**ORIGINAL ARTICLE**

**Percutaneous access to the upper calyx with patients in the supine position: an initial experience**

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Percutaneous nephrolithotomy: Supine position; Renal lithiasis; Upper pole

**Abstract**

**Background:** The correct choice for the percutaneous puncture site is key to the success of any percutaneous nephrolithotomy. The ideal puncture should maximize the effectiveness of the procedure in terms of stone-free rate and minimize the risk for complications. It is necessary to correctly choose the calyx to be accessed; in certain cases the upper calyx is the ideal site.

**Aims:** To report our experience with the percutaneous approach to the upper pole with patients in the supine position.

**Methods:** A retrospective, observational, descriptive study was carried out on patients with stones in the renal pelvis or upper calyx treated through percutaneous nephrolithotomy.

**Results:** A total of 17 patients were included in the study, and 17 kidney units were treated. All 17 patients (100%) underwent general anesthesia. Nine (53%) of the patients were men and 8 (47%) were women, with a mean age of 45.8 years (range: 18-72). Stone site was the right kidney in 10 (59%) patients and the left in 7 (41%). A total of 13 (76%) patients were symptomatic. The mean body mass index was 27 kg/m\(^2\) (range: 20-34). ASA classification was I in 13 (76.4%) patients, II in 3 (17.6%) patients, and III in one (5.8%) patient. Eight (47%) patients underwent previous treatments. Procedure success or stone-free rate was achieved in 14 (82.3%) patients with the first treatment and in 17 (100%) with the second treatment.

**Discussion:** Current knowledge of the pleural and diaphragmatic anatomy, the use of real time ultrasound for percutaneous puncture, and the development of new surgical techniques have considerably reduced the risk for intrathoracic complications.
Resumen

Antecedentes: La correcta elección del sitio de punción percutánea es un punto clave para el éxito de cualquier nefrolitotomía percutánea. La punción ideal debe maximizar la efectividad del procedimiento en términos de tasa libre de cálculos y minimizar el riesgo de complicaciones. Es necesario elegir correctamente el cáliz a abordar; en algunas ocasiones el cáliz idóneo es el superior.

Objetivo: Reportamos nuestra experiencia en posición supina en el abordaje percutáneo del polo superior.

Material y método: estudio retrospectivo, descriptivo, observacional. Se incluyeron pacientes con cálculos renales en la pelvis o el cáliz superior que fueron tratados mediante nefrolitotomía percutánea.

Resultados: Se incluyeron un total de 17 pacientes y 17 unidades renales fueron tratadas. Se llevó a cabo anestesia general en las 17 (100%) cirugías. Nueve pacientes eran varones (53%), y 8, mujeres (47%), con una edad media de 45.8 (rango: 18-72) años. Sitio del cálculo derecho/izquierdo: 10 (59%)/7 (41%). Pacientes sintomáticos: 13 (76%). Índice de masa corporal 27 (rango: 20-34) m²sc. ASA I, 13 (76.4%), ASA II, 3 (17.6%), ASA III, uno (5.8%). Ocho pacientes habían sido sometidos a tratamientos previos (47%). Tamaño del cálculo: 28.5 (15-42) mm. Éxito del procedimiento o tasa libre de cálculo: 14 (82.3%) en el primer tratamiento y 17 (100%) en el segundo.

Discusión: El actual conocimiento de la anatomía pleuropulmonal, el uso del ultrasonido en tiempo real para la punción percutánea y el desarrollo de nuevas técnicas quirúrgicas ha reducido notablemente el riesgo de complicaciones intratorácicas.

Conclusión: el acceso al cáliz superior en posición supina es seguro y reproducible. Este acceso ofrece una excelente visión de todo el sistema pielocalicial y solo se debe reservar para casos en donde el cáliz inferior no resulta ser la mejor opción.

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Percutaneous access to the upper calyx with patients in the supine position: an initial experience

Methods

A retrospective, descriptive, observational study was conducted that included a total of 17 patients, and consequently 17 kidney units, diagnosed with kidney stones predominantly in the UC or that had the highest success rate with UC access. The variables included were: age, sex, affected kidney, ASA, body mass index, prior treatment failure, stone size, technique employed for UC puncture, surgery duration, transfusion rate, use of nephrostomy or not, use of Holmium laser or not, success rate, hospital stay, and complications. All the patients were operated on by the same surgeon (JAZG). Patients with incomplete case records or that had 2 or more percutaneous tracts were excluded from the study.

