complications (N=22)	P-value	Odds ratio (95% CI)
Age	48.43+/-15.71(11-84)	52.59+/-21.90(16-87)	0.4135	0.986(0.959-1.014)
Gender (Male)	35(46.05%)	10(45.45%)	0.9605	0.976(0.377-2.531)
Weight	90.67+/-29.05(12-208)	85.27+/-23.16(47-134)	0.4256	1.008(0.989-1.026)
Height	168.2+/-9.79(140-190)	163.2+/-13.61(132-182)	0.1197	1.043(0.998-1.090)
Co-morbidities				
DM	10(13.16%)	3(13.64%)	>0.999	0.959(0.240-3.841)
CHF	2(2.63%)	1(4.55%)	0.5378	0.753(0.221-2.563)
COPD	4(5.26%)	1(4.55%)	>0.999	1.053(0.498-2.225)
CAD	6(7.89%)	4(18.18%)	0.2248	0.788(0.560-1.109)
PVD	1(1.32%)	2(9.09%)	0.1256	0.668(0.409-1.091)
Hyperlipidemia	16(21.05%)	1(4.55%)	0.1084	1.333(0.942-1.885)
Hypertension	35(46.05%)	5(22.73%)	0.0500*	1.164(0.996-1.361)
*- Statistically significant at level of significance of 0.05				

Table 2: Patient's characteristics with respect to Ureteral Calculi Parameters

	Patients with complications (N=76)	Patients without complications (N=22)	P-value	Odds ratio (95% CI)
Need for Intra-op Ureteral Dilation	50(76.92%)	12(57.14%)	0.0789	2.500(0.884-7.067)
Hydroureter proximal to the stone (present)	44(72.13%)	14(66.67%)	0.6350	0.773(0.266-2.244)
Stone density	719.7+/-283.0(300-1350)	612.3+/-234.5(350-1110)	0.1144	1.002(1.000-1.004)
Stone size	0.67+/-0.23(0.3-1.2)	0.55+/-0.16(0.3-1)	0.0195*	19.922(1.488-266.707)
Stone location				
Upper	41(54.67%)	5(23.81%)	0.0102*	0.455(0.257-0.805)
Middle	5(6.67%)	0		
Lower	29(38.67%)	16(76.19%)		
Stone Composition				
Calcium	72(94.74%)	20(90.91%)	0.6139	1.800(0.307-10.549)
Uric Acid	1(1.32%)	0	>0.999	N.A.
Struvite	3(3.95%)	0	>0.999	N.A.
Cystine	0	0	N.A.	N.A.
Operative Time(Min)	47.82+/-25.39(17-137)	37.72+/-21.81(9-96)	0.0938	1.023(0.996-1.051)
Placement of Ureteral stent	74(97.37%)	19(86.36%)	0.0732	5.841(0.910-37.475)
Intra-op difficulties				
Bleeding	3(3.95%)	0	>0.999	N.A.
Perforation	2(2.63%)	0	>0.999	N.A.
Vascular Injury	0	0	N.A.	N.A.
*- Statistically significant at level of significance of 0.05				

Individual analysis based on the type of complication revealed that stone density is an important factor in predicting major complications and hematuria in addition to stone size and location stone density. Specific complications like hematuria (n=27) and stone migration (n=9) were examined individually. Stone density greater than 800 HF units, stone size greater than 8 mm, and operative time longer than 53 minutes were independent risk factors for hematuria. Whereas more proximal ureteral calculi were more likely to have advanced operative time greater than 77 minutes and stone migration.

Table 3: Multivariate Logistic Regression

	P-value	Odds ratio	95% Wald Confidence Limits
Stone location (Upper)	0.0114	4.320	1.391-13.420

Based on multivariate logistic regression for predicting any ureteroscopic complication, stones in the proximal 1/3 of the ureter were more likely to experience a complication than stones in the middle or lower ureter with a hazard ratio of 4.3 (Table 3) (p=0.0114, CI=1.39-13.42).

Discussion

Because of its accuracy and rapid acquisition time, unenhanced CT scan has now become the gold standard for the evaluation of urolithiasis.[5] It provides information regarding location, density, and size of the stone. In addition, degree of obstruction caused by the stone can also observed. Each of these parameters can be useful when selecting the most appropriate management of ureteric stones.[6] Developing the ability to use these parameters to predict intra-operative and post-operative complication will improve the safety and quality of ureteroscopic treatment of ureteral calculi.

Because URS is highly successful, it has become a common treatment modality in the management of ureterolithiasis. Technological advances in ureteroscopy have led to an improved rate of major complications. Prior studies have identified the overall rate and type of complications commonly encountered during ureteroscopy. The most commonly recognized intraoperative ureteroscopic complications include excessive bleeding from ureteral manipulation, ureteral perforation, ureteral avulsion, stone migration, or stone extrusion. [7-9] Post-operative complications may also be evident such as renal colic, stone granuloma, sepsis, vesicoureteral reflux, stent migration, persistent hematuria, or ureteral stricture. [8-10].

Previously, several parameters have been considered in prospective analysis in regards to intraoperative complications during semi-rigid URS. Fuganti et al investigated potential factors predictive of ureteroscopic complications in the treatment of ureteral calculi. They analyzed 1235 URS cases with emphasis on patient age, gender, length of symptoms, previous ESWL, associated urinary tract infection, stone location and degree of hydronephrosis. At the conclusion of the study, the overall complication rate was 4.4 percent. [11] A total of eight ureteral perforations, 5 paraureteral stones, 3 ureteral avulsions, 5 mucosal eversions, 1 urethral injury and 34 mucosal tears occurred. It was found that larger stone size, more proximally located stones, and patients with previous ESWL were statistically significant in terms of preoperative predictors of intra-operative ureteroscopic complications. Additional research by Abdelrahim et al reviewed in the 2008 Journal of Endourology concluded similar data in regards to predictive ureteroscopic complications. Factors associated with increased adverse events included symptomatology greater than 3 months, previous ureteral surgery, stones >5mm, dilated proximal ureter, decreased renal excretory function, stones above the ischial spines, and involvement of a more junior urologist. [12] To our knowledge, no one has reviewed the CT characteristics of ureteral calculi in both complicated and routine URS cases. Certain factors that can be reviewed on CT prior to treatment planning may allow urologists to avoid potential complications by not performing complicated procedures unless experienced to do so.

