Original Paper

Current Urology

Curr Urol 2018;12:195–200
DOI: 10.1159/000499306

Received: January 26, 2018
Accepted: May 9, 2018
Published online: July 20, 2019

# Factors Predicting Operating Room Time in Ureteroscopy and Ureterorenoscopy

Ioannis Katafigiotis[a,b] Itay M. Sabler[a] Eliyahu M. Heifetz[c] Ayman Isid[a]
Stavros Sfoungaristos[a,d] Amitay Lorber[a] Vladimir Yutkin[a] Guy Hidas[a]
Arie Latke[a] Ezekiel H. Landau[a] Dov Pode[a] Ofer N. Gofrit[a] Mordechai Duvdevani[a]

[a]Department of Urology, Hadassah Hebrew University Medical Center, Jerusalem, Israel; [b]1st University Urology Clinic, Laiko Hospital, Athens, Greece; [c]Department of Health Informatics, Jerusalem College of Technology, Jerusalem, Israel; [d]1st Department of Urology, Aristotle University, G. Gennimatas Hospital, Thessaloniki, Greece

**Key Words**
Laser • Renal stone • Ureteral stone • Ureteroscopy • Urolithiasis

**Abstract**
***Backgrounds/Aims:*** Operation room (OR) time is of great value affecting surgical outcome, complications and the daily surgical program with financial implications. ***Methods:*** We retrospectively evaluated 570 consecutive patients submitted to ureteroscopy or ureterorenoscopy for the treatment of ureteral or renal stones. Demographic parameters, patient's stones characteristics, type of ureteroscope, surgeon experience and surgical theater characteristics were analyzed. OR time was calculated from the initiation of anesthesia to patient extubation. Multivariate analysis was conducted using a linear regression test with multiple parameters to identify predictors of OR time. ***Results:*** Eight factors were identified as significant. These include total stones volume, ureteroscope used, stone number, nurses experience, radio-opacity of the stone on kidney-ureter-bladder X-ray, main surgeon experience, operating room type, and having a nephrostomy tube prior to surgery. ***Conclusions:*** The surgical team experience and familiarity with endourological procedure, and the surgical room characteristics has a crucial impact on OR time and effectiveness.



## Introduction

Accurate estimation of the operation room (OR) time affects daily operation program with significant financial implications for the institution, and it is important for patient's knowledge. Moreover, OR time influences also surgical outcomes and complications [1, 2]. OR time is not just the net surgical time. It includes induction of anesthesia, patient positioning, general preparations, procedure time, and emergence from anesthesia after the completion of the operation.

Various additional factors may influence OR time in endourological procedures. These include patients and stone characteristics, surgical team expertise with endourological procedures and an endourological oriented operating room.

We retrospectively analyzed and evaluated potential factors for predicting total OR time in ureteroscopy and retrograde intrarenal surgery (RIRS).

## Material and Methods

The data of 570 consecutive patients submitted to ureteroscopy or ureterorenoscopy between July 2012 and July 2014 for ureteral and renal stones were retrospectively retrieved. Mean population age was 51.52 years (range 10–89 years). In the presence of multiple stones, the total stone volume and the average Hounsfield unit (HU) of all stones were calculated. Stones characteristics are summarized in table 1.

KARGER

Fax +41 61 306 12 34
E-Mail karger@karger.com
www.karger.com



Ioannis Katafigiotis
Hadassah Ein-Kerem University Hospital
The Hebrew University
Jerusalem (Israel)
E-Mail katafigiotis.giannis@gmail.com

