CLINICAL STUDY

Long-Term Percutaneous Nephrostomy Management of Malignant Urinary Obstruction: Estimation of Optimal Exchange Frequency and Estimation of the Financial Impact of Patient Compliance

Joseph L. McDevitt, MD, MBA, Stefany Acosta-Torres, MD, Ning Zhang, MD, Tianshen Hu, MD, Ayobami Odu, MBBS, Jijia Wang, MS, Yin Xi, PhD, Daniel Lamus, MD, David S. Miller, MD, and Anil K. Pillai, MD

ABSTRACT

Purpose: To estimate the least costly routine exchange frequency for percutaneous nephrostomies (PCNs) placed for malignant urinary obstruction, as measured by annual hospital charges, and to estimate the financial impact of patient compliance.

Materials and Methods: Patients with PCNs placed for malignant urinary obstruction were studied from 2011 to 2013. Exchanges were classified as routine or due to 1 of 3 complication types: mechanical (tube dislodgment), obstruction, or infection. Representative cases were identified, and median representative charges were used as inputs for the model. Accelerated failure time and Markov chain Monte Carlo models were used to estimate distribution of exchange types and annual hospital charges under different routine exchange frequency and compliance scenarios.

Results: Long-term PCN management was required in 57 patients, with 87 total exchange encounters. Median representative hospital charges for pyelonephritis and obstruction were 11.8 and 9.3 times greater, respectively, than a routine exchange. The projected proportion of routine exchanges increased and the projected proportion of infection-related exchanges decreased when moving from a 90-day exchange with 50% compliance to a 60-day exchange with 75% compliance, and this was associated with a projected reduction in annual charges. Projected cost reductions resulting from increased compliance were generally greater than reductions resulting from changes in exchange frequency.

Conclusions: This simulation model suggests that the optimal routine exchange interval for PCN exchange in patients with malignant urinary obstruction is approximately 60 days and that the degree of reduction in charges likely depends more on patient compliance than exact exchange interval.

ABBREVIATION

PCN = percutaneous nephrostomy

Percutaneous nephrostomy (PCN) is often employed for relief of malignant urinary obstruction (1). The rate of placement success (84%–99%) and periprocedural complications, such as sepsis and vascular injury, are well documented (2). Data regarding complications after discharge and best practices for long-term management are limited (1). Complications that occur after discharge include catheter dislodgment, catheter obstruction, and infection,

From the Department of Radiology (J.L.M., N.Z., T.H., A.O., J.W., Y.X., D.L.), and Division of Gynecologic Oncology (D.S.M.), Department of Obstetrics and Gynecology (S.A.-T.), University of Texas Southwestern Medical Center, 5323 Harry Hines Boulevard, Dallas, TX 75235; and Division of Vascular and Interventional Radiology (A.K.P.), Department of Diagnostic and Interventional Imaging, University of Texas Health Sciences Center at Houston, Houston, Texas. Received December 12, 2016; final revision received February 19, 2017; accepted February 22, 2017. **Address correspondence to** J.L.M.; E-mail: josephlmcdevitt@icloud.com

None of the authors have identified a conflict of interest.

Tables E1 and E2 are available online at *www.jvir.org*.

J Vasc Interv Radiol 2017; ■*:1–7*

http://dx.doi.org/10.1016/j.jvir.2017.02.031

which can result in life-threatening pyelonephritis (1,3,4). The literature lacks evidence-based guidelines on the optimal frequency of PCN exchanges, and current recommendations are based on expert opinion (1,4,5). The most recent Society of Interventional Radiology (SIR) and American Urologic Association guidelines do not provide guidance for management after procedures or a recommended exchange frequency (2,6,7). Patients with PCN-related pyelonephritis are at high risk for complicated pyelonephritis associated with increased risk of severe complications, which is often further exacerbated by immunosuppression secondary to antineoplastic chemotherapy (8). Consequently, there is an opportunity for interventional radiologists, gynecologic oncologists, and urologists to improve quality of life of these patients and to reduce preventable health expenditures via active surveillance and exchange of nephrostomy tubes at a data-driven interval. Thus, in the present study, a simulation was designed based on retrospective data to identify the routine exchange frequency that would minimize costs associated with long-term PCN management for patients with malignant obstruction and to quantify the financial impact of patient compliance.

