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Original Article

Differences between types of tract dilatation techniques during percutaneous nephrolithotomy (PCNL)

Perkütan nefrolitotomi (pcnl) esnasında trakt dilatasyon teknikleri arasındaki farklılıklar

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ABSTRACT

Aim: Dilation of the distance from the skin to the kidney stone is one of the important steps of percutaneous nephrolithotomy (PCNL). However, due to cost and exposure to radiation, there is a debate about the proper dilatation method. For this purpose, a controlled clinical trial was planned to evaluate the effectiveness of the use of 12 F Amplatz dilator + balloon dilator in terms of shorter duration of tract dilation and scopy time during PCNL.

Material and Methods: 60 patients with kidney stones and performed PCNL were included in the study and divided into 3 groups. While balloon dilation was maintained after using 12F Amplatz dilator -only- in Group 1, balloon dilation was performed after using 8/10 dilator/sheat set, dual-lumen ureteral catheter and ZebraTM angled type guidewire as described in the teachings in Group 2. Dilation in patients in Group 3 was performed with just Amplatz dilators ranging from 10F to 30F without using balloon dilation. The access time, dilation time, operation time, scopy time, cost, nephrostomy tube removal time, hospital stay period parameters were recorded.

Results: Dilation, operation and scopy times were significantly lower in Group 1 compared to the two other groups ($p<0.05$). The costs were higher in Group 2.

Conclusion: Due to the shorter dilation, scopy and operation time and cost benefits, using 12F Amplatz dilator before and then balloon dilator seems advantageous.

Key Words: kidney stones, Percutaneous nephrolithotomy, 12F amplatz dilator, balloon dilatation, radiation exposure

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ÖZ

Amaç: Ciltten böbrek taşına kadar olan mesafenin dilatasyonu Perkütan Nefrolitotomi (PCNL) operasyonunun önemli adımlarındandır. Ancak, maliyet ve radyasyon maruziyeti nedeniyle uygun dilatasyon metodu konusunda tartışmalar sürmektedir. Bu amaçla, PCNL'de trakt dilatasyonu esnasında 12F Amplatz dilatatör + balon dilatatör kullanımının dilatasyon ve skopi süresi üzerine etkisini değerlendirmek için kontrollü klinik çalışma planlandı.

Gereç ve Yöntemler: Böbrek taşı nedeniyle PCNL endikasyonu olan 60 hasta çalışmaya dahil edildi ve 3 gruba ayrıldılar. Grup 1'de sadece 12F Amplatz ile dilatasyon sonrası balon dilatasyonu yapılırken, Grup 2'de öğretilerde tarif edildiği gibi sırasıyla 8/10 dilatatör/sheat set, dual-lümen üreteral katater ve ZebraTM açılı uçlu kılavuz tel sonrası balon dilatasyon uygulandı. Grup 3'de ise balon dilatatör uygulanmadan 10-30F arası Amplatz dilatatörler ile trakt dilatasyonu sağlandı. Taşa erişim süresi, dilatasyon süresi, amelitay süresi, skopi süresi, maliyet, nefrostomi tüpünün çıkarılma süresi ve hastanede kalış süresi parametreleri kaydedildi.

Bulgular: Dilatasyon süresi, operasyon süresi ve skopi süresi Grup 1'de diğer iki grup ile karşılaştırıldığında anlamlı derecede daha kısaydı ($p<0.05$). Maliyet Grup 2'de diğer gruplar ile karşılaştırıldığında daha fazlaydı.

Sonuç: Kısa dilatasyon süresi, kısa operasyon süresi, düşük skopi zamanı ve düşük maliyet nedeniyle 12F Amplatz dilatör kullanılarak balon dilatasyonun yapılması avantajlı görünmektedir.

Anahtar Kelimeler: Böbrek taşları; PCNL; 12F amplatz dilatatör; Balon dilatasyonu; Radyasyona maruz kalma

Introduction

Percutaneous nephrolithotomy (PCNL) is a preferred treatment method in multiple and Staghorn kidney stones larger than 2cm [1]. Serious reductions in complications, morbidity, and mortality have been observed with the application of this percutaneous intervention in patients, who were inevitably treated with open surgery methods previously. Percutaneous intervention to the kidneys was first used by Goodwin in 1955 [2] and then the percutaneous surgery method for the treatment of kidney stones was described by Fernstrom and Johansson in 1976 [3]. Due to faster elimination of large stones, acceptable level of complications, shorter recovery times, shorter hospital stays, increased post-operative patient comfort, and reduced labor force loss, PCNL is suggested in the current guides for larger than 2cm, resistant to extracorporeal shock wave lithotripsy, complex, staghorn kidney stones and certain kidney stones with anomalies [4].