**Table 1.** Patient and stone characteristics

| | Cases, n (%) | Total stone volume, p | Operative time, minutes | p |
|---|---|---|---|---|
| Gender | | 0.499 | | 0.878 |
| Male | 420 | | 70.44 | |
| Female | 150 | | 70.85 | |
| Age, years | | 0.455 | | 0.041 |
| < 16 | | | 85.33 | |
| 16–69 | | | 69.2 | |
| > 70 | | | 76.69 | |
| Mean CT stone volume, $mm^3$ 365.72 (5.66–4,613.27) | 570 | | 70.55 (23–271) | < 0.005 |
| Mean stone HU 967.54 (203–1,844) | | | | 0.71 |
| Stone number | | < 0.001 | | 0.001 |
| 1 | 423 (74.2%) | | 67.62 | |
| 2 | 104 (18.2%) | | 77.73 | |
| 3 or more | 43 (7.5%) | | 83.70 | |
| Stone location | | < 0.005 | | < 0.005 |
| Kidney | 171 (30%) | | 78 | |
| Ureter | 353 (61.9%) | | 65.43 | |
| Both | 46 (8.1%) | | 82.53 | |
| KUB radiopaque | | 0.701 | | 0.004 |
| Yes | 399 (77.2%) | | 71.93 | |
| No | 118 (22.8%) | | 64.42 | |
| Bilateral treatment | | 0.237 | | 0.194 |
| Yes | 18 (3.2%) | | 78.88 | |
| No | 552 (96.8%) | | 70.27 | |
| Hydronephrosis | | 0.731 | | 0.786 |
| Yes | 438 (76.9%) | | 70.33 | |
| No | 132 (23.1%) | | 71.08 | |
| Prior stent | | 0.076 | | 0.002 |
| Yes | 154 (27.1%) | | 76.41 | |
| No | 416 (72.9%) | | 68.27 | |
| Prior nephrostomy | | 0.5 | | 0.163 |
| Yes | 14 (2.5%) | | 85.63 | |
| No | 556 (97.5%) | | 71.79 | |
| Ureteroscope used | | < 0.005 | | < 0.005 |
| Semirigid | 319 (56%) | | 64.72 | |
| Flexible | 229 (40.1%) | | 78.1 | |
| Both | 22 (3.9%) | | 77 | |

The stone volume was measured using a non-contrast abdominal CT scan and was calculated using the equation of a sphere with the three maximal dimensions of the stone as were measured using the abdominal CT scan.

A standard dorsal lithotomy position under general anesthesia was used in all operations. Stones located below the iliac vessels were managed using a 6.5F semirigid ureteroscope with a 550 μm laser fiber, whereas ureteral stones above the iliac vessels and kidneys stones were treated using a 7F flexible ureteroscope with a 200 μm laser fiber. In the semirigid cases stones were fragmented and retrieved using a 2.2F basket, whereas in the flexible cases, a dusting technique without a ureteral access sheath (UAS) was utilized. We choose not to use an UAS because our strategy is to dust the stones and thus we don't perform multiple accesses to the ureter. Completion of the procedures was deemed in the absence of fragments in the ureter or in complete dusting in the kidney. Operations were performed, either in a dedicated endourology operation room where all facilities and instrumentation were strictly in every detail organized for a ureteroscopic procedure, or in a general operating room using surgical kits. Availability determined the choice of the operating theater regardless of patients or stone characteristics. The assigning of the endourological team (surgeon, nurses and anesthesiologist) was unrelated to the specific operation room.

**Table 2.** Surgical team characteristics

| | Cases, n (%) | Total stone volume, p | Operative time, minutes | p |
|---|---|---|---|---|
| Main surgeon | | 0.016 | | < 0.057 |
| Experienced endourologist | 403 (70.8%) | | 69.1 | |
| Fellow | 166 (29.2%) | | 74 | |
| Anesthesiologist | | 0.076 | | < 0.005 |
| Experienced with endourology | 429 (75.2%) | | 67.12 | |
| Urology | 92 (16.2%) | | 81.75 | |
| Other | 49 (8.6%) | | 80.60 | |
| Nursing team | | 0.554 | | < 0.005 |
| Experienced with endourology | 392 (68.8%) | | 64.74 | |
| Urology | 141 (24.7%) | | 79.48 | |
| Other | 37 (6.5%) | | 79.94 | |
| Operating room type | | 0.487 | | < 0.002 |
| Dedicated endourology theater | 529 (92.8%) | | 69.07 | |
| General operating room | 41 (7.2%) | | 89.76 | |

The endourological team included a main surgeon (experienced endourologist with more than 10 years of experience in a high volume university lithiasis center, with over 15 cases of RIRS per week, after completing an official endourology fellowship or a fellow during his training in the same center), anesthesiologist (either experienced with endourological procedure, or nonspecific urological procedure and other surgical procedures), and 2 nurses (divided to the same sub-groups).

OR time was defined as the duration from the initiation of anesthesia to extubation of the patient and termination of anesthesia. Factors that could influence OR time were collected and evaluated (table 1, 2). Statistical analysis was conducted using SPSS software, version 17.0 (SPSS Inc., Chicago, IL, USA). Categorical dependent variables were evaluated using *t*-test whereas continues dependent variables were analyzed using Pearson correlation analysis. A one-way ANOVA was conducted to compare means when we had more than 2 categorical variables. Multivariate analysis was conducted using a linear regression test with multiple parameters.

## Results

The results of the univariate analysis depicting the influence of each factor on OR time is summarized in table 1 and 2. The average stone volume was 365.72 $mm^3$ (range 5.66–4,613.27 $mm^3$) with a mean HU of 967.54 (range 203–1,844) (table 1).

