SURGICAL TECHNIQUE

A different approach to the percutaneous nephrostomy by urologists

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Received 21 December 2011; accepted 12 February 2012

KEYWORDS
Percutaneous nephrostomy; Ultrasound; Urologist

Abstract
Introduction: Percutaneous nephrostomy (PCN) tube placement is generally performed in radiologic departments worldwide. However, there are a few urologist-directed studies about PCN performed with ultrasound guidance. Needle direction using a convex abdominal ultrasound probe might be difficult in unexperienced hands. In order to perform this procedure easily, we propose that a probe placed on flank or intercostal region and a long grooved needle director that never allows needle movement would be useful. We considered that a transrectal ultrasound (TRUS) probe was suitable to resolve this issue.

Materials and method: From January 2007 to April 2011, a total of 113 percutaneous renal access (PRA) were performed using a TRUS probe in 102 patients, aged 20–84 years old. Because of the insufficient imaging capability of the TRUS probe in obese patients, with a body mass index (BMI) greater than 30 kg/m², these were excluded. Forty-two PRA were performed under local anesthesia and this group was named local anesthesia (LA) group. Seventy-one PRA were performed for nephrostomy insertion under local anesthesia supplemented by deep sedation and this cluster was named deep sedation (DS) group.

Results: Targeted calyx puncture and guide wire placement was performed in all patients (100%) but success rate of tube insertion in each group was different. Successful PCN insertion rate was 69.1% (29 of 42 cases) in LA group and 95.8% (68 of 71 cases) in DS group. No major vascular injury and/or adjacent organ injury to bowel, liver, spleen or lung was seen in any patient.

Conclusion: Guidance of TRUS probe, deep sedation, and modified dilators may offer a high success rate to the urologists with little experience in PCN insertion which they would find it difficult to perform.

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Un abordaje diferente a la nefrostomía percutánea por urólogos

Resumen

Introducción: La colocación de un tubo de nefrostomía percutánea (NPC) se realiza generalmente en los servicios de radiología de todo el mundo. Sin embargo, hay unos pocos estudios dirigidos a urólogos sobre la NPC realizada con guía ecográfica. La dirección de la aguja utilizando una sonda de ecografía abdominal convexa puede ser difícil en manos inexpertas. Para res-olzar este procedimiento de manera sencilla, proponemos que una sonda colocada en el flanco o la región intercostal y un director de aguja ranurada larga que no permita el movimiento de la aguja serían útiles. Se consideró que una sonda para ecografía transrectal (ETR) era adecuada para resolver este problema.

Material y Método: Desde enero de 2007 hasta abril de 2011, se realizaron un total de 113 accesos renales percutáneos (ARP) utilizando una sonda de ETR en 102 pacientes, de 20 a 84 años de edad. Debido a la insuficiente capacidad de imagen de la sonda de ETR en pacientes obesos con un índice de masa corporal (IMC) mayor de 30 kg/m², estos fueron excluidos. Se realizaron cuarenta y dos ARP bajo anestesia local y a este grupo se le llamó grupo de anestesia local (AL). Se realizaron setenta y un ARP para la inserción de la nefrostomía bajo anestesia local complementados con sedación profunda y a este grupo se le denominó grupo de sedación profunda (SP).

Resultados: Se llevó a cabo la punción dirigida al cáliz y la colocación de alambre de guía en todos los pacientes (100%) pero la tasa de éxito de la inserción del tubo en cada grupo fue diferente. La tasa de inserción exitosa de la NPC fue del 69,1% (29 de 42 casos) en el grupo de AL y del 95,8% (68 de 71 casos) en el grupo de SP. No se observó lesión vascular mayor y/o lesión de órganos adyacentes al intestino, el hígado, el bazo o el pulmón en ningún paciente. Conclusión: La orientación para la sonda para ETR, la sedación profunda y los dilatadores modificados pueden ofrecer una alta tasa de éxito para los urólogos con poca experiencia en la inserción de la NPC que les resultaría difícil de realizar.