Dilation is one of the important steps of the PCNL operation [5]. Tracts can be formed using Amplatz, balloon, and metal telescopic dilation [6-8]. There are controversies around the appropriate method of dilation. These techniques have certain advantages and disadvantages, particularly regarding bleeding and costs. Reducing the dilation time also reduces the dose of radiation exposed to during the procedure. Therefore, we have aimed to evaluate the efficiency of balloon dilation using 12 F Amplatz dilator to shorten the duration of the dilation procedure, particularly with regards to duration and thereby, the amount of radiation exposure and costs.

Material and Methods

60 patients between the ages of 18 and 78 with an established diagnosis of kidney stones and identified with PCNL indication and operated by the same urologist were included in the study between February 2015 - June 2017. Patients with a single kidney lower pole stone in the size of 2 to 3 cm and patients with guide wire catheter passing ureter after routine lower pole posterior calyx entry were included in the study. Patients with congenital renal anomalies and middle-upper pole kidney stones were excluded from the study. Patients were randomly assigned to groups. Each patient in each group was assessed by a blinded person about the procedure performed for the patients.

Procedures

The patients were prospective randomly divided into three groups. All the patients were operated under general anesthesia. Cystoscopy in gynecologic position was performed on the patients and catheters with both ends open were placed in the urethra on the side planned for surgery. During the operation, urethral catheters were placed to decompress the bladder. The patients were brought to the prone position and the required areas were supported with silicone pads. After cleaning the flank and genital regions of all the patients with antiseptics, these regions were covered with covers that contain irrigation pouches to collect irrigation fluids during surgical procedures.

Access to all the patients was achieved through the posterior calyx. Access in a single plan was preferred. Calyx was determined with C-arm X-ray device at 90 degrees. The 18 gauge inroducer needle was advanced to the target through the appropriate skin area, making a 30 degrees angle with the patient. The inner needle sheath was removed and following the observance of the arrival of urine or opaque matter, the 0.038 inch ZIPwire guidewire was advanced. Needle was removed after a 1cm incision was made over it. 12F Amplatz dilator was inserted over guidewire towards the calyx in the patients in group 1 (n: 20). Then dilatation of the tract was achieved with a NephromaxTM High Pressure balloon dilatation catheter (30F) (Figure 1). In Group 2 patients (n: 20), however, 8/10 Dilator/Sheat Set (8F x 70 cm dilator, 10 F x 35 cm sheat) was first forwarded over the 0.038 inch ZIPwire guidewire and then a dual-lumen ureteral catheter (10 F x 50 cm) was placed and a 0.038 inch ZebraTM Angled Type guidewire was inserted into the renal collective system over it. After the double-lumen catheter was removed, the NephromaxTM High Pressure balloon dilatation catheter (30 F) was forwarded over the zebra guidewire and dilatation of the tract was achieved. In Group 3 patients (n: 20), a 8/10 Dilator/Sheat Set was first forwarded over the 0.038 inch ZIPwire guidewire and then the outer sheath was removed and dilatation was performed by forwarding Amplatz Type renal dilatators/sheath set (8F-30 F x 35 cm) through the calyx. The collective system was accessed with a 26 F nephroscope through inside of the 30 F Amplatz sheath and the stones were broken down with the help of pneumatic and the fragments were taken out with endoscopic graspers. After the operation, the procedure was ended following placing a nephrostomy tube and fixing it on the skin.

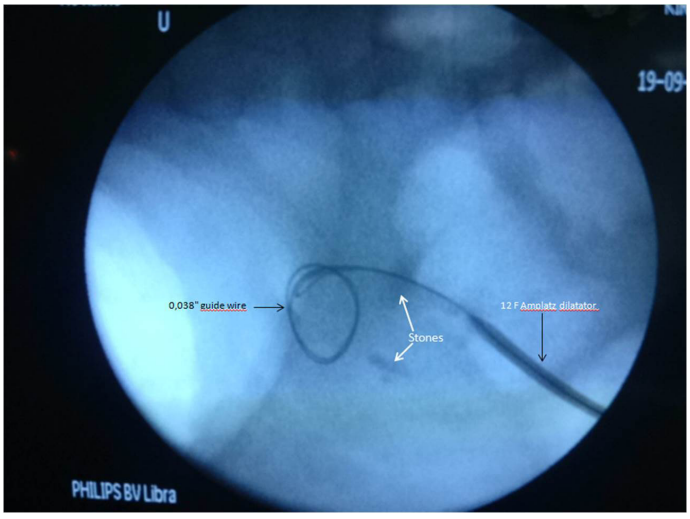

Figure 1. 12F Amplatz dilator was inserted over guidewire towards the calyx

The time interval between the ureteral passage of the guidewire catheter and the placement of the renal sheath was determined as the duration of the dilatation. The time between accessing the kidney with needle and placement of nephrostomy tube was considered as operation duration. Access to the kidney, dilatation and operation were performed by the same urologist.

The prices of materials used during dilation were added to the cost of operation. Hospitalization time was not included in the cost of operation.

Statistical Analysis

Access time, dilation time, operative time, scopy (fluoroscopy) time, cost, preoperative/postoperative hemoglobin levels, transfusion requirement, stone clearance rate, nephrostomy tube removal time, duration of hospital stay, need for additional intervention parameters were recorded. Statistical analyses between the groups were made using the one way ANOVA test.

Results

The demographic characteristics of the patients are shown in Table 1. The parameters related to the operation are provided in Table 2. No statistical differences in terms of age, sex, stone volume, body mass index and other previous procedures due to stone were observed between the groups. No statistical differences between the three groups were identified in the parameters of preoperative/postoperative hemoglobin levels, transfusion requirement, stone clearance rate, nephrostomy tube removal time, duration of hospital stay, and need for additional intervention.

Table 1. Demographic characteristics of the 60 patients in the study. (SWL: Shockwave lithotripsy; PCNL: Percutaneous nephrolithotomy) Mean ± Standard Deviation (SD) One Way ANOVA test, p<0.05, NS: Statistically Nonsignificant

	Group 1	Group 2	Group3	*P*
Patients no	20	20	20	
Mean age (years)	40.8±14.6	41.6±15.2	42.2±15.9	0.869
Gender (Male/Female)	12/8	13/7	12/8	0.972
Mean stone surface area (mm2)	416.4±89.6	452.6±78.5	435±82.4	0.169
Mean body mass index (kg/m2)	25.8±6.3	26.5±6.4	25.6±6.2	0.989
Previous SWL	3	4	3	0.910
Previous PCNL	2	2	3	0.985
Previous open stone surgery	3	4	2	0.754

Table 2. The operative properties of patients in groups. Mean ± Standard Deviation (SD)

	Group 1	Group 2	Group 3
Mean access time (minute)	1.2±0.8	1.4±6.6	1.3±0.6
Mean dilatation time (minute)	3.7±1.6	7.4±2.8	9.3±3.7
Mean operative time (minute)	48.6±22.4	51±25.1	53.2±26.7
Mean fluoroscopy time (minute)	1.8±0.9	3.8±1.2	4.2±1.6
Preop Hb/Postop Hb (mg/DL)	13.2±1.8/12.4±1.6	13.5±1.8/12.8±1.5	13.4±1.8/12.7±1.5
Blood transfusion	-	-	1
Nephrostomy tube removal time (hours)	18.5±2.4	20.2±2.9	21.3±3.1
Mean postoperative hospital stay (hours)	22.6±2.7	24.5±3.4	25.2±3.6
Auxiliary procedures	1	1	2
Cost (dollars)	368	458	372

The fluoroscopy, dilatation, and operation times in Group 1 were statistically significantly lower than those in Group 2 and Group 3. With regards to fluoroscopy time, the p value between Group 1 and 2 was 0.009; the p value between Group 1 and 3 was 0.003; and the p value between Group 2 and 3 was 0.585. Based on dilation time, the p value between Group 1 and 2 was 0.011; the p value between Group 1 and 3 was 0.002; and the p value between Group 2 and 3 was 0.634. With regards to operation time, the p value between Group 1 and 2 was 0.019; the p value between Group 1 and 3 was 0.014; and the p value between Group 2 and 3 was 0.569 (Table 3).

Table 3. Multiple Comparisons of The Groups and Associated p Values. ANOVA test (with post hoc Tukey test for unequal groups) and statistical significance is determined as $p < 0.05$

Groups	Mean dilatation time (minute)	Mean operative time (minute)	Mean fluoroscopy time (minute)
Group 1 vs 2	p = 0.011	p = 0.019	p = 0.009
Group 1 vs 3	p = 0.002	p = 0.014	p = 0.003
Group 2 vs 3	p = 0.0634	p = 0.569	p = 0.585

Discussion

Due to its advantages such as short duration of hospital stay, low cost of treatment, enabling patients return to their jobs earlier, avoidance of a large incision scar as it requires a minimal surgical incision, PCNL is preferred over open surgery today4. With its satisfactory results, PCNL finds special areas of application in patients with complex kidney stones, isolated stones in calyx, and diverticula and in patients who are overweight, who has orthopedic deformities and congenital renal anomalies (horseshoe kidney, ectopic kidney), and in transplanted kidneys [9].