Our data indicate an overall complication rate of 77.5 percent. The majority of complications were minor such as renal colic and hematuria which required no further treatment outside of the usual standard of care. Renal colic although being a more common complaint did not show any direct correlation to CT scan parameters. For this reason we can conclude that most patients undergoing ureteroscopy will likely have some degree of renal colic irrespective of stone size, location, density, or stone composition without predictive parameters to determine in which patients it will occur. Hematuria associated with ureteroscopy can occur in varying degrees; however, one is usually able to complete the procedure without significant visual impairment. Abdel-Razzak and Bagley reported that in approximately 2% of cases bleeding was so severe that vision was impaired to a degree that termination of the operation was necessary. 5 Such bleeding can be secondary to vascular injury of the crossing vessels at the ureteropelvic or ureterovesicular junction or an intrarenal artery at an infundibulum. [6] Stone density greater than 800 HF units, stone size greater than 8 mm, and operative time longer than 53 minutes were independent risk factors for hematuria in this study.

The major complication rate was consistent with prior studies in which ureteral avulsion was less than one percent, ureteral perforation eight percent, and excessive bleeding two percent. [4] This data indicate similar findings compared to Fuganti et al in which larger, more proximal stones were more predictive of complications. Pre-operative CT scan parameters is a valuable asset in predicting intra-operative and post-operative complications. CT findings of stones greater than or equal to 0.67 centimeters and more proximal ureteral stones appear to be independent risk factors for predicting intra-operative and/or post-operative ureteroscopic complications. Stone density greater than 800 hounsfield units was predictive of major complications. These parameters can be used in the pre-surgical setting to help the urologist assess the risks and avoid complications by increased awareness. Recognizing these parameters may help reduce the morbidity in patients undergoing ureteroscopy. In addition, the urologist can provide better informed consent to the patient with complication rates more specific to the patients preoperative CT findings.

Limitations to our study include its retrospective nature and small sample size which may introduce bias in the results. To avoid any possible bias, further research will be necessary to confirm results in a multi-institutional study.

Conclusion

Pre-operative CT scan parameters can be a valuable asset in predicting intra-operative and post-operative complications. CT findings of stones greater than or equal to 0.67 centimeters and more proximal ureteral stones appear to be independent risk factors for predicting intra-operative and/or post-operative ureteroscopic complications. CT scan interpretation in the pre-surgical setting is a vital tool in assessing risk and preventing complications related to the treatment of ureterolithiasis using ureteroscopy.

Conflict of Interest: The authors declare that they have no conflict of interest.

References

1. Smith RC, Verga M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain: value of unenhanced helical CT. AJR Am J Roentgenol. 1996, 166(1): 97-101.

2. Sourtzis S, Thibeau JF, Damry N et al. Radiologic investigation of renal colic: unenhanced helical CT compared with excretory urography. AJR Am J Roentgenol. 1999, 172(6): 1491-1494.

3. Preminger GM, Tiselius HG, Assimos DG et al. EAU/AUA Nephrolithiasis Guideline Panel. guidelines for the management of ureteral calculi. J Urol. 2007, 178: 2418-2434.

4. Molina WR, Kim FK, Spendlove J et al. The S.T.O.N.E score: a new assessment tool to predict stone free rates in ureteroscopy from pre-operative radiological features. IBJU . 2014, 40(1): 23-29.

5. Nazim SM, Ather MH, Khan N. Measurement of ureteric stone diameter in different planes on multidetector computed tomography – Impact on the clinical decision making. Urol. 2014, 83(2): 288-292.

6. Coll DM, Varanelli MJ, Smith RC. Relationship of spontaneous passage of ureteral calculi to stone size and location as revealed by unenhanced helical CT. AJR Am J Reentgenol. 2002, 178(1): 101-103.

7. Hoffman R. Ureteroscopy (URS) for ureteric calculi. Urologe A. 2006, 45(5):W637-646,quiz W647.

8. Geavlete P, Georgescu D, Nita G, Mirciulescu V, Cauni V. Com-

plications of 2735 retrograde semirigid ureteroscopy procedures: a single center experience. J Endourol . 2006, 20(3): 179-185.

9. Semins MJ, Matlaga BR. Complications of ureteroscopy. American Urological Association Update Series (2008) Volume 27: Lesson 27.5. Abdel-Razzak OM, Bagley DH. Clinical experience with flexible ureteropyeloscopy. J Urol 1992, 148: 788.

10. Johnson DB, Pearle MS. Complications of ureteroscopy. Urol Clin North Am. 2004, 31(1): 157-171.

11. Fuganti PE, Pires S, Branco R, Porto J. Predictive factors for intraoperative complications in semirigid ureteroscopy: analysis of 1235 ballistic ureterolithotripsies. Urology. 2008,72(4): 770-774.

12. Abdelrahim AF, Abdelmaguid A, Abuzeid H, Amin M, Mousa el-S et al. Rigid Ureteroscopy for ureteral stones:factors associated with intraoperative adverse events. J Endourol. 2008, 22(2): 277-280.