Preoperative protocol

The following studies were done on the patients: Computed axial tomography, urine culture, and preoperative antibiotic management in all patients. Postoperative protocol: Measurements were made using the visual analogue scale for pain, use or administration of simple analgesics for all patients, removal of the nephrostomy tube, and computed axial tomography to evaluate stone clearance (success rate).

Technique

1) Caudal displacement of the lower pole

The previously described position and percutaneous access technique were used. General or regional anesthesia were indiscriminately utilized. The modified Galdakao or Valdivia positions were used. After cystoscopy and the placement of a 6 Fr straight catheter to perform retrograde pyelography or diagnostic flexible ureterorenoscopy, we made an initial subcostal incision to the lower calyx (LC) with an 18 G diamond-tip Chiba needle. We introduced a hydrophilic guidewire and then we shifted the proximal end of the needle in a cephalad direction achieving caudal displacement of the kidney (fig. 1). We attached this needle with a Kelly forceps and proceeded in a subcostal manner to the puncture of the upper pole with a new needle, thus achieving a kidney displacement of 3 cm, on average.

A completely subcostal puncture of the upper calyx was made with the previously described “one shot” technique (fig. 2). The Endovision technique is sometimes employed for puncture precision and safety (fig. 3). The majority of times we use ultrasound to identify the pleura or the colon. In the nephrostomy we generally use a Foley or a 16 Fr Nelaton catheter.

2) Intercostal puncture guided by fluoroscopy and ultrasound

On some occasions the intercostal approach can be imminent. Through ultrasound, we locate the upper pole, ensuring that there is no pleural interposition, and guided by fluoroscopy, we access the upper calyceal system. The transducer is placed perpendicular to the major axis of the kidney for correct visualization of the UC.

3) Intercostal puncture guided by fluoroscopy and controlled ventilation (fig. 4): when intraoperative ultrasound is not available, we reproduce the described technique for puncture in the prone position, puncturing the skin and perirenal tissues during expiration, and puncturing the collecting system during inspiration. Theoretically,
this reduces the risk for pleural puncture. After puncture, we place a Roadrunner® guidewire and dilate it in one shot to 24 Fr (fig. 5). Flexible nephroscopy is routinely carried out at the end of the procedure, regardless of the calyx accessed.

Results

A total of 17 patients were included in the study, representing the treatment of 17 kidney units. General anesthesia was used in the 17 (100%) surgeries. Nine (53%) of the patients were men and 8 (47%) were women. The mean age was 45.8 (range: 18-72) years. Stone laterality was: 10 (59%) right side and 7 (41%) left side. Symptomatic patients: 13 (76%). The mean body mass index of the patients was 27 (range: 20-34) kg/m². ASA 1: 13 (76.4%), ASA 2: 3 (17.6%), and ASA 3: 1 (5.8%) (table 1). Patients that underwent previous treatments: extracorporeal lithotripsy/ureteroscopy/failed PNL): 8 (47%). Partial staghorn stones: 5 (29.4%). Mean stone size: 28.5 (range:15-42) mm. Ultrasound assistance for making the tract: 12 (70.5%) patients. UC percutaneous access: 17 (100%) patients. 24 Fr operating tube was used in 17 (100%) patients. Double-J catheter was left in 100% of the patients and nephrostomy was done in only 14 (82.3%) patients. Mean surgery duration

| Table 1  Preoperative patient values |
|------------------|------------------|
| Patients/surgeries performed, n | 17/17 |
| Age (years), mean (range) | 45.8 (18-72) |
| Sex W/M, n | 8/9 |
| Stone side (R/L), n | 10/7 |
| BMI 1/2/3, n | 13/3/1 |
| BMI, m² body surface area, n (range) | 27 (20-34) |
| Previous treatment, n (%) | 8 (47%) |
| Symptomatic patients, n (%) | 8 (47%) |
| Stone size in mm, mean (range) | 25.8 (15-42) |