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Introduction

Percutaneous nephrostomy (PCN) insertion is an essential component in the treatment of upper urinary tract obstruction when a retrograde catheterization cannot be achieved anatomically or technically.1,2 The technique of percutaneous nephrostomy tube insertion was first described by Goodwin in 1955.3 Although PCN insertion has technically high success rates,4-6 it may lead to major complications such as excessive intra-abdominal hemorrhage, late reconstructive surgery, and decrease in the likelihood of renal loss.7-10

Traditionally, PCN insertion is performed under the fluoroscopic guidance system because it allows for good visualization of the opacified urinary tract, guidewires, dilators, and drainage tubes. Ultrasound, the same as fluoroscopy, is also a reliable guidance system for percutaneous nephrostomy.10

Kidney imaging with a convex ultrasound probe at the level of 12th costa has some drawbacks in flank position. Needle direction using a convex abdominal ultrasound probe might be difficult in unexperienced hands. These drawbacks can be resolved by using a small probe. In order to perform this procedure easily, we propose that a probe placed on the flank or intercostal region and its long-grooved needle director that never allows for needle movement would be useful. We considered a transrectal ultrasound (TRUS) probe that was suitable to resolve this issue.

PCN tube placement is generally performed in radiologic departments worldwide. However, there are a few urologist-directed studies about PCN performed with ultrasound guidance.11,12 Each patient has different pain threshold and they also have different pain tolerance level. Therefore, local anesthesia may not be sufficient for some patients during PCN insertion. An anesthesia which is better than local anesthesia may increase patient comfort level and success rate, and also this may decrease the complication rate.

The objective of this study is presentation of our experiences in nephrostomy tube insertion which is performed under deep sedation and with guidance of TRUS probe and modified dilators.

Materials and method

From January 2007 to April 2011, a total of 113 PRAs were performed using a TRUS probe in 102 patients (84 men and 18 women), aged 20–84 years old (mean 55.4). Because of the insufficient imaging capability of the TRUS probe in obese patients, patients with body mass index (BMI) greater than 30 kg/m² were excluded. All demographic variables, PRA indications, technical details relating to the procedures, complications, and success rate were researched in clinical databases retrospectively.

Forty-two PRAs were performed with guidance of the TRUS probe for nephrostomy insertion under local anesthesia and this group was named local anesthesia (LA) group, comprising our initial experience. Because of the low success rate in tube placement under local anesthesia, we decided to perform the procedure under deep sedation. Seventy-one
PRAs were performed for nephrostomy insertion under local anesthesia supplemented by deep sedation and this cluster was named deep sedation (DS) group.

Consent was taken after informing the patients about the benefits and risks associated with this intervention. Interventional radiologists were not included in any of the procedures and all PRAs were performed by urologists.

History of bleeding diathesis, prothrombin time, and platelet count of patients were evaluated before the procedure. Prophylactic antibiotics were routinely administered in cases of pyonephrosis or urinary lithiasis. All procedures were performed in the operation room under sterile conditions. Patients were placed in the lateral decubitus position and counter side was raised with a silicone pillow.

In the LA group, local infiltration anesthesia was applied with 5–10 mL Prilocain 2% (Citanest® Astra Zeneca, United Kingdom). Participants in the DS group were given 0.1 μg/kg/min continuous intravenous infusion of Remifentanyl (Ultiva® GlaxoSmithKline, Belgium) that was prepared at 40 μg/mL. After 2 min of the Remifentanyl infusion, we used propofol (Propofol 1% Fresenius® Fresenius Kabi, Sweden) as a hypnotic drug. Its starting dose was 0.5 mg/kg. Additional intravenous 0.25 mg/kg doses of propofol were given until a Ramsay sedation score of 3–4 was achieved. Before calyx puncture with needle, the Ramsay sedation score was 4–5 via additional intravenous 0.5 mg/kg doses of propofol, thus ensuring deep sedation.

Ramsay Sedation Scale[13]

1. patient is anxious and agitated or restless, or both;
2. patient is cooperative, oriented, and tranquil;
3. patient responds to commands only;
4. patient exhibits brisk response to light glabellar tap or loud auditory stimulus;
5. patient exhibits a sluggish response to light glabellar tap or loud auditory stimulus;
6. patient exhibits no response.

