Supracostal punctures in supine percutaneous nephrolithotomy are safe

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Introduction: *The feasibility and safety of supracostal punctures in supine percutaneous nephrolithotomy (PCNL) are still controversial. In this study we aim to compare success and complication rates from prone and supine PCNL with at least one supracostal puncture.*

Material and methods: *We reviewed our electronic database for all supracostal PCNLs performed in our institution from February 2008 to September 2013. Patients were enrolled in the study if at least one supracostal puncture was required during surgery. Patients' demographics data, stone characteristics, intra and postoperative data, and success on first postoperative day CT were compared.*

Results: *A total of 132 procedures were included in the analysis. Twenty-eight PCNLs were performed in supine position (21.2%), while 104 were done in prone position (78.8%). Patient's demographics and distribution of stones based on Guy's Score were similar between groups. Mean operative time and blood transfusion rate were not statistically different. There was no significant difference in the success rate (63.5% prone versus 71.4% supine, p = 0.507). Major complication rate (Clavien ≥ 3) was 16.3% in the prone group versus 3.6% in the supine group (p = 0.119).*

Conclusions: *Supracostal punctures are safe and feasible in supine PCNL. It does not add additional risks and might provide equivalent success rates when compared to prone PCNLs.*

Key Words: complications, kidney calculi, lithotripsy, urolithiasis

Introduction

Percutaneous nephrolithotomy (PCNL) is the gold standard procedure for treatment of kidney stones greater than 2.0 cm in diameter.[1,2] Despite being considered a minimally invasive technique, it is associated with considerable morbidity. A global study conducted by the Endourological Society (CROES PCNL global study) reported a complication rate of 20.5% among 5,803 patients worldwide.[3]

Although traditionally performed in prone position, recent studies suggesting advantages of the supine position have been published, encouraging urologists to adopt the supine position in their medical practice. Less operative time, the possibility of performing a simultaneous retrograde approach, and more comfort to the surgeon during the procedure have increased the popularity of supine PCNL in the last few years.[4-6] From the anesthesiologists point-of-view, the supine position is associated with less respiratory complications, as it provides an easier management of the airways. Furthermore, it has an lower risk of injuries in pressure dependent areas, as well as a reduced chance of ocular damage.[7]

On the other hand, treating upper pole kidney stones with supine PCNL remains controversial among surgeons. Some urologists advocate that supine PCNL does not provide adequate access to the stones located in the upper pole and that high punctures are less likely to result in complications in prone position.[4,8] Furthermore, previous studies have shown higher stone-free rates in the treatment of complex cases (staghorn calculi) in the prone position.[8]

In order to address the feasibility and safety of supracostal punctures in supine PCNL, we aim to compare success and complication rates from prone and supine PCNL with at least one supracostal puncture.

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Materials and methods

We retrospectively reviewed our electronic database searching for all patients who underwent PCNL at our institution from February 2008 to September 2013. Patients were enrolled in the study if at least one supracostal puncture was performed during the surgery. Exclusion criteria were patients under 18 years old, patients with renal abnormalities (i.e. pelvic/horseshoe kidneys), and patients with incomplete data or inadequate follow up. Computed tomography (CT) scan is routinely performed at our institution in the first postoperative day to assess residual stone fragments.

All procedures were performed in a high-volume urology center, with over 150 PCNL cases per year. Approximately 30% of the cases are performed in the supine position, and supracostal punctures are used in 15% of the time. Supine and prone PCNLs were routinely performed according to the surgeon's preference. Patients who underwent supine PCNL were either placed in lithotomy position or in complete supine position, based on the requirement of concomitant ureteral procedure.[5,9] Urologists, guided by fluoroscopy, performed all punctures.

Patients' demographics data, American Society of Anesthesiologists (ASA) score, previous surgeries, stone side and stone characteristics (classified by the Guy's Score), operative time (from the beginning of the cystoscopy until nephrostomy placement or skin closure), blood transfusion rate, success (residual fragments ≤ 4 mm on first postoperative day CT scan) and complication rates were recorded and compared based on patients' position.[10,11] Major complications were defined as those classified as Clavien ≥ 3.

Categorical variables were compared with chi-square and Fisher exact test, as appropriate; continuous variables were compared using Student t test for independent groups, after normality testing. All statistical analysis was performed using SPSS version 20.0 (SPSS Inc. Chicago, IL, USA). Significance level was set at $p < 0.05$, and all tests were two-tailed.

Results

From February 2008 to September 2013, 905 PCNLs were performed at our institution. At least one supracostal puncture was required in 139 procedures (15.3%). Seven patients were excluded from the analysis because of incomplete medical records or loss of follow up. Twenty-eight procedures were performed in supine position (21.2%), while 104 were done in prone position (78.8%).