Use of prolonged fluoroscopy increases the amount of radiation exposure for both the patient and the team that conducts the interventional procedure [10]. Three forms of radiation exposure occur during PCNL. The first is direct radiation and an example of this is rays taken by the hands. Vulnerability is higher in this form as compared to the other forms. The second form is indirect radiation. An X-ray is a form of energy that diffuses around from the first obstacle it hits (PCNL desk and the patient) after it leaves its source. The third form is exposure via leakage. Because the received dose of radiation reduces in reverse proportion with the square of distance, while the risk is relatively lower for other staff working around, the situation is more serious for the urologist who constantly deals with this surgery and works closest to the source of the X-ray [11]. The impact of radiation on the human body changes by the amount of exposed dose and tissues. While the thyroid gland, bone marrows, gonads, and the lenses are the most sensitive organs, the brain and bone tissues are more resistant. The International Commission on Radiological Protection has identified safety limits for each tissue [12].

It has been demonstrated that in case of 10 minutes of fluoroscopy use during PCNL, the regions most impacted by radiation are the lower extremities/feet (0.02mSv), fingers (0.036 mSv), hands (0.057 mSv), and eyes (0.07 mSv) [13]. In a study conducted by Kumar, it has been found that the trunk is less and the head-neck region is relatively more exposed to the rays during PCNL [14]. Inglis et al., on the other hand, have identified the dose received by the thyroid tissue during an average of 4.4 minutes of fluoroscopy as 0.035 mSv [15]. Accordingly, although it emerges that even PCNL procedures performed in as many as 1000 cases annually are safe with regards to radiation, because the hands of the urologist is exposed to both direct and reflecting rays, they are more exposed to radiation as compared to the other organs. It has

been revealed that the average dose received per case without wearing lead-lined gloves is 0.92 mSv for the left hand and 0.26 mSv for the right hand [16]. In the study by Kumar, it has been determined that during a 20-minute fluoroscopy use, hands are exposed to 5.2 mSv of radiation and fingers to 7.5 mSV of it [14]. Considering that the safety limit is 750 mSv for hands, it should be remembered that this dose can be surpassed within a short while. Lead aprons, lead gloves, thyroid collars, and lead glasses must definitely be worn for safe operation.

When the operation is evaluated with regards to the patient, the average exposure dosages on the organs of the patient during PCNL are 0.24 mSv on the skin; 0.043 mSv on the liver; 0.003 mSv on the opposite kidney; and 0.002 mSv on the transverse colon [17].

After access is achieved, the main principle in the subsequent dilatation is that it must always be performed over a guidewire [18]. In order to avoid encountering problems such as displacement of the wire during dilatation, the objective is to forward the guidewire to the ureter before dilatation. However, this may not be always possible. It could be difficult to place the guidewire into the anatomic space when percutaneous access is needed to intervene a coraliform stone and this necessitates special experience. The use of an extra safety wire in addition to the initially used guidewire is commonly recommended. This safety wire is placed next to the wire used with the help of a double-lumen catheter or coaxial system. Thus, if the wire used is bent or displaced, dilatation of the nephrostomy tract is maintained through the other wire [19,20]. Another important data of our study is complications. We had an extra safety guide wire only in group 2 and on the other hand there was no complications in group 1 or 3 because of the lack of extra safety guide wire.

An Amplatz dilatation set, metal accessory dilators, and high pressure balloons are used for dilatation of the nephrostomy tract [21]. Although it is pointed out that using balloon dilator decreases the transfusion rate and hemorrhage compared to Amplatz fascial dilatation, some studies report that the type of the dilatation used is not related to total blood loss [22,23]. Depending on the preference and experience of the surgeon, all dilatation techniques can be used safely.

The goal of balloon dilatation is to achieve tract formation in a single step, without a need for serial dilatation [21]. Balloons produce lateral pressure force, not angular chop force. Although they are easy to use, they are costlier than the other systems. Concomitant use of 8/10 dilator/sheat set, dual-lumen ureteral catheter and ZebraTM angled type guidewire further increases the cost of the procedure. Besides, the necessity of fluoroscopic check while 8/10 dilator/sheat set, dual-lumen ureteral catheter and ZebraTM angled type guidewire is inserted can increase the amount of exposed radiation. Kidney access time can be longer and the amount of radiation can be higher during the procedure of dilatation by using Amplatz dilators ranging between 10 F to 30 F [22,23].

Conclusion

In our study, not using a 8/10 dilator/sheat set, dual-lumen ureteral catheter and ZebraTM angled type guidewire in the dilatation procedure, which was performed using only a 12 F Amplatz dilator followed by balloon dilator, lowered the cost and decreased procedure time, and thereby reduced fluoroscopy exposure. It did not demonstrate any difference with the other dilatation systems in terms of hemorrhage.

Realization of balloon dilatation with the help of a 12 F Amplatz dilatator is noteworthy as an advantageous procedure in terms of time, cost, and exposure to radiation.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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