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Formation and composition of crust in the nephrostomy tube of patients undergoing percutaneous nephrostomy

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Abstract

To investigate the formation and composition of crust in the nephrostomy tube (NT) of patients undergoing percutaneous nephrostomy (PCN). Consecutive patients undergoing PCN for the treatment of obstructive nephropathy who then underwent NT exchange between January 2020 and May 2022 were included in the study. The composition of crust in NTs was analyzed using infrared spectrum automatic analysis system. A total of 46 NTs were collected from 46 consecutive patients (19 men, 27 women; mean age, 68.5 ± 13.4 years) who underwent PCN. The median indwelling time of NTs was 96 days (Q1, 90 days; Q3, 140 days). Among the 46 NTs, 20 (43.5%) were positive for the presence of crust. The mean indwelling time was significantly longer in NTs positive for crust than in those negative for crust (169.7 ± 55.7 days vs 86.5 ± 15.0 days; $P < .01$). In the NTs positive for crust, the crust was composed of mixed components (apatite carbonate and magnesium ammonium phosphate hexahydrate, n = 7; apatite carbonate and calcium oxalate monohydrate, n = 4) in 11 NTs and a single component (apatite carbonate, n = 5; anhydrous uric acid, n = 2; calcium oxalate monohydrate, n = 2) in 9 NTs. When the NT indwelling time was longer than 3 months, the incidence of crust formation in the NT was significantly increased. Crust was most commonly composed of mixed components. In light of these findings, we suggest that NTs should be exchanged every 3 to 4 months to prevent the formation of crust and thus prevent obstruction of the NT.

Abbreviations: NT = nephrostomy tube, PCN = percutaneous nephrostomy.

Keywords: composition, crust, percutaneous nephrostomy, tube

1. Introduction

Percutaneous nephrostomy (PCN) is widely used for the treatment of obstructive nephropathy.[1,2] When this procedure is used, some patients require a long indwelling time for the nephrostomy tube (NT). However, during this indwelling time, the tube may become obstructed by the formation of crust, which may aggravate the obstructive nephropathy and lead to urinary tract infection. NTs should therefore be exchanged regularly to prevent this type of obstruction. However, the exchanging of NTs is an invasive procedure that may increase not only the risk of kidney injury, but also the risk of urinary tract infection.[3–6] The necessity of these procedures to exchange tubes also increases the financial burden to the patient.[3,4] Although the exchanging of NTs is typically performed every 3 to 4 months in clinical practice, there is currently no consensus regarding how often these tubes should be exchanged.

The necessity for NT exchange is based on the formation of crust within the tubes; however, knowledge regarding the formation and composition of this crust in NTs is limited. The goal of this prospective study, therefore, was to explore the formation and composition of crust in NTs.

2. Materials and methods

2.1. Patients

This prospective study was approved by both institutional review boards. All participants provided written informed consent. Consecutive patients who underwent PCN for the treatment of obstructive nephropathy and who then underwent NT exchange between January 2020 and May 2022 were eligible for study inclusion. Patients were excluded if the urine volume discharged from the NT was < 1000 mL per day

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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due to impaired kidney function, if pus was discharged from the NT, if the NT was acutely obstructed by a blood clot or pus, or if pregnancy. Patients were also excluded if an NT had been collected previously (only 1 NT was collected from a patient).

2.2. PCN and exchanging of NTs

PCN and exchanging of NTs were performed according to standard methodology. In general, an 8F NT (Argon Medical Devices, Athens, Texas) was used, and the NTs were exchanged regularly (approximately every 3–4 months). The exchanged NTs were collected for analysis; in patients with bilateral NTs, only 1 NT was collected. All patients were closely monitored for procedure-related complications after these PCN and exchange procedures.

2.3. Clinical follow-up

Outpatient clinic visits were offered every month. More frequent evaluations were performed when necessary. During follow-up, the urine volume discharged from the NT was recorded, and the patency of the NT was evaluated, and kidney function tests were performed.

2.4. Component analysis of the crust

The collected NTs were cut open with scissors to obtain any crust (Fig 1). The composition of the crust was then analyzed using an infrared spectrum automatic analysis system (Tianjin Energy Spectrum Technology Co., Ltd, Tianjin, China). An NT was considered positive for the presence of crust if the amount of crust collected was enough for composition analysis; otherwise, the NT was considered negative for the presence of crust.

2.5. Statistical analysis

All statistical analyses were performed using SPSS version 17.0 (SPSS Inc., Chicago, Illinois). The skewness of distribution data was expressed as full distance (median), and variables with normal distribution were expressed as mean ± standard deviation (SD). A t test was used for intergroup comparisons of variables with normal distribution. P values < .05 were considered statistically significant.