Concerning patient and stone characteristics (table 1), the significant factors occurred from the univariate analysis were age of the patient, mean CT stone volume, stone number, stone location, radio-opacity of the stone at kidney-ureter-bladder (KUB), pre-operative stent and the type of the ureteroscope used.

There was a statistically significant difference in the total stone volume that was treated between the experienced surgeon and the fellow (table 2). The surgical team characteristics are summarized in table 2.

In the univariate analysis, patient's age was found to have an influence on OR time. A significant difference was found comparing the pediatric group of patients younger than 16 years (85.33 minutes), patients older than 70 years (79.61 minutes) and the rest (69.2 minutes) ($p = 0.041$). No difference was found when the total stone volume was compared between these group ($p = 0.455$).

Concerning stone parameters, stone volume was found to be correlated with OR time ($p < 0.005$) whereas the stone density (measured by HU) wasn't ($p = 0.71$). Stone volume of patients having stent prior to surgery was not significantly higher (426.26 vs 343.50 $mm^3$, $p = 0.076$). The same applied for the patients that had pre-operatively a nephrostomy tube ($p = 0.5$). Prior stent influenced OR time significantly (76 vs. 68 minutes, $p = 0.002$), while nephrostomy had no impact on the OR time ($p = 0.5$) (table1). Finally in the univariate analysis there was a statistical significant difference in the OR time between the cases performed with the flexible and semirigid ureteroscope (78 vs. 64 minutes, $p = 0.005$).

The univariate analysis of the surgical team characteristics revealed that factors, anesthesiologist experience, nursing team experience and type of OR, in which the surgery was performed, were statistically significant and had an impact on the OR time (table 2). Specifically, it is important to mention that the experienced endourologist managed cases with statistical significant larger total

**Table 3.** Multivariate analysis: predicting factors for RIRS OR time

| | Unstandardized coefficients (standard error) | Standardized coefficients t | significance |
|---|---|---|---|
| Predicting factors | | | |
| All stones volume | 0.003 | 5.187 | 0.000 |
| Ureteroscope type | 2.588 | 4.866 | 0.000 |
| Stone number | 2.236 | 3.128 | 0.002 |
| Surgeon | 2.840 | 2.926 | 0.004 |
| KUB radio-opacity | 3.055 | 2.724 | 0.007 |
| Nurse | 2.308 | 2.674 | 0.008 |
| OR type | 6.391 | -2.690 | 0.008 |
| Nephrostomy | 8.068 | 2.553 | 0.011 |

stone volume comparing to the fellows ($p = 0.016$), and that seemed to contribute to the loss of the significance in the duration of the operation (69.1 vs. 74 minutes, $p < 0.057$). Regardless that there was not a statistical significant difference in the time needed to perform the operation, the experienced endourologist performed in less time the procedures.

A multivariate analysis was conducted and the significant predictors for OR time are depicted in total stones volume, type of ureteroscope used (flexible, semirigid or both), stone number, main surgeon experience, radio-opacity on KUB X-ray, nurses experience, operating room type, and having a nephrostomy tube prior to surgery (table 3).

## Discussion

With the advances of laser technology and miniaturization of endoscopes, ureteroscopy and RIRS became the mainstay in the treatment of ureteral and kidney stones. However the instruments and devices are unique to these procedures, becoming more delicate requiring a specialized surgical team. We retrospectively tried to recognize potential predictors of OR time, analyzing 570 cases of retrograde treatment of upper urinary tract stones.

For a given type of surgery, the surgeon is the major source of variability in OR time, and surgical skills can affect OR time [3, 4]. In contrast, van Eijk et al. [5] in a recent study of 16,480 general surgery cases found that differences between main surgeons can account for only 2.9% of the variability in OR time, and differences between anesthesiologists is negligible and can account for only 0.1% of the variability in OR time. In other studies, it was shown that decreased operative time and better efficiency were facilitated by a devoted, well-trained and consistent team that are prominent in general surgery [6–8]. In our study there was a statistical significant difference ($p < 0.005$) in operative time between the experienced endourologist (mean OR time 69.1 minutes) and the fellow (mean OR time 74 minutes) even though the former treated a larger mean total stone volume ($p = 0.016$, table 2). Depicting the importance of both the familiarity to the specialized instruments and the experience to the specific requirements of the stone management in the upper urinary tract (table 2, 3). Surprisingly this was not the most important factor, but the fourth.

