Does Peak Inspiratory Pressure Increase in the Prone Position? An Analysis Related to Body Mass Index

Michael Siev, Piruz Motamedinia, David Leavitt, Mathew Fakhoury, Kevin Barcohana, David Hoenig, Arthur D. Smith and Zeph Okeke*

From the Smith Institute for Urology and Department of Anesthesia (KB), NorthShore-LIJ Health System, New Hyde Park, New York

Abbreviations and Acronyms

ARDS = acute respiratory distress syndrome

BMI = body mass index

PCNL = percutaneous nephrolithotomy

PIP = peak inspiratory pressure

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* Correspondence: 450 Lakeville Rd., Suite M41, New Hyde Park, New York 11042 (telephone: 516-734-8500; FAX: 516-734-8537; e-mail: zokeke@nshs.edu).

Purpose: Percutaneous nephrolithotomy is commonly performed with the patient prone. There is concern that the prone position, especially in obese patients, negatively affects ventilation due to the restriction of chest compliance and respiratory mechanics. We analyzed the change in airway resistance between supine and prone positioning of patients undergoing percutaneous nephrolithotomy.

Materials and Methods: We retrospectively reviewed the intraoperative respiratory parameters of 101 patients who underwent prone percutaneous nephrolithotomy. Peak inspiratory pressure was assessed with the patient supine, at several time points after being turned prone and at the end of the case. The change in peak inspiratory pressure with time was calculated. Results were stratified based on body mass index and data were compared using the paired t-test and Spearman ρ.

Results: Of 101 patients 50 (50%) were obese (body mass index 30 kg/m^2 or greater). Median body mass index was 25.6 kg/m^2 in the nonobese cohort and 38.3 kg/m^2 in the obese cohort. Average peak inspiratory pressure while supine and prone was 18.0 and 18.5 cm H_2O in the nonobese cohort, and 25.5 and 26.6 cm H_2O, respectively, in the obese cohort. Obese patients had significantly higher peak inspiratory pressure in the supine and the prone positions relative to nonobese patients ($p < 0.0001$). However, there was no change in peak inspiratory pressure from the supine to the prone position in either cohort.

Conclusions: Obese patients have higher baseline peak inspiratory pressure regardless of position. However, prone positioning does not impact peak inspiratory pressure in either cohort. It remains a safe and viable option.

Key Words: kidney; nephrostomy, percutaneous; obesity; inhalation; patient positioning

Since it was first described in 1976,[1] PCNL has traditionally been performed with the patient in the prone position to facilitate access to the calyces and provide a wide field for instrumentation. More recently supine positioning has been described as an alternative[2] under the assumptions of better airway control during surgery as well as the ability to simultaneously perform ureteroscopic procedures.[3] There is currently debate in the literature over optimal patient positioning during PCNL, particularly regarding obese patients. One often cited justification in preferring the supine position in obese patients is respiratory mechanics, although there is no solid evidence to make this claim.

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Some have posited that supine positioning is safer for the obese patient with fewer cardiovascular effects and better ventilation.[4] They hypothesize that the prone position results in limited space for chest expansion and elevated airway pressure but data substantiating this claim are limited. There have been studies of changes in hematological and metabolic parameters in prone vs supine PCNL.[5,6] Al-Dessoukey et al compared airway pressure between oblique supine lithotomy and prone positioning.[7] However, they did not examine the effects of BMI on ventilation and reported ventilatory parameters at a single time point rather than the change with the change in position and throughout the procedure.

PIP is a ventilatory parameter that combines resistive airway pressure, elastic airway pressure and positive end expiratory pressure. An increase in PIP represents an increase in resistance or decrease in compliance of the respiratory system.[8] Despite the lack of a uniform consensus safe PIP is usually defined as less than 35 cm H_2O.[9] Elevated PIP (greater than 40 cm H_2O) can indicate inadequate ventilation or the potential for barotrauma if sustained.[10] As such it is a useful indicator of ventilation.