MATERIALS AND METHODS

Data Collection

The study was approved by the institutional review board and was compliant with the Health Insurance Portability and Accountability Act. Retrospective review of all patients who underwent placement of a PCN for malignancy-related obstruction with at least 1 subsequent exchange from January 2011 to December 2013 was performed. Placement and exchange procedures were identified by the Current Procedural Terminology codes 50392 and 50398, respectively. Patients with malignancies were identified via codes from the International Classification of Diseases, Ninth Revision, and reviewed to determine if they had malignancy-related urinary obstruction. Patients with nonmalignant obstruction and patients who underwent PCN placement but did not require subsequent exchange, such as patients who needed the PCN only temporarily or patients who died within several months of placement, were not included. Periprocedural complications (within 48 h) were excluded from analysis, as the goal of the study was to determine optimal exchange frequency once a PCN was in place and the periprocedural period was completed.

Inclusion criteria were met by 57 patients with malignant urinary obstruction. There were 41 (72%) female patients, and the mean age at placement was 48 years (range, 21–79 y). Malignancies included cervical cancer in 26 (46%) patients, colorectal cancer in 6 (11%) patients, prostate cancer in 6 (11%) patients, bladder cancer in 4 (7%) patients, lymphoma in 3 (5%) patients, ovarian cancer in 3 (5%) patients, breast cancer in 2 (4%) patients, endometrial cancer in 2 (4%) patients, uterine sarcoma in 2 (4%) patients, appendiceal cancer in 1 (2%) patient, cloacogenic carcinoma in 1 (2%) patient, and renal cell carcinoma in 1 (2%) patient.

All exchanges meeting the above-mentioned criteria were retrospectively reviewed. Exchanges were classified as follows: (*i*) routine (no identifiable complication before exchange), (*ii*) mechanical complication (tube dislodgment), (*iii*) obstruction (without pyelonephritis), and (*iv*) infection (pyelonephritis, with or without concomitant obstruction). Hospital encounter–level charge data were then obtained. As charges were available only at the encounter level, charges related to complications and exchanges were assessed at the per-patient level rather than the per-nephrostomy level. Time to exchange was defined as the time in days between the date of the exchange and the most recent placement or exchange.

Given the heterogeneity in encounters, representative cases were defined to determine cost inputs for each exchange type in the simulation model. For example, including total encounter charges for patients who were admitted for further surgery, chemotherapy, or postsurgical complications, such as abscess or small bowel obstruction, and subsequently developed a PCN-related complication while an inpatient would overestimate the costs attributable to the patient's PCN-related complication. Thus, in consultation with the referring services, the following criteria were developed to define a representative encounter for cost analysis: (*a*) chief complaint was related to PCN and (*b*) no surgery or antineoplastic chemotherapy was provided. The median of the charges from the representative encounters was used to represent the costs associated with each exchange type in the simulation model. A sample hospital bill for each type of representative exchange encounter is presented in **Tables E1a–d** (available online at *www.jvir.org*). During the years included for retrospective review, the general recommendation to referring services was that the patient return in 3 months for PCN exchange, although scheduling was at the discretion of the referring service.

Statistical Analysis

A cause-specific survival analysis was performed to estimate the distributions of time to each complication type from the retrospectively collected data (9). Specifically, each type of complication was analyzed using an accelerated failure time model (10–12) in which all other complications and routine exchanges were treated as censored cases. Weibull distribution was assumed for the time to each type of complication so that the error term followed extreme value distributions (13). Parameters for the accelerated failure time model were then produced for each exchange type based on the complication distribution observed in the patient sample (**Table E2** [available online at *www.jvir.org*]). Independence was assumed both between consecutive follow-up evaluations and among patients.

The effect of routine exchange was then considered. To account for real-world scheduling variability, for patients who were simulated to be compliant with routine exchange, the actual time to routine exchange was assumed to be a