

Arterial Injury during Percutaneous Nephrostomy: Angiography Findings from an Isolated Porcine Kidney Model

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Purpose: To investigate the extent of renal arterial injury incurred by different size of nephrostomy tracts from 10 French (F) to 32F in vitro porcine kidney.

Materials and Methods: To simulate the technique of percutaneous nephrostomy we set up 12 groups of different size nephrostomy tracts from 10F to 32F, including 40 nephrostomy tracts in each group. Digital subtraction angiography (DSA) was used to inspect and analysis of arterial injury.

Results: When the size of nephrostomy tracts is increased from 10F to 32F, the degree of arterial injury is also aggravated. With 14F compared to 24F, the number of nephrostomy tracts with serious arterial injury was 12 (12/40) and 23 (23/40), respectively ($P < .05$). With 18F compared to 30F, the number of nephrostomy tracts with serious arterial injury was 16 (16/40) and 30 (28/40), respectively ($P < .01$).

Conclusion: When the size of nephrostomy tract is increased, the degree of renal arterial injury is also heightened. When 18F tracts was compared to 30F tracts and 14F tracts compared to 24F tracts, obvious reduction of arterial injury is observed.

Keywords: nephrostomy, percutaneous; kidney; angiography, digital subtraction; hemorrhage; animal.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a well-established treatment option for managing upper urinary tract stones.^(1,2) Despite advances in equipment and increased experience with this treatment, renal hemorrhage remains the most concerning complication of PCNL. The reported transfusion rate following PCNL in the literature ranges from 8-37%.⁽³⁻⁵⁾ Although most patients with bleeding can be managed conservatively, severe hemorrhage is occasionally life-threatening, and nephrectomy is occasionally required in cases of failed angiography and embolization.⁽⁶⁾ Massive hemorrhage is a severe complication following PCNL and is one of the classical indication of selective artery embolization (SAE), which has a high success rate, and the reported frequency of severe hemorrhage requiring SAE after PCNL is 0.3-1.5%.⁽⁶⁻¹⁰⁾

Over the past decades, modifications to the conventional PCNL technique have been made to decrease morbidity. In 1997, Jackman and colleagues⁽¹¹⁾ initially described the “mini-PCNL” technique in children using an 11F peel-away vascular access sheath. Lahme and colleagues⁽¹²⁾ also reported their experience with mini-PCNL in 2001.

Small PNCL tracts are believed to cause less trauma to kidney than standard PCNL tracts, but rare studies have confirmed this hypothesis. Angiography is a good method to evaluate vascular injury following percutaneous nephrostomy and for demonstrating the tracts associated with trauma. Routine angiography following PCNL is unrealistic and inhumane; therefore, isolated porcine kidneys from sacrificed miniature pigs were used as a model for evaluating with angiography. To our best knowledge, this is the first report to investigate arterial injury following percutaneous nephrostomy based on angiography findings in an isolated porcine kidney model. This study evaluated the trauma from differently sized percutaneous nephrostomy tracts.

MATERIALS AND METHODS

Study Subjects

This study was performed in strict accordance with the recommendations in the Guide for the Care and Use of Laboratory Animals of the National Institutes of Health. The protocol was approved by the Committee on the Ethics of Animal Experiments of the University of Ningbo. The materials were fresh in vitro kidneys taken from mixed breed adult farm pigs slaughtered at 4 to 5