3. Results

3.1. Patients

A total of 46 NTs were collected from 46 consecutive patients (19 men; 27 women; mean age 68.5 ± 13.4 years). Table 1 summarizes the clinical characteristics of all study patients. No patient has procedure related complication.

3.2. Crust in the NTs

Among the 46 NTs, 20 (43.5%) were positive for the presence of crust, and the remaining 26 (56.5%) were negative for the presence of crust. The mean indwelling time of NTs positive for crust was significantly longer than the indwelling time of those negative for crust (169.7 ± 55.7 days vs 86.5 ± 15.0 days; $P < .01$). The gender and indication of PCN insertion between 2 groups were not statistically significant ($P > .05$).

Analysis of the crust from the 20 positive NTs demonstrated that the composition of the crust was mixed in 11 NTs (55.0%; apatite carbonate and magnesium ammonium phosphate hexahydrate or apatite carbonate and calcium oxalate monohydrate) and consisted of a single component in 9 NTs (45.0%; apatite carbonate, anhydrous uric acid, or calcium oxalate monohydrate) (Table 2).

4. Discussion

In this study, crust was observed in 43.5% of NTs, and the mean indwelling time was significantly longer in NTs with crust than in those without. The crust was composed of either mixed components (apatite carbonate and magnesium ammonium phosphate hexahydrate or apatite carbonate and calcium oxalate monohydrate) or a single component (apatite carbonate, anhydrous uric acid, or calcium oxalate monohydrate).

Many diseases can induce obstructive nephropathy, with affected patients often needing to undergo PCN, a minimally invasive procedure, to conserve kidney function.[4,7–10] In this

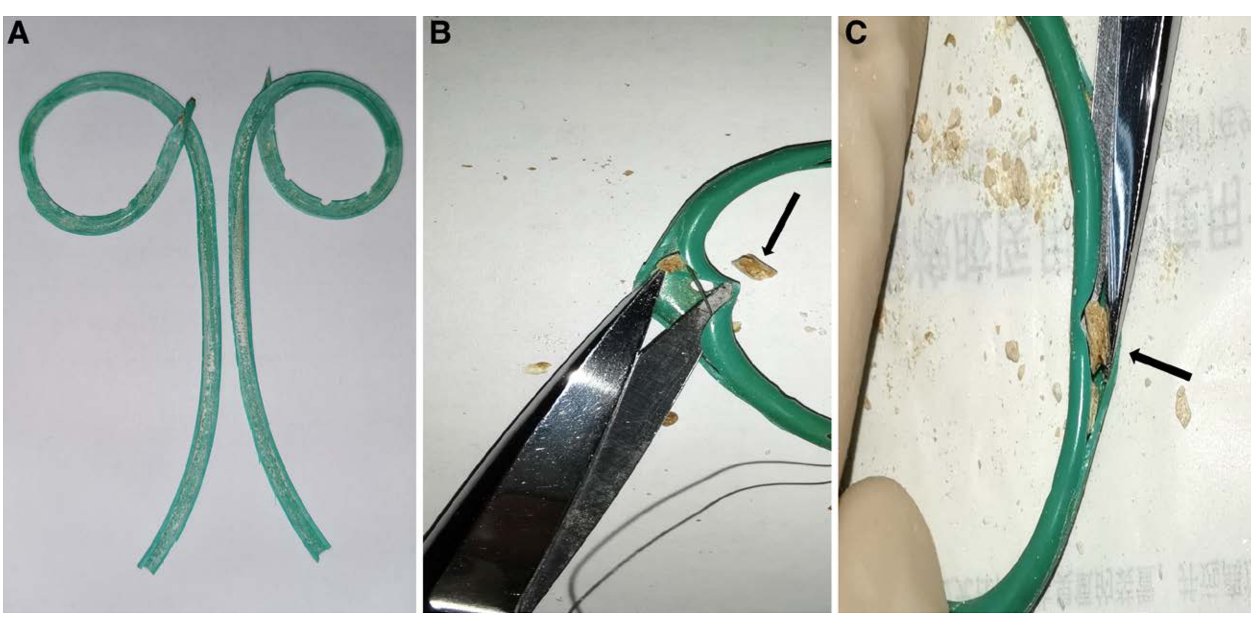

Figure 1. (A) A nephrostomy tube that was cut open and found to be negative for the presence of crust. (B and C) A nephrostomy tube that was cut open (B) and found to be positive for the presence of crust (C) (arrows).

Table 1

Clinical characteristics of study patients (N = 46).