| Table 2  Procedure results |
|------------------|------------------|
| Puncture technique, n (%) |
| Fluoroscopy alone | 7 (29.5) |
| Fluoroscopy + ultrasound | 12 (70.5) |
| Lower pole distraction technique | 4 (23) |
| Surgery duration (min), mean (range) | 91.5 (55-140) |
| Laser use n (%) | 3 (16) |
| Success at first event, n (%) | 14 (82) |
| Success at second event, n (%) | 3 (18) |
| Complications, n (%) |
| Urosepsis n (%) | 1 (5.7) |
| Urocutaneous fistula | 1 (5.7) |
was 91.5 (55-140) min. Laser lithotripsy was carried out on 3 (17.6%) patients. In regard to procedure success or stone-free rate: 14 (82.3%) with the first treatment and 17 (100%) with the second treatment. Three patients underwent a second look in the second treatment. Mean hospital stay was 2 (range:1-4) days. There were complications in 2 patients (11.7%) patients: urosepsis 1(5.7%), urinary fistula 1(5.7%), and there were no transfusions (0%) (table 2). A transurethral catheter was placed in the patient with urinary fistula for 7 days and the fistula was resolved.

The UC was punctured using the technique of caudal kidney displacement in 4 (23%) patients.

The controlled ventilation technique was used in 4 (23%) patients.

Three (17%) patients had intense pain, making it necessary to remove the nephrostomy tube in fewer than 24 h.

Postoperative pain was routinely treated in the postoperative period with 90 to 120 mg of ketorolac daily.

Discussion

The supine position for percutaneous approaches is not new. In 1954, radiologists described kidney punctures for the purpose of performing pyelography.13 Later, Valdivia-Uria et al. described access in the supine position finding the same results in relation to clearance and complication rates.14

It is widely described that supracostal approaches imply a risk for pulmonary and intrathoracic injury and this risk progressively increases the “higher” the puncture. 15-17

The choice of which calyx to puncture is based on the ability to provide maximum stone clearance through a point of entrance with minimum trauma to the parenchyma or adjacent organs. Once the operating tube has been placed, the UC offers the best course for checking the entire pyelocaliceal system.18

In comparison, with the LC approach, the operating tube has less torque, less reach, and less stability.

Current knowledge of pleurodiaphragmatic anatomy, the use of real time ultrasound for percutaneous puncture, and the development of new surgical techniques have noticeably reduced the risk for intrathoracic complications. The great versatility of upper access for resolving pathology of the upper collecting system, pelvis, lower collecting system, and upper third of the ureter make it ideal in many situations.18

Some series have reported a complication rate of 3-12.5% in patients that underwent intercostal access. Obviously, access above the eleventh rib has a higher complication rate than access above the twelfth rib.7-8,18

Intercostal access is transthoracic but extrapleural, whereas above the 11th rib (supracostal), access is transthoracic and transpleural.15,19

The upper pole of the right kidney is surrounded by the 12th rib, whereas the upper pole of the left kidney is surrounded by the eleventh and twelfth ribs. The upper pole is usually medial and posterior, compared with the lower pole. The lung is posteriorly located at the level of the tenth thoracic vertebra and the lowest part lies above the eleventh rib and in the tenth intercostal space. It can move caudally as much as 2 vertebral bodies during inspiration in the prone position. During total expiration, 80% of the upper pole lies above the twelfth rib and at the end of expiration, when the supracostal approach is being used, the pleura can be passed through on the right side in 29% of the cases and on the left side in 14% of the cases.20

With these anatomic data, it could be said that puncture above the twelfth rib could be safe, but there never should be puncture above the eleventh rib, and much less above the tenth.8

The following recommendations have been described for reducing the incidence of complications during intercostal puncture:

1. Maintain a puncture site as medial as possible, outside the lateral edge of the erector-spinal muscle.
2. The puncture should be made at the lateral half of the rib.
3. With the patient in total expiration, the surgeon penetrates the retroperitoneum, whereas entrance to the collecting system is carried out during total inspiration, a maneuver that caudally displaces the kidney.

Some case series have reported the UC approach through a subcostal puncture of the LC, despite the risks and limitations that the oblique course of the tract could have. Rigid instruments could damage the peri-infundibular vessels when attempting to introduce them into the UC due to the sharp angle between that calyx and the renal pelvis.21

With respect to the UC approach, the literature is clear about possible intrathoracic complications.16-21 Access above the tenth rib has a high complication rate and it should never be used. There are many techniques that describe access to the UC in the prone position,21 none of which have been shown to be better than the other, and these same techniques have been extrapolated to the supine position with similar results. Falahatkar et al. describe pulmonary insufflation as a puncture method, thus abandoning the supracostal punctures.22 Goyal et al. describe the technique of caudal displacement of the lower kidney pole, stating that they managed to caudally displace the kidney 3.2 cm, on average, thus avoiding intercostal punctures.23

An advantage of Endoscopic Combined IntraRenal Surgery is that there is no need for intercostal punctures or multitracts. Theoretically, retrograde access enables better revision of the collecting systems. The use of flexible instruments and the “pass the ball” technique has resulted in the UC approach not being frequently used, something we do not agree with.4

In the supine position, access to the UC is much shorter than to the LC. The tract is more stable and the rest of the calyceal systems and the ureter are reached more easily, but it has the disadvantage that it is not very mobile and in general the immediate postoperative period is more painful than with access to the LC. Perhaps this is due to trauma to the periosteum of the ribs with the dilators or to the rupture of the intercostal muscles.

There are not many reports in the literature in regard to the UC approach. In fact, Nour et al. state that puncture in the UCs is almost impossible with the patient in the supine position and tends to only be used for treating staghorn stones.24
The majority of the reports state that it is preferable to access the kidney through the LC in either the prone or the supine position, because it is safer in terms of intrathoracic complications. Despite this, the upper and middle calices should be accessed when it is deemed necessary. In the case series by Neto et al., UC access was used in 5.7% of their patients, which was a very similar result to ours.\textsuperscript{10,25}

There are also few reports on complications of the UC approach in the supine position. However, the prone position has been associated with a higher complication rate than the subcostal approach. Punctures in the prone position above the eleventh rib have a particularly high complication rate. More than 23% of those cases present with pneumothorax and hemothorax, as well as with pleural fistula. This is related to the fact that it is a transthoracic and tranpleural puncture, despite being performed with the lung in the expiratory phase.

With respect to punctures above the twelfth rib (or intercostal), the incidence of hydropneumothorax has been reported at an incidence of 4-15% and at 0% with subcostal access.\textsuperscript{19,26}

In relation to the differences we have found regarding a subcostal approach in the supine position, the following stand out: 1) the kidney is less mobile or floating at the time of performing the puncture in the UC, 2) one shot dilation generally is more resistant, 3) the operating tube has much less mobility, 4) intraoperative blood loss could be considered a bit higher, and 5) pain at the puncture site is more intense in the postoperative period. This coincides with the observations stated by El Harrech et al.\textsuperscript{11}

Despite the accumulated literature on the subject, it is still uncertain which of the 2 positions is the best (prone vs. supine) and intercostal access in the supine position is defined even less. Based on the CROES results, it is more probable to receive an UC puncture in the prone position than in the supine position (11.4 vs. 4.0%), as well as punctures at multiple sites (9.0 vs. 4.1%). Supracostal access (above the twelfth rib) is much more common in the supine position (17.6% vs. 5.5%).\textsuperscript{6}

In their work with more than 300 cases of percutaneous surgery performed in the supine position, El Harrech et al.\textsuperscript{11} describe using the UC as the puncture site in 78 (24.3%) cases, the middle calyx in 128 (40%) cases, and the LC in 166 (51.6%) cases, with 0% complications of hydrothorax or pneumothorax, coinciding with our results.

Conclusions

Access to the UC in the supine position is safe and reproducible. Different techniques can be employed to ensure procedure success. It is versatile in relation to the resolution of upper urinary tract pathologies. This access offers excellent vision of all the pyelocaliceal system (ureter, pelvis, and collecting groups). It should be reserved for cases in which entrance to the pyelocaliceal system is not feasible through the lower collecting system. The frequent use of real time ultrasound allows us to familiarize ourselves with an ultrasound-guided puncture, performing at this time anterograde pyelography, thus avoiding the routine instrumentation of the lower urinary tract.

Ethical responsibilities

Protection of persons and animals. The authors declare that the procedures followed conformed to the ethical standards of the responsible committee on human experimentation and were in accordance with the World Medical Association and the Declaration of Helsinki.

Data confidentiality. The authors declare that they have followed the protocols of their work center in relation to the publication of patient data.

Right to privacy and informed consent. The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the corresponding author.

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Conflict of interest

The authors declare that there is no conflict of interest.

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