To our knowledge there have been no studies tracking incremental changes in individual patient ventilatory parameters throughout PCNL. We sought to do so by comparing the PIP of obese and nonobese patients undergoing PCNL. The aim of this study was to compare changes in PIP vs BMI at various time points throughout PCNL.

PATIENTS AND METHODS

In this institutional review board approved, retrospective chart review all PCNL procedures performed between June 2014 and mid January 2015 were analyzed. Cases performed prior to our included dates did not actively chart airway pressures in the anesthesia record and were excluded from study. All cases were performed by 1 of 3 high volume, fellowship trained endourologists (DH, ZO and ADS) at a single institution. Patient demographics, perioperative characteristics, postoperative complications and ventilatory parameters were retrospectively recorded. In consultation with an anesthesiologist (KB) PIP was recorded with the patient in the supine position and then again 1, 5, 10 and 20 minutes after prone positioning. PIP was also recorded at the completion of the case before patient repositioning to the supine position for extubation. Operative time included patient repositioning prone, percutaneous access, stone clearance and drain placement. Patients were excluded from study if they were younger than 18 years or they lacked anesthesia records.

Ventilatory parameters were recorded using the CompuRecord® Perioperative System anesthesia console. All patients were induced and intubated in the supine position. Patients then underwent cystoscopy and ureteral catheterization in the dorsal lithotomy or prone position according to operating surgeon preference prior to the commencement of PCNL. All PCNLs were performed with the patient prone. Percutaneous access was obtained under fluoroscopic guidance in all cases. Tract dilation was done with Amplatz renal dilators (Cook® Medical) or X-Force® balloon dilators according to surgeon preference. A 26Fr rigid nephroscope, a CyberWand™ ultrasonic lithotripter and stone graspers were used for stone clearance in all cases. Flexible nephroscopy and antegrade ureteroscopy were performed as needed.

Postoperative renal drainage was left to the discretion of the operating surgeon. All patients were monitored in the hospital at least 2 nights postoperatively and longer as medically necessary. Complications were graded according to the modified Clavien-Dindo classification.[11]

BMI in kg/m^2 was categorized based on WHO criteria with obesity defined as BMI 30.0 kg/m^2 or greater and nonobese defined as BMI 29.9 kg/m^2 or less.[12] Data were analyzed using STATA® and Prism® 6. The paired t-test and ANOVA with the Bonferroni post hoc test were used to compare means, the Mann-Whitney-Wilcoxon U test was used to compare medians and the Fisher exact test was used to compare frequencies. Spearman ρ was used to demonstrate correlations between 2 groups. A ρ of closer to 1 can be interpreted as a more perfect correlation (-1 for a negative correlation) vs zero for a less perfect correlation.

RESULTS

A total of 109 patient charts were reviewed. Eight cases (7.3%) were excluded from analysis because they lacked anesthesia records. Of the 101 patients included in study 57 (56%) were male. Median age was 58 years (IQR 47–66) and median BMI was 29.4 kg/m^2 (IQR 25.2–37.6). Mean $\pm$ SD operative time was 92 ± 50 minutes and mean estimated blood loss was 133 ± 112 ml. The supplementary table (http://jurology.com/) lists patient demographics, comorbidities and operative parameters. There was 1 pulmonary complication in an obese patient (BMI 45.5 kg/m^2), which was related to self-extubation following an otherwise unremarkable procedure.

Increased BMI was significantly associated with higher PIP in the supine and prone positions ($\rho = 0.69$ and 0.67, each $p < 0.001$). As such PIP was significantly higher in obese patients than in nonobese patients throughout the procedure (see figure). However, there was no significant change in PIP from the supine to the prone position at any time point in either group (see table).

DISCUSSION

PIP is the highest pressure generated by the ventilator during inflation of the lung, although it is not equal to the air pressure that reaches the alveoli.[13]