Ultrasound machine General Electric Logiq 5 Pro with 7.5 MHz frequency, TRUS probe and its needle director were used for calyx puncture with an 18 gauge needle from the posterolateral abdominal wall in the flank position. The needle was removed after calyx puncture but the needle sheath remained, and the exact distance between the skin and the targeted calyx was measured. A soft-tipped 0.097 mm guide wire was inserted through the needle and placed into the targeted calyx. If movement of the guide wire tip was viewed clearly in the calyx by ultrasound, we were assured about the location of the needle tip and guide wire (Fig. 1).

We did not require any confirmation methods such as aspiration of urine. Grade 1 calyceal ectasia was sufficient to access the targeted calyx. 3.5 MHz frequency convex probe was used for subsequent steps. The layers between skin and kidney were incised with a cystostick needle through the guidance of guidewire and needle sheath. The tract was dilated with modified 8–12 F elastic semi rigid dilators. Modified dilators were developed by us which allow saline infusion in order to create a fluid stream that could be viewed easily by the convex probe while the guide wire was in the dilator. If the dilators were in the pelvicalyceal system, a fluid stream could be detected by ultrasound. Thus, the operator could be assured about the location of dilators in the urinary system. To avoid renovascular reflux with infected urine, the saline infusion procedure was not repeated more than twice and the amount of infused saline did not exceed 10 mL. Finally, the drainage catheter was positioned over the guide wire.

In some patients, the guide wire was removed from the calyx to the pararenal area accidentally during tract dilation, and this situation could become serious if the degree of hydrenephrosis decreased to grade 0 (it occurred in 4 patients who were in the LA group). To solve this problem, we infused 20–40 mg furosemid for enforcement of diuresis after intravenous hydration in the same way as Sanjay et al.[14] Thus, the grade of dilation of the collecting urinary system was increased by one degree via a physiological pathway. Then, we repeated the calyx puncture stage. We never applied Sanjay et al.’s technique to patients who had grade 0 hydrenephrosis; they were excluded initially.

A blood count was performed on the first day after the procedure to assess the hematocrit level change. Antegrade nephrostography was conducted on the first day after PCN insertion to detect urine extravasation and to check nephrostomy tube localization.

The success of the procedure was evaluated according to the following criteria: percentage of successful access and nephrostography tube placement, transfusion requirements, visceral organ injury, and urine extravasation.

Results

113 PRAs were performed using the TRUS probe in 102 patients, aged 20–84 years old (mean 55.4). Each targeted calyx was easily reached by using the biopsy attachment as needle director and by imaging with the TRUS probe. Targeted calyx puncture and guide wire placement were performed in all patients (100%), but the success rate of the tube insertion in each group was different. Successful PCN insertion rate was 69.1% (29 of 42 cases) in the LA group and 95.8% (68 of 71 cases) in the DS group.
Table 1  Demographic and clinical features of patients.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>LA group</th>
<th>DS group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>53.2 (20–79)</td>
<td>56.8 (22–84)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>34</td>
<td>52</td>
</tr>
<tr>
<td>Female</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Right kidney</td>
<td>27</td>
<td>38</td>
</tr>
<tr>
<td>Left kidney</td>
<td>15</td>
<td>33</td>
</tr>
<tr>
<td>PNT indications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malign diseases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prostate</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Bladder</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Cervix</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Benign diseases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stone disease</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Ureteral stricture</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Pyonephrosis</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Anastomosis leaking</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td>Grade of hydroureteritis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grade 1</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>Grade 2</td>
<td>15</td>
<td>29</td>
</tr>
<tr>
<td>Grade 3</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Grade 4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Collecting system access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower calyx</td>
<td>28</td>
<td>41</td>
</tr>
<tr>
<td>Middle calyx</td>
<td>9</td>
<td>24</td>
</tr>
<tr>
<td>Upper calyx</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Skin entrance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle axillary line</td>
<td>19</td>
<td>34</td>
</tr>
<tr>
<td>Posterior axillary line</td>
<td>23</td>
<td>37</td>
</tr>
<tr>
<td>Access over 12 rib</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