Endourological surgeries and especially ureteroscopy and RIRS, are advanced surgical procedures that lean on high technology and delicate devices and instruments. The data on pre-operative factors that can predict OR time in endourological surgery in the current literature is limited. Gender, body weight, stone volume, maximum and mean HU, diameter of the UAS, and experience of the surgeon are all factors that have been implicated as possible significant coefficients that influence OR time of flexible ureteroscopy [9]. However, when considered in multivariate analysis, stone volume, experience of the surgeon, maximum HU, and lack of pre-operative stenting were the most important factors affecting OR time [9]. In our study various important parameters were examined both in a univariate and multivariate analysis and in the multivariate analysis the important factors were total stones volume, type of ureteroscope used (flexible, semirigid or both), stone number, main surgeon experience, radio-opacity on KUB X-ray, nurses experience, OR type, and having a nephrostomy tube prior to surgery (table 1–3).

In a recent study, it was demonstrated that stone volume has the strongest impact on operative time, while the HU measurements didn't affect the OR time [10]. In our multivariate analysis we found that the total stone volume was the strongest predicting factor, whereas the total stone number was the third most important factor (table 3). We also found that the HU measurement is not a significant factor for OR time. In contrast, radio-opacity on KUB X-ray did affect the length of surgery (table 1, 3). Less time was needed to complete the surgery in case of radiolucent stones versus radiopaque stones (mean OR time 64.42 vs. 71.93 minutes) for fragmentation (table 1, 3) in accordance to literature data [11].

The type of ureteroscope used was found to be also a very strong predictor for OR time ($p < 0.005$) (table 1, 3). Procedures that were completed using just a semirigid scope were shorter (mean 64.72 minutes) compared to those when a flexible ureteroscope was utilized (mean 78.1 minutes), or a combination of both (table 1, 3). In general, the stone burden when semirigid scope was used was significantly smaller ($p < 0.005$), and small fragments were grasped out from the ureter comparing to renal stones where dusting technique was applied (table 1). The type of the ureteroscope used was the second most important factor after total stone volume in our multivariate analysis (table 3). OR time for kidney stones (mean OR time: 78 minutes) was significantly longer than ureteric stones (mean OR time: 65.43 minutes) (table 1), but in the multivariate analysis the stone location lost its statistical significance (table 3).

In previous publications, pre-operative stenting was found to facilitate ureteroscopy [12–14]. However, although in the univariate analysis prior stenting was found to elongate the procedure significantly (76.41 vs. 68.27 minutes, table 1) in the multivariate analysis (table 3) prior stenting was not significantly influencing the OR time. In our practice we do not use access sheath for RIRS, which probably spares the need for stenting the ureter pre-operatively in most cases that flexible ureteroscope was utilized.

Prior nephrostomy tube was significantly influencing the total OR times in univariate and the multivariate analysis. Out of the 8 factors that were found to be affecting the OR time, prior nephrostomy was the least important (table 3). This population generally had higher stone burden, sepsis on initial presentation, or included cases that the effort of stent insertion had failed. Moreover, in patients that had nephrostomy tube during the surgery, the manipulation of the flexible ureteroscope inside the kidney was more challenging and complicated.

The experience of the nurses is also a potential factor that may affect the total OR time. Familiarity with equipment, devices, specific terminology, and possible complications are important in all kind of surgeries, especially in surgeries that are very specific and delicate like endourological surgeries. We found that nurse's experience is an important predicting factor that affect total OR time both in the univariate and multivariate analysis contributing to the efficacy and time saving of the procedure (tables 2, 3). When experienced nurses in endourological procedures were assigned to a specific surgery, the OR time was significantly shorter ($p < 0.005$) (mean OR time: 64.74 minutes) comparing to other general urological nurses (mean OR time: 79.48 minutes), or those without any experience in urology (mean OR time: 79.94 minutes) (table 2, 3). As far as we know this is the first time that this is reported and has a significant importance in educating specific surgical teams and planning the surgical list more efficiently.

The anesthesiologist has also a crucial role in every surgery. The anesthesia time before starting the surgery and after completing the procedure is also a factor that influence the total OR time. Moreover, knowledge of the limitations and specific needs in endourology operations by the anesthesiologist is also very important. For instance, controlling the tidal volume may help the endourologist to achieve better dusting of a stone in the kidney. In our study the familiarity in endourological procedures of the anesthesiologist was found to be significant in a univariate analysis ($p < 0.005$), but was not significant when evaluated in the multivariate analysis (table 2, 3). RIRS procedures though demanding for the main surgeon the requirements from the anesthesiologist are not so important when adjusted to the other factors.

The type and orientation of the surgical theater is also an important parameter that affect OR time and efficiency in various studies [15, 16]. However, this role has not been investigated in endourology yet. In our study, it was found to be significant as well. When the operations were performed in a endourology oriented theater, OR time was significantly shorter (mean 69.07 minutes) comparing to cases conducted in the general OR (mean 89.76 minutes) ($p < 0.005$). Concerning the clinical implication of our results, we now perform our ureteroscope operations only in the endourology oriented OR consisted in all the hierarchy of trained staff fully dedicated in the particular procedure, increasing the number of operations performed but yet another study is needed in order to support this conclusion with solid evidence.

## Conclusions

In this study we identified several important pre-operative predicting factors that affect total OR time. These include: total stones volume, type of ureteroscope used, stone number, main surgeon experience, radio-opacity on KUB X-ray, nurse's experience, operating room type, and having a nephrostomy tube prior to surgery.

Taking these factors into consideration while planning the OR schedule, we can improve the cost-effectiveness of a given surgical day, and improve patient's satisfaction from the overall treatment. A dedicated endourological team and theatre is crucial in reducing the OR time in ureteroscopy and RIRS. Future studies are needed for external validation of our results.

## References


1 Mitropoulos D, Artibani W, Graefen M, Remzi M, Roupret M, Truss M: Reporting and grading of complications after urologic surgical procedures: an ad hoc EAU guidelines panel assessment and recommendations. Eur Urol 2012;61:341–349.

2 Sugihara T, Yasunaga H, Horiguchi H, Nishimatsu H, Kume H, Ohe K, Matsuda S, Fushimi K, Homma Y: A nomogram predicting severe adverse events after ureteroscopic lithotripsy: 12,372 patients in a Japanese national series. BJU Int 2013;111:459–466.

3 Allen RW, Pruitt M, Taaffe KM: Effect of resident involvement on operative time and operating room staffing costs. J Surg Educ 2016;73:979–985.

4 Vinden C, Malthaner R, McGee J, McClure JA, Winick-Ng J, Liu K, Nash DM, Welk B, Dubois L: Teaching surgery takes time: the impact of surgical education on time in the operating room. Can J Surg 2016;59:87–92.

5 van Eijk RP, van Veen-Berkx E, Kazemier G, Eijkemans MJ: Effect of individual surgeons and anesthesiologists on operating room time. Anesth Analg 2016;123:445–451.

6 Mantoo S, Rigaud J, Naulet S, Lehur PA, Meurette G: Standardized surgical technique and dedicated operating room environment can reduce the operative time during robotic-assisted surgery for pelvic floor disorders. J Robot Surg 2014;8:7–12.

7 Avery DM 3rd, Matullo KS: The efficiency of a dedicated staff on operating room turnover time in hand surgery. J Hand Surg Am 2014;39:108–110.

8 Stepaniak PS, Vrijland WW, de Quelerij M, de Vries G, Heij C: Working with a fixed operating room team on consecutive similar cases and the effect on case duration and turnover time. Arch Surg 2010;145:1165–1170.

9 Ito H, Kuroda S, Kawahara T, Makiyama K, Yao M, Matsuzaki J: Clinical factors prolonging the operative time of flexible ureteroscopy for renal stones: a single-center analysis. Urolithiasis 2015;43:467–475.

10 Sorokin I, Cardona-Grau DK, Rehfuss A, Birney A, Stavrakis C, Leinwand G, Herr A, Feustel PJ, White MD: Stone volume is best predictor of operative time required in retrograde intrarenal surgery for renal calculi: implications for surgical planning and quality improvement. Urolithiasis 2016;44:545–550.

11 Ringdén I, Tiselius HG: Composition and clinically determined hardness of urinary tract stones. Scand J Urol Nephrol 2007;41:316–323.

12 Jones BJ, Ryan PC, Lyons O, Grainger R, McDermott TE, Butler MR: Use of the double pigtail stent in stone retrieval following unsuccessful ureteroscopy. Br J Urol 1990;66:254–256.

13 Hubert KC, Palmer JS: Passive dilation by ureteral stenting before ureteroscopy: eliminating the need for active dilation. J Urol 2005;174:1079–1080.

14 Chu L, Sternberg KM, Averch TD: Preoperative stenting decreases operative time and reoperative rates of ureteroscopy. J Endourol 2011;25:751–754.

15 Brusalis CM, Shah AS, Luan X, Lutts MK, Sankar WN: A dedicated orthopaedic trauma operating room improves efficiency at a pediatric center. J Bone Joint Surg Am 2017;99:42–47.

16 van Veen-Berkx E, Elkhuizen SG, Kuijper B, Kazemier G; Dutch Operating Room Benchmarking Collaborative: Dedicated operating room for emergency surgery generates more utilization, less overtime, and less cancellations. Am J Surg 2016;211:122–128.