

The Debate Over Percutaneous Nephrolithotomy Positioning: A Comprehensive Review

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Abbreviations and Acronyms

BMI = body mass index
CT = computerized tomography
PNL = percutaneous nephrolithotomy

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Purpose: We summarized the arguments for and against prone and supine percutaneous nephrolithotomy, and determined whether any clinical characteristics warrant 1 position over the other.

Materials and Methods: We searched PubMed® for articles on prone anesthesia, abdominal organ movement between the prone and supine positions, and percutaneous nephrolithotomy case series since 1998.

Results: The prone position is associated with a decrease in the cardiac index and an increase in pulmonary functional residual capacity. An increased risk of liver and spleen injury exists for upper pole puncture with the patient supine. Potential injury to the colon is greatest during prone lower pole access. A greater surface area for percutaneous access exists with the patient prone. The supine position decreases surgeon radiation exposure and promotes spontaneous stone drainage during the procedure. Two comparative series show that the supine position is associated with significantly shorter operative time. In contrast, noncomparative case series suggest decreased operative time and blood loss when treating staghorn calculi with the patient prone.

Conclusions: Each position is feasible but more randomized studies are needed to accurately determine the relative efficacy and morbidity of the 2 positions.

Key Words: kidney; kidney calculi; nephrostomy, percutaneous; patient positioning; intraoperative complications

THE transition from open surgery to minimally invasive management for renal calculi began with the report by Goodwin et al of percutaneous nephrostomy tube placement,¹ and the description by Fernstrom and Johansson of percutaneous tract dilation for stone extraction.² During the next 3 decades advances in equipment and technique allowed PNL to become the first line treatment modality for large, complex and staghorn calculi.³

PNL was initially described and became firmly established with the patient in the prone position. However, in 1987 Valdivia-Uria et al reported a feasibility study of supine

PNL in cadavers.⁴ In 1998 they reported on more than 500 patients treated via supine access.⁵ Multiple supine studies have subsequently been published with various modifications, most notably the Galdakao modified supine Valdivia position. In this position the patient is in a modified lithotomy position, allowing simultaneous antegrade and retrograde intrarenal access.⁶

The growing number of supine PNL studies has sparked debate in the urological literature on optimal patient positioning. Most studies of the topic are retrospective case series by groups arguing for the prone or the supine technique. Several review ar-

ticles highlight the principal arguments on each side of the debate.^{7,8} However, recommendations to help guide urologists have largely not been made despite the undeniable fact that each approach is feasible.

We detail the purported pros and cons of prone and supine renal access. The veracity of these arguments was evaluated by reviewing the medical literature. Finally, we make evidence-based recommendations that consider patient clinical characteristics.

MATERIALS AND METHODS

We searched PubMed for published articles on physiological changes occurring with prone anesthesia and for articles on changes in liver, spleen and colon position between the prone and supine positions. PubMed was also searched for articles published since 1998 on PNL done with the patient prone or supine. We chose 1998 because this was the year the initial supine PNL case series by Valdivia-Uria et al was published.⁵ The search focused primarily on original articles but review articles were included. NonEnglish articles and letters to the editor were excluded from study.

RESULTS

Commonly cited arguments on PNL patient positioning can be combined into certain general categories, including anesthetic considerations, visceral injury risk and collecting system access options.

Anesthetic Considerations

Various physiological changes occur upon transferring the patient from the supine to the prone position. Many proponents of the supine approach argue that these changes place patients at increased risk for cardiovascular, pulmonary, neurological and ophthalmic injury during prone PNL.

In a study of 16 patients with cardiovascular disease the prone position was associated with a mean 24% decrease in the cardiac index.⁹ However, mean arterial pressure was unchanged as a result of a compensatory increase in peripheral vascular resistance. Several other studies also demonstrate a decreased cardiac index with preserved systolic blood pressure.¹⁰ This hemodynamic response is believed to result from the combination of increased intrathoracic pressure and decreased venous return secondary to inferior vena caval compression.

The effects of prone positioning on pulmonary function have also been extensively studied. Pelosi et al found an improvement in functional residual capacity and oxygenation in 17 healthy patients undergoing elective spinal surgery.¹¹ They noted similar results the following year in 10 obese patients.¹² Improved oxygenation while prone is thought to be due to preferential perfusion of dependent lung positions, resulting in improved ventilation/perfusion matching.

Although central nervous system injury is exceedingly rare, it was reported when transferring the patient from the supine to the prone position.¹⁰ Various causes have been implicated, including vertebral and carotid artery occlusion, venous sinus thrombosis and cervical spine injury for excessive neck flexion/extension. Postoperative vision loss was also reported in the prone position due to increased intraocular pressure, which can cause ischemic optic neuropathy or central retinal artery occlusion.¹⁰ Of 9,285 patients undergoing a total of 11,942 spinal procedures, most while prone, none experienced postoperative vision loss greater than 30 days in duration.¹³ In 8 patients transient vision loss completely resolved by 1 month after surgery. Risk factors for postoperative vision loss regardless of surgical position included cardiac surgery (75 times more likely), diabetes, intraoperative hypotension, prolonged surgical duration (greater than 4 hours) and peripheral vascular disease.

Independent of potential physiological changes prone PNL requires transferring the patient from the supine position, placing the patient at risk for accidental extubation and inadvertent removal of vascular lines. Extreme care must be taken to avoid these untoward events. Operating room staff must also exercise caution when moving obese patients to avoid personal injury.

In summary, the majority of reported complications attributable to the prone position have been published in the neurosurgical and orthopedic literature. In most patients who experienced adverse events operative time was much longer than that of the average PNL. In 2 studies of complications after PNL, each in more than 1,000 patients, no complications were attributable to prone physiological changes.^{14,15} It is our practice to have morbidly obese patients lie prone before undergoing general anesthesia. Patients who become dyspneic are treated in the lateral decubitus position.

Risk of Visceral Injury

Establishing a percutaneous access tract into the renal collecting system carries inherent danger to adjacent organs, most notably the colon, liver and spleen. A retrorenal position places these organs at highest risk for injury. In 1987 Hopper et al retrospectively evaluated the position of the ascending and descending colon in 500 supine abdominal CTs.¹⁶ An ascending retrorenal colon was found adjacent to the upper pole, mid kidney and lower pole in 0%, 0% and 7.5% of cases, respectively. The descending colon was retrorenal in 0%, 0.4% and 9.3% of patients adjacent to the upper pole, mid kidney and lower pole, respectively.

Punwani et al evaluated changes in colon position between the prone and supine orientations, and

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