Demographic and clinical features of patients, and results of our technique are summarized in Tables 1 and 2. Bilateral PCN insertion was performed in 11 patients, their indications were obstructive uropathy caused by malignant disease. The first 42 PCN insertions were performed under local anesthesia, the other 71 PCN insertions were performed under local anesthesia with deep sedation. In some patients the guide wire was removed accidentally from the calyx to the pararenal area during tract dilation, therefore we repeated the calyx puncture stage. We applied 61 calyx punctures to the 42 hydronephrotic kidneys in the LA group. The puncture amount was 78 in the SD group which had 71 hydronephrotic kidneys. The mean rate of calyx puncture procedure was 1.45 in the LA group and 1.09 in the DS group (Table 2). No major vascular injury and/or adjacent organ injury to bowel, liver, spleen, or lung was seen in any patient. No patients showed hemodynamic instability necessitating surgical exploration. According to nephrostography findings, collecting system perforation occurred in 3 patients in the LA group and in 2 patients in the DS group. Their tubes were not removed before perforated areas healed spontaneously. Leukocytosis with fever occurred in 3 patients in the LA group and in 5 patients in the DS group and these patients were treated with third-generation cephalosporin (Table 3). No patients died from septicemia. The average time taken for the procedure was 24.2 min (15–32 min) for the LA group and 19.7 min (14–26 min) for the DS group.

Table 2  Results of PCN insertions which were performed with guidance of TRUS probe.

<table>
<thead>
<tr>
<th>Malign diseases</th>
<th>LA group</th>
<th>DS group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>NCP</td>
</tr>
<tr>
<td>Prostate</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Bladder</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Cervix</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Stone disease</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>Ureteral stricture</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Pyonephrosis</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Anastomosis leaking</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>61</td>
</tr>
</tbody>
</table>

NCP, number of calyx puncture; NTIF, number of tube insertion failure.
Discussion

PRA can be carried out in a number of ways with a variety of guidance systems, such as fluoroscopy, ultrasound + fluoroscopy or CT. Depending on the imaging modality reported, technical success of PCN was 91–99% with ultrasound + fluoroscopy guidance, 90–100% with ultrasound guidance, and 98–100% with fluoroscopy guidance.\textsuperscript{15,16}

The most common practice worldwide is to use ultrasound for the initial puncture and fluoroscopy for the subsequent procedure.\textsuperscript{10} In our country, PRA procedures are generally conducted by radiologists under guidance of ultrasonography before nephrostomy tube insertions, whereas urologists perform it under fluorescent imaging before percutaneous nephrolithotomy. In contrast to fluoroscopy, real time ultrasound imaging provides excellent cross-sectional anatomic detail that allows for access to the kidney in a single puncture with confidence.\textsuperscript{7,10} Ultrasound-guided calyx puncture has several advantages such as avoiding radiation, avoiding adjacent visceral tissue injury and major vascular injury. Ultrasound also allows for the shortest and most direct access to the targeted renal calyx with minimal morbidity. The aspiration of urine after calyx puncture may be helpful to confirm the correct placement of the needle tip, but in cases with mild dilation, injection of 5–10 cc normal saline through the needle can be confirmed by ultrasound.

If fluoroscopy is selected for imaging, the operator can only image the contrast-filled pelvicalyceal system and cannot see renal and extra-renal structures. Contrast filling to the pelvicalyceal system directly or intravenously is not possible in every patient either. However, ultrasound shows all the tissues along the intended nephrostomy tract from skin to renal calyx including bowel loops and vessels.\textsuperscript{17} Three-dimensional information during puncture can be easily obtained by simply shifting, tilting, and rotating the head of the ultrasound transducer.\textsuperscript{10}

Comprehensive knowledge regarding anatomical relationships, variations, and landmarks are more important to prevent the complications during PRA.\textsuperscript{7} Notwithstanding useful landmarks, PRA and tube placement is still very operator dependant and seems to have a high risk of complications. Many radiologists with various levels of training perform this procedure with obvious variations in success and complication rates.\textsuperscript{10}

Urologists generally want to perform PRA by themselves but the percentage of urologