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Comparison of cost-effectiveness and postoperative outcomes following integration of a stiff shaft glidewire into percutaneous nephrolithotripsy

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Abstract

Aims: To analyze the cost effectiveness of integrating a stiff shaft glidewire (SSGW) in percutaneous nephrolithotripsy (PCNL) relative to standard technique (ST). This is prudent because healthcare providers are experiencing increased pressure to improve procedure-related cost containment.

Methods: ST for PCNL at our institution involves a hydrophilic glidewire during initial percutaneous access and then two new stiff shaft wires. The SSGW is a hydrophilic wire used for initial access and the remainder of the procedure. We collected operating room (OR) costs for all primary, unilateral PCNL cases over a 5-month period during which ST for PCNL was used at a single institution with a single surgeon and compared with a 6-month period during which a SSGW was used. Mean costs for each period were then compared along with stone-free rates and complications.

Results: We included 17 total cases in the ST group and 22 in the SSGW group. The average operating room supply cost for the ST group was $1937.32 and $1559.39 in the SSGW group. The net difference of $377.93 represents a nearly 20% decrease in cost. This difference was statistically significant ($p = 0.031$). There was no difference in postoperative stone-free rates (82.4% *versus* 86.4%, $p = 1.0$, respectively) or complications (23.5% *versus* 13.6%, $p = 0.677$, respectively) between ST and SSGW groups.

Conclusion: Transitioning to a SSGW has reduced OR supply cost by reducing the number of supplies required. The change in wire did not affect stone-free rates or complications.

Keywords: cost analysis, nephrolithiasis, percutaneous nephrolithotomy, stone disease, technology, urolithiasis

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Introduction

Healthcare providers are experiencing increased pressure to identify areas of cost-reduction to minimize waste and unnecessary spending, while maximizing health outcomes.[1] An effective way of identifying areas for improvement is to perform cost analysis studies on surgical procedures. Several cost analysis studies have been conducted in the field of endourology over the past several years.

Within ureteroscopy, Chapman *et al*. sought to minimize cost associated with flexible ureteroscopy (fURS).[2] The authors compared the use of disposable laser fibers with reusable laser fibers to determine if there was a cost benefit associated with either of these products. Their results showed that it was actually more cost-effective to implement disposable laser fibers because it minimized scope damage and decreased time allocated for sterilization of the reusable laser fibers.

However, disposable instruments have not universally been cost effective. One study, conducted by Ozimek *et al.*, found that, within high-volume centers, disposable fURS is more expensive.[3] Factors such as complex stone burden and anatomic difficulties such as steep infundibulopelvic angles were associated with higher fURS damage, deeming disposable fURS as the more expensive alternative. Another cost analysis conducted by Schoenthaler *et al.* compared ultra-mini percutaneous nephrolithotripsy (UMP) with fURS to determine which approach was more cost-effective in the removal of kidney stones.[4] The results showed that UMP was more cost-effective in the end because the costs for the endoscopes and disposable materials were lower in comparison with those for fURS.

In line with these studies, we sought to identify a cost-saving that could be produced within our own high-volume surgical practice. The goal of this study was to analyze the cost effectiveness of integrating a stiff shaft glidewire (SSGW) in percutaneous nephrolithotripsy (PCNL) relative to standard technique (ST).

Methods

Patient selection

This study was approved by the Indiana University Institutional Review Board (#1912552281), which utilizes Kuali Coeus IRB. As this study was conducted retrospectively, the requirement for obtaining informed written consent was waived by the IRB. Patient records were obtained from the Department of Urology at Methodist Hospital, which is part of Indiana University/IU Health. Inclusion criteria were patients >18 years of age who were scheduled for primary, unilateral PCNL with the use of SSGW over a 6-month time-period from October 2018 through March 2019. Exclusion criteria included patients who underwent concomitant surgery for non-stone disease and patients who underwent a contralateral stone procedure. Patients undergoing PCNL with the same inclusion criteria over a 5-month time period (January–May 2018) prior to implementation of SSGW were placed in the ST group.

Study procedures

ST for PCNL at our institution involves insertion of a standard hydrophilic glidewire during initial percutaneous access and then two new stiff shaft wires. In general, we would use one superstiff wire as the working wire and a 0.035″ removable core straight wire as a safety wire. The SSGW is a hydrophilic hybrid glidewire that has more rigidity and can be utilized as both an access wire and a working wire for PCNL. The SSGW has similar capability to other wires such as a superstiff wire. We used the SSGW for both initial access and as a working wire for the remainder of the procedure, and therefore used only two total wires (SSGW plus a safety wire) for completion of the case.

We use a standardized technique for percutaneous access, as well as for stone removal, which is described in brief as follows. First, flexible cystoscopy is performed and a five French ureteral access catheter is placed into the ipsilateral side for surgery. The patient is then placed in prone position and prepped and draped for percutaneous access. Using triangulation technique with fluoroscopy, we access the collecting system percutaneously using a diamond-tipped needle. A hydrophilic glidewire is passed into the collecting system and advanced down the ureter; if needed, we will use an angled catheter to direct the wire down the ureter. An 8–10 French sequential dilator is passed over the wire. If using ST, the glide wire is removed and replaced by a superstiff wire and 0.035″ removable core wire. If using a SSGW, this wire is kept in place and a hydrophilic-tipped (sensor) wire is then advanced as a safety wire. A 30 French balloon and access sheath are advanced over the superstiff wire or SSGW, leaving either the removable core wire (for ST) or sensor (for SSGW) as a safety wire. During the intervening time period when we transitioned from ST to SSGW, we also transitioned our use safety wire from the removable core wire to the hydrophilic-tipped wire. Rigid and flexible nephroscopy are performed, with some cases utilizing laser lithotripsy and basket extraction. During the period of this analysis, a ShockPulse Stone Eliminator (Olympus, Tokyo, Japan) lithotrite was used during rigid nephroscopy. Upon completion of lithotripsy, a 10 French nephrostomy tube is placed.

Postoperative management was standardized for all patients. All patients had a low dose non-contrast CT scan on postoperative day 1 in the hospital to assess for immediate complications and significant residual calculi. Long-term follow-up consisted of imaging at 6 weeks after PCNL, which included either low-dose renal computed tomography (CT) or plain abdominal X-ray with renal ultrasound to evaluate for stone-free rates, along with full 24-h metabolic stone evaluations.

Data collection

The preoperative variables collected included mean age, previous stone surgery, and stone size. Postoperative outcome variables included stone-free rate, stone type, and hospital complication rates using the Clavien classification system.[5] The stone-free rate was defined as no evidence of residual stone on the postoperative CT scan or 6-week follow-up imaging as read by a blinded radiologists.

Operating room (OR) costs were obtained by accessing the OR supply utilization information based on documentation of each surgical case. The system utilized within the OR to document the instruments and resources utilized is termed Surginet. After successfully identifying the supplies utilized, item pricing was obtained by referring to vendor invoices. The use of the stiff shaft wire was the only difference between treatment groups.

Outcomes

The primary outcome of interest for this analysis was operative cost of PCNL with use of the SSGW *versus* ST. Secondary outcomes included stone-free rates and complication rates. These variables were analyzed to assure that both patient outcomes and safety were up to level of standard of care.

Statistical analysis

Descriptive statistics were used to analyze outcomes; t tests for differences in means and Mann–Whitney tests were utilized for normally and non-normally distributed continuous variables respectively. Pearson Chi-squared test and Fisher's exact tests were used for categorical variables. Statistical tests were two-sided and performed with a significance level of $p < 0.05$. IBM SPSS Version 25 software was utilized.

Results

We identified 22 patients over a 6-month period treated with PCNL using a SSGW who met study inclusion criteria. The standard therapy group consisted of 17 patients over a 5-month period who met inclusion criteria. The preoperative variables collected indicate that there was no difference in regard to the demographic profile between the two groups (Table 1). The mean age for those in the ST group was 57 years *versus* 50 years in the SSGW group ($p = 0.173$). Seven patients in the ST group and nine patients in the SSGW group had undergone a previous stone surgery ($p = 0.701$). There was also no difference between the average stone size ($p = 0.491$) or stone type ($p = 0.585$) between the two cohorts. The mean OR supply cost for the ST group was $1937.32. In comparison, the SSGW group had a mean cost of $1559.39. The net difference of $377.93 represents a 19.5% reduction in cost from the ST group with implementation of the SSGW. This difference was statistically significant ($p = 0.031$). There was no difference in mean operative time between the two groups (67.7 min in ST *versus* 74.4 min in SSGW, $p = 0.766$).

Operative details are seen in Table 1. Basket extraction was utilized in 15/17 (88.2%) of ST cases and in all 22 SSGW cases. This difference was not statistically significant ($p = 0.184$). Laser lithotripsy was utilized in 1/17 ST cases (5.8%) *versus* 3/22 SSGW cases (13.6%) and this difference was not statistically significant ($p = 0.618$). The stone-free rate of 82.4% in the ST groups was comparable with the 86.4% seen in the SSGW groups ($p = 1.000$). In the ST group, two patients had residual stone on post-operative day 1 and were managed conservatively and asymptomatic at follow up, and one patient had a spontaneously passed stone just prior to 6-week follow up. In the SSGW group, all three of the patients with residual stone were found to have stone at initial follow up. Two underwent secondary procedures: ureteroscopy and PCNL, respectively. Complication rates were also similarly low in both groups. The ST group had a 23.5% complication rate consisting solely of Clavien grade I–II complications. The SSGW group had a lower complication rate of 13.6%, although no significant difference was observed ($p = 0.677$). The SSGW complications included a single Clavien IIIa and IIIb complication; those were, respectively, a pneumothorax requiring chest tube placement and a persistent nephrocutaneous fistula requiring cystoscopy and ureteral stent placement.

Discussion

In this limited cohort, we found that the use of SSGW did influence the cost of the PCNL procedure. While no significant difference in operative

Table 1. Patient characteristics and outcomes following SSGW integration.

Patient characteristics and outcomes	ST group	SSGW group	*p* value
Total number (%) of patients	17 (44)	22 (56)	–
Mean age, years	57 (18–85)	50 (18–80)	0.173
Prior stone surgery, *n* (%)	7 (41)	9 (41)	0.701
Preoperative mean (SD) stone size in millimeters	19.5 (25.9)	19.4 (22.1)	0.491
Predominant stone type, *n* (%)			
CAP (%)	3 (17.6)	7 (31.9)	
COM (%)	5 (29.4)	3 (13.6)	
Mixed COM and CAP (%)	6 (35.3)	10 (45.5)	0.585
Uric acid (%)	2 (11.8)	1 (4.5)	
Cysteine (%)	1 (5.9)	1 (4.5)	
Mean operative time in minutes	67.7	74.4	0.766
Basket extraction usage (%)	15 (88.2)	22 (100)	0.184
Laster lithotripsy usage (%)	1 (5.8)	3 (13.6)	0.618
Stone free rate (%)	14 (82.4)	19 (86.4)	1.000
Complication rate (%)	4 (23.5)	3 (13.6)	0.677
Mean operating room supply cost	$1937.32	$1559.39	–

CAP, calcium phosphate; COM, calcium oxalate monohydrate; SD, standard deviation; SSGW, stiff shaft glidewire; ST, standard treatment

time was observed between the two groups, implementation of the SSGW was associated with nearly a 20% reduction in OR supply costs from $1937.32 to $1559.39. No differences in rates of basket extraction or laser lithotripsy were seen between the two groups. No significant differences in complications or stone-free rates were seen between treatment groups.

We observed that PCNL with the substitution of a single SSGW in place of two wires is associated with a decrease in OR costs. The SSGW is hydrophilic in itself, allowing for use during percutaneous access but has a firm component ideal for advancing working wires with or alongside it. Its use allows for a reduction in the total amount of wires utilized during PCNL without a significant difference in operative time. Implementation of the SSGW resulted in a reduction of over $375 for an individual surgery cost. Logically, this makes sense that the reduction of equipment should translate into cost savings, assuming no additional equipment is required. In our experience, no other change in equipment was required, and therefore the cost changes we observed appeared to be accurate.

Physicians have a responsibility to accept the role they play in the current healthcare economy. Increasing awareness of the costs associated with tests, treatments, and procedures that they recommend to patients is a critical aspect of initiating change. Studies indicate that few physicians within the United States employ cost-conscious care.[6] When physicians are more aware of the associated care costs, they will ultimately provide beneficial savings towards their institution and even eliminate unnecessary waste. One such approach to potential savings includes making practical changes within the OR that do not negatively impact patient care. Tactics that can be employed to achieve positive results include: eliminating obsolescence, increasing standardization, and ensuring utilization of supplies.[7] All of these strategies help to implement inventory reduction, which in turn causes a significant decrease in expenses incurred.

As Chapman *et al*. showed with laser fibers in ureteroscopy and Schoenthaler *et al*. showed comparing ultra mini PCNL with fURS,[2,4] there continues to be a need in endourology analyses to determine the most cost effective method that maximize patient outcomes.[2–4] The studies by Chapman *et al*. and Ozimek *et al*. together demonstrate that there is not single universal cost-effective approach within endourology for all patients.[2,3] Factors such as a patient's recurrent stone formation history, body habitus, anatomical difficulties, and stone characteristics should be taken into account when determining which approach will be most efficacious. In contrast, our study focuses solely on actual equipment utilization and standardization – rather than the procedural approach – in order to achieve a beneficial financial outcome. A recent study by Zhang *et al*. comparing UMP, fURS, and shock wave lithotripsy (SWL) for 1–2 cm lower pole calculi,[8] found that the cost of SWL was lower than UMP or fURS; however, there was a higher rate of retreatment with SWL. In our study, the absence of difference in stone-free rate when using a SSGW is associated with a lack of need for additional treatment and downstream healthcare costs.

The results of our study must be viewed in the context of certain limitations. Due to its retrospective nature, this study does not have the benefit of a randomized control trial. The small number of patients included within each cohort should also be taken into account. In particular, it is hard to draw conclusions regarding potential complications. Our complication rates are similar to the reported literature, but larger series could elucidate if there are potential complications specifically related to the choice of wire and therefore related to the technique of percutaneous access. Regardless of these factors, to our knowledge this is the largest report on the reduction of health care cost with use of a SSGW in PCNL. This study was performed entirely within a single institution and thus it may not be completely replicable in other settings. However, the concept that a single guidewire with a stiff shaft component could reduce the number of wires needed for PCNL should be universal regardless of PCNL technique. Additionally, there was not a one to one patient matching between the SSGW and ST cohorts. In spite of this, all patients underwent primary unilateral PCNL and similar postoperative stone-free rates indicate relatively similar outcomes. Finally, healthcare costs are not determined solely by equipment use; hospitalization lengths and management of complications add to healthcare costs.

Notwithstanding these limitations, the importance of this report on cost effectiveness of SSGW implementation for PCNL remains. A strength of our study is the utilization of real-world data with actual charges per case and not theoretical extrapolated numbers. When utilized for primary unilateral PCNL, OR costs are decreased with no adverse outcomes in patient complications or stone free rates. As technology continues to expand along with a population with a high stone burden, there will continue to be a need to discover safe cost-reducing techniques for urologists to implement.

Conclusion

Utilization of a hybrid wire, SSGW, during PCNL was shown in this study to reduce operating room cost by minimizing the number of supplies required during the procedure. These outcomes were the result of comparing actual case supply charges over time at a single institution. Furthermore, the results were achieved without any significant impact on the stone-free rate or complication outcomes.

Conflict of interest statement

The author(s) declare that there is no conflict of interest.

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