Characteristic	Value
Mean age ± SD, yr (range)	68.5 ± 13.4 (46–89)
Sex, n (%)	
Male	19 (41.3)
Female	27 (58.7)
Primary disease causing obstructive nephropathy, n (%)	
Cervical cancer	18 (39.1)
Bladder cancer	11 (23.9)
Ureteral calculi	10 (21.8)
Sigmoid colon cancer	7 (15.2)
Side of percutaneous nephrostomy, n (%)	
Left side	24 (52.2)
Right side	18 (39.1)
Bilateral	4 (8.7)
Median indwelling time, d (Q1, Q3)	96 (90, 140)
Crust in the nephrostomy tube, n (%)	
Positive	20 (43.5)
Negative	26 (56.5)

Table 2

Components of crust in nephrostomy tubes (N = 20).

Components of crust	n (%)
Mixed components	11
Apatite carbonate and magnesium ammonium phosphate hexahydrate	7 (63.6)
Apatite carbonate and calcium oxalate monohydrate	4 (36.4)
Single component	9
Apatite carbonate	5 (55.6)
Anhydrous uric acid	2 (22.2)
Calcium oxalate monohydrate	2 (22.2)

study, obstructive nephropathy was mainly caused by cancer, especially cervical cancer and bladder cancer; obstructive nephropathy was less commonly caused by a benign disease process (i.e., ureteral calculus).

In patients who undergo PCN for the treatment of obstructive nephropathy, chronic obstruction of the NT placed during the procedure can be caused by the formation of crust in the tube.[11,12] To prevent this occurrence, NTs should be exchanged regularly. However, many patients do not present for NT exchange at the correct time, especially in developing countries, which can lead to chronic obstruction of the NT and further impairment in kidney function.[1,5,6] Although the median indwelling time of NTs was approximately 3 months in this study, some NTs remained in place for up to 1 year because of poor patient compliance. This resulted in a wide range of indwelling times. The potential financial burden of undergoing NT exchange may be 1 reason for this lack of patient compliance.

In this study, the mean indwelling time of NTs that were positive for crust was significantly longer than the indwelling time of NTs that were negative for crust. This suggests that a longer indwelling time is associated with a higher risk of crust formation. In light of this finding, it is recommended that NTs should be exchanged regularly (every 3–4 months) to prevent chronic obstruction caused by the formation of crust.

Although the composition of urinary calculi is well known, the composition of crust in NTs was previously unreported. In the current study, crust was most commonly found to be composed of apatite carbonate plus magnesium ammonium phosphate hexahydrate, followed by apatite carbonate, apatite carbonate plus calcium oxalate monohydrate, anhydrous uric acid, and calcium oxalate monohydrate. These findings suggest that the composition of crust in NTs is similar to that of urinary calculi, as apatite carbonate accounts for approximately 10% of urinary calculi, and calcium oxalate monohydrate accounts for approximately 80% of urinary calculi.[13,14] Apatite carbonate may be seen in patients with urinary tract infection and obstruction, whereas calcium oxalate monohydrate is usually seen in patients with a high concentration of oxalate in the urine.[13,14] The synthesis of anhydrous uric acid is related to abnormal purine metabolism.[13,14] The presence of magnesium ammonium phosphate hexahydrate is caused by urease produced by bacteria in the urinary tract. This urease can catalyze the decomposition of urea into ammonia and carbon dioxide; ammonia and water combine to synthesize ammonium hydroxide, which is an alkaline substance and therefore can substantially increase the pH of urine.[13,14] When the urine pH value is 7.2, ammonium ions can combine with magnesium and phosphate radicals to create magnesium ammonium phosphate.[13,14]

The results of this study suggest that the formation of crust in the NT is similar to the formation of urinary calculi. Thus, the methods used to prevent the formation of urinary calculi should also be effective in preventing the formation of crust in NTs. These methods may include preventing the occurrence of urinary tract infection, instructing the patient to drink more water to help with urinary excretion, and adjusting the diet of the patient to keep the body in balance.[7,15]

This study was limited by its small sample size. In addition, most study patients had obstructive nephropathy caused by tumors; changes in the diets of patients with tumors may influence urine composition, which may in turn affect the formation of crust. Larger studies in more varied patient populations are needed to confirm these initial results. Finally, the urine bacterial cultures were performed in 6 patients only and all were negative, thus, we did not mention it in the result and discuss sections.

In conclusion, this study found that an NT indwelling time longer than 3 months was associated with a higher risk of crust formation. Crust in NTs was most commonly composed of components similar to those seen in urinary calculi. In light of these findings, we suggest that NTs should be exchanged every 3 to 4 months to prevent the formation of crust and thus prevent obstruction of the NT. Additionally, a stent with a tapering configuration or a newer-generation stent with better flexibility and weaker radial force may be appropriate options in this patient population.

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