Patients' demographic data and stone characteristics are summarized in Table 1. Age, gender, body mass index, ASA score and prevalence of previous surgeries were similar between groups. Distribution of stones according to Guy's Score was not statistically different

TABLE 1. **Patient demographic and clinical characteristics**

	Prone (n = 104)	**Supine (n = 28)**	**p value**
Age (years) mean (SD)	44.98 (12.9)	45.89 (12.0)	0.738
Gender (male %/female %)	40 (38.5)/64 (61.5)	11 (39.3)/17 (60.7)	1.000
BMI (kg/m^2) mean (SD)	28.67 (7.0)	28.42 (6.2)	0.870
Obesity (%)	37 (35.6)	9 (32.1)	0.735
ASA score (%)			0.185
ASA 1	47 (45.2)	16 (57.1)	
ASA 2	47 (45.2)	12 (42.9)	
ASA 3	10 (9.6)	0	
Previous surgery (%)	23 (22.1)	6 (21.4)	1.000
Side (right %/left %)	56 (53.8)/48 (46.2)	15 (53.6)/13 (46.4)	1.000
Guys score (%)			0.133
Guys 1	8 (7.7)	5 (17.9)	
Guys 2	30 (28.8)	3 (10.7)	
Guys 3	33 (31.7)	11 (39.4)	
Guys 4	33 (31.7)	9 (32.1)	
Complex cases (%)	66 (63.5)	20 (71.4)	0.507

BMI = body mass index; ASA = American Society of Anesthesiologists score; SD = standard deviation

TABLE 2. **Intraoperative and postoperative data**

	Prone (n = 104)	Supine (n = 28)	p value
Operative time (min) mean (SD)	163.3 (66.7)	160.1 (56.8)	0.817
Upper calyx puncture (%)	49 (47.1)	10 (35.7)	0.281
Multiple punctures (%)	37 (35.6)	15 (53.6)	0.126
Tubeless (%)	15 (14.4)	3 (10.7)	0.612
Overall complications (%)	41 (39.4)	8 (28.6)	0.379
Complications - Clavien ≥ 2 (%)	20 (19.2)	4 (14.3)	0.783
Complications - Clavien ≥ 3 (%)	17 (16.3)	1 (3.6)	0.119
Blood transfusion (%)	11 (10.6)	3 (10.7)	1.000
Thoracic complications (%)	26 (25)	3 (10.7)	0.128
Thoracic complications requiring intervention (%)	9 (8.7)	0	0.203
Visceral lesions (%)	1 (0.96)	1 (3.57)	0.381
Success (%)	66 (63.5)	15 (71.4)	0.507

SD = standard deviation

between groups (p = 0.133). As expected in surgeries requiring supracostal punctures, a higher (but not significantly different) prevalence of complex cases (Guys 3 and 4) was observed – 66 patients in the prone group versus 20 in the supine group (63.5% versus 71.4%, p = 0.432).

Intra and postoperative data are described in Table 2. Mean operative time was 163.3 minutes and 160 minutes in the prone and supine groups, respectively (p = 0.801). Surgeries that required multiple punctures were more frequent in the supine group, although it was not statistically different (35.6% versus 53.6%, p = 0.126). Upper calyx punctures were not statistically different among groups (47.1% in the prone group versus 35.7% in the supine group, p = 0.281).

There was no significant difference in the success rate (63.5% prone versus 71.4% supine, p = 0.507). Blood transfusion was required in 11 and 3 patients in the prone and supine groups, respectively (10.6% versus 10.7%, p = 1.000). Major complication rate (Clavien ≥ 3) was 16.3% in the prone group versus 3.6% in the supine group (p = 0.119). Supracostal punctures in supine position did not cause a higher rate of thoracic complications that required medical intervention (8.7% prone group versus 0% supine group, p = 0.203). A similar proportion of tubeless cases was observed in both groups (14.4% in the prone group versus 10.7% in the supine group, p = 0.612). There was one liver injury in each group and both were treated conservatively. There was one death in the prone group, due to complications from chronic hepatitis and coagulopathy. There were no colon injuries. Arteriography embolization was required in one patient with low platelet count in the prone group.

Discussion

Supracostal punctures have been a concern for urologists since the development of the PCNL technique. In 1985, Young and associates described for the first time the use of an intercostal approach to treat challenging kidney and upper ureteral stones.[12] Among 24 patients, 11 had complications following the procedure, one of them requiring thoracentesis. The authors concluded that despite a higher complication rate than the traditional infracostal approach, supracostal punctures can provide benefits for the treatment of upper pole stones, staghorn calculi and upper ureteral stones. Since then, literature reports complication rates ranging from 0 to 37.5% for PCNL requiring intercostal punctures.[13-18] When compared to infracostal approach, the supracostal approach has been associated with a higher incidence of thoracic complications.[17,19] Renal access performed above the 11th rib has also been related to a higher complication rate than punctures done between the 12th and 11th rib.[20]

The posterior portion of the diaphragm arises from the distal ends of the 11th and 12th ribs. Therefore, any puncture performed between the ribs will cross the diaphragm. On the other hand, the posterior pleural reflection crosses the tenth rib in the mid axillary line, and the 12th rib at the lateral border of the sacrospinalis muscle, Figure 1. Consequently, not all punctures will result in pulmonary injuries and pneumothorax.[12]

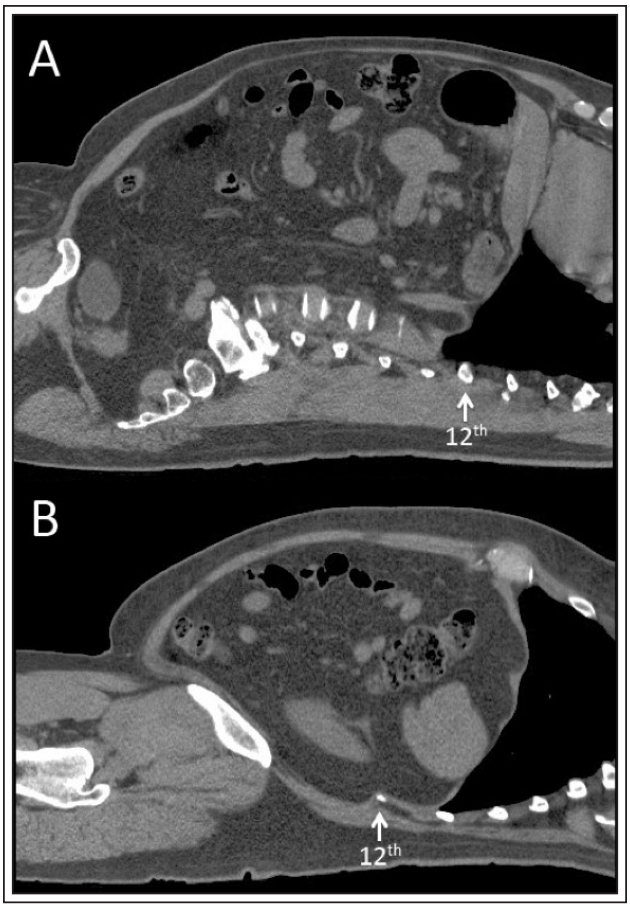

Figure 1. Computed tomography scan showing the relation of ribs to lung and pleura. **A)** Medial slice, adjacent to the spine. **B)** Lateral slice, on the tip of the 12th rib. In both images the 12th rib is marked with an arrow. As the puncture is performed more laterally, safer it is to avoid the pleura.

Possibly mostly because of the training offered nowadays in residency and fellowship programs, the majority of PCNLs in the world are performed in the prone position. The CROES Study reported 19.7% of the PCNLs performed in the supine position throughout the participant centers.[3] After comparing outcomes between positions, Valdivia and colleagues concluded that PCNLs performed in the prone position tend to provide better outcomes for upper pole stones.[4] However, observing closely their data, only 6.7% of the PNCLs in the supine position included a supracostal puncture, opposed to 19.2% of the prone procedures. That reflects the old concern among urologists that the supracostal approach delivers more complications and/or is more difficult to be performed when the patient is lying down on the back. Falahatkar et al published in 2013 a study showing that supracostal punctures in supine position can be avoided with lungs hyperinsuflation.[21] In our supine PCNL cases the supracostal approach was chosen only when the hyperinsuflation technique was not able to avoid a high puncture.

In our study we did not find any difference regarding success and complication rates between both positions, possibly because our data comprises only cases that had a supracostal puncture. Actually, we observed no cases in the supine position that required a thoracic drainage and, despite of not statistically significant, it has a clear clinical significance.

In 1998, Stening and Bourne reported 21 PCNLs with a supracostal approach, without any thoracic complication.[22] All their supracostal punctures were performed close to the lateral half of the 12th rib. Moreover, after comparing medial versus lateral supracostal punctures, Yadav et al reported lower pleural morbidity in lateral supracostal punctures, when compared to medial supracostal punctures.[23] Supine PCNL punctures are by definition performed laterally. In 2015 Marchini and associates demonstrated that kidney relationship to other inter-abdominal organs changes considerably between supine and prone position.[24] They also demonstrated a higher potential of organ injuries in prone position compared to supine position when trying to reach the upper kidney pole. All those studies favor the safety of supine over prone PCNLs, and our findings add more evidence to that.

To our knowledge, our study is the first to compare PCNL positioning including only procedures with at least one supracostal puncture. Previous randomized studies in the literature that compared supine versus prone PCNLs comprised uncomplicated cases only, therefore excluding challenging cases that frequently require a supracostal puncture; or did not explore the differences between high punctures performed in both positions.[6,25-27] Our results come to break down misconceptions regarding the use of supracostal punctures in the supine position and open new possibilities for the treatment of complex kidney stones.

Our study has some limitations that are inherent to its retrospective design. It also comprises only cases from a high volume center, with at least 8 years of experience with supine PCNLs. Therefore, our results might not be easily reproduced in smaller centers. Some of our data did not achieve statistically significant results, maybe because of our sample size

Conclusions

Supracostal punctures are safe and feasible in supine PCNL. It does not add additional risks and might provide equivalent success rates when compared to prone PCNLs. □

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