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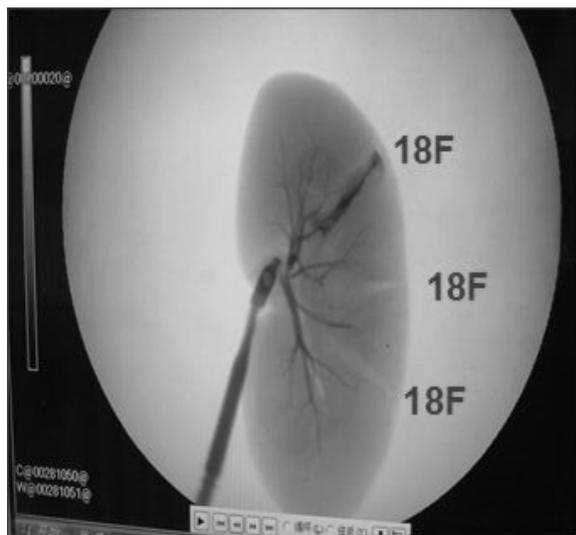


Figure 1. The upper nephrostomy tract with obvious contrast agent is considered as renal arterial injury.

months of age and 60 to 90 kg of weight. The kidneys were 160 ± 10 g, whose length, width, and thickness were 14.0 ± 1.0 cm, 6.5 ± 0.5 cm and 3.2 ± 0.2 cm, respectively. Percutaneous nephrostomy was performed in the upper, middle, and lower part in each kidney.

The vascular system was completely perfused with heparin and physiological saline and then fixed on the bench. Percutaneous nephrostomy was performed in a manner similar to PCNL in human patients. An 18 gauge needle was punctured into the targeted calyx, and then, a 0.038 inch guide wire was inserted through the needle into the renal pelvis. The nephrostomy tract was dilated with fascial dilators (Cook Urological, Spencer, IN, USA) from the cortex to the pelvis along the guide wire. Then, from 10F to 32F, 12 groups with nephrostomy tracts were established, with each group including of 40 nephrostomy tracts. The kidney artery was then connected to the angiography system, and digital subtraction angiography (DSA) was performed to identify arterial injuries.

Evaluation and Statistical Analysis

During angiography, the nephrostomy tracts with obvious contrast agent are considered as renal arterial injury (Figure 1). The incidences of arterial injury were recorded and compared between the groups. Statistical analyses were performed using Statistical Package for the Social Science (SPSS Inc, Chicago, Illinois, USA) version 15.0. Categorical variables between the two groups were compared with a chi-squared test. A P value less than .05 was considered statistically significant.

RESULTS

A total of 480 tracts were established in 12 groups, with 40 tracts in each group. When from 10F to 32F were compared, arterial injury is increased with increasing tract diameter (Figure 2).

When we compared 14F to 24F, the number of nephrostomy tracts with serious arterial injury was 12 (12/40) and 23 (23/40), respectively ($\chi^2 = 6.15, P < .05$). When 18F compared with 30F, the number of nephrostomy tracts with serious arterial injury was 16 (16/40) and 30 (28/40), respectively ($\chi^2 = 7.27, P < .01$).

DISCUSSION

Trauma from percutaneous tracts to the kidney is one of the most frequently concerning issues in PCNL due to the potential risk of post-PCNL severe hemorrhage and related renal function damage.

The risk of blood loss in PCNL depends on a variety of factors, including general patient condition, stone burden, operative technique, and experience. Kukreja and colleagues prospective evaluated factors affecting blood loss during PCNL.⁽⁴⁾ They reported that, diabetes, multiple tract procedures, prolonged operation time and intraoperative complications were associated with significantly greater blood loss. Turna and colleagues⁽²⁾ performed a prospective study with multivariate regression analysis; they identified five significant factors that

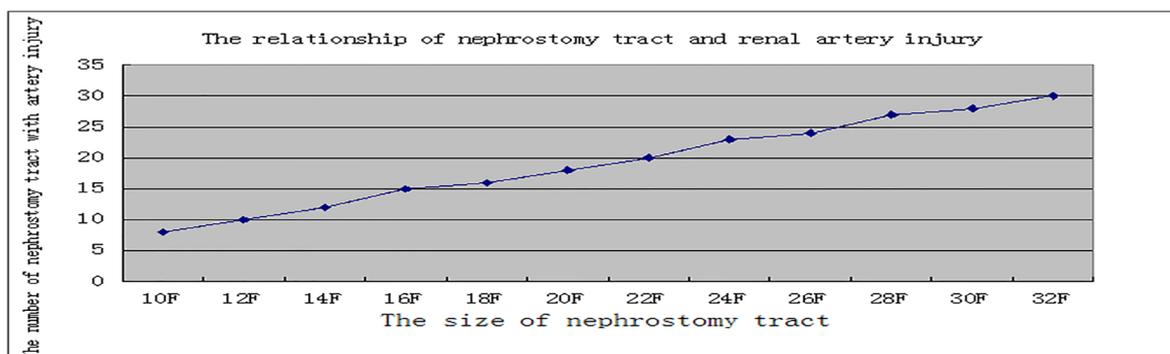


Figure 2. The relationship between the size of nephrostomy tract and renal arterial injury.

influenced PCNL related hemorrhage: stone type, tract number, dilation method, diabetes and stone surface area. Upper calyceal puncture, solitary kidney, staghorn stone, multiple punctures and an inexperienced surgeon were also significant risk factors for severe bleeding.⁽³⁾ An increased percutaneous tract size potentially induced lacerations to vessels during dilation during the PCNL procedures.

The elastic reaction of the vessels affect blood loss during percutaneous nephrostomy. Clayman and colleagues⁽¹³⁾ and Traxer and colleagues⁽¹⁴⁾ examined the extent of renal damage caused by different nephrostomy tract dilatation sizes in pigs and found that the mean scar volume was 0.294-0.43 mm³ and that the ratio to total kidney volume was 0.13-0.16%. No significant differences were noted. In a clinical study, Li and colleagues did not observe significant advantages of mini-PCNL in terms of reduced surgical trauma and associated invasiveness compared with standard PCNL based on determination of acute-phase markers, namely tumor necrosis factor-alpha (TNF-alpha), interleukin-6 (IL-6), IL-10, C-reactive protein (CRP), and serum amyloid A (SAA).⁽¹⁵⁾ Unfortunately, the immediate effects of percutaneous nephrostomy tracts on kidney vessels have not yet been determined. But, in the recent literature, miniperc and ultraminiperc (UMP) are associated with similar clearance rate as the standard PCNL but they are associated with decreased hemoglobin drop, hospital stay, analgesic requirement, and complication rates.⁽¹⁶⁻¹⁸⁾

In this study, we investigated the extent of renal arterial injury incurred by different size of nephrostomy tracts in vitro porcine kidney. We found that the fascial dilators gradually pushed the renal artery and parenchymal away during the dilation procedures. In the range of 10F to 32F, the number of nephrostomy tracts with evident arterial injury increased as the tract diameter enlarged. It is notable that the number of tracts with evident arterial injury was half the total in the group of 22F tracts. Decreasing the tract size will further decrease the complications while maintaining similar stone-free rate. This is the basis to further narrow the tract size. The UMP technique is normally always use tract small than 14F, but the 24F tract is normally used in standard PCNL. In this study, we found that the number of tracts with arterial injury in 14F and 24F groups was 12 (12/40) and 23 (23/40), respectively, and the incidence of arterial injury was significantly different between two groups ($P < .05$). The 18F percutaneous tract is universally used in China as a Chinese mini-PCNL. The 30F tract is the commonly used big tract in world-

wide practices. In this study, we found that 18F tracts induced fewer renal arterial injury than 30F tracts.

The limitation of this study is that the vessels of isolated porcine kidneys lack of plasma thromboplastin component and complete elasticity compared with kidneys in vivo. To confirm our present findings, a study based on porcine kidneys in vivo is required.

CONCLUSIONS

Our findings indicate that the renal arterial injury is aggravated when the nephrostomy tract grows bigger, and it is of proven advantage to use smaller nephrostomy tracts to prevent renal arterial injury.

CONFLICT OF INTEREST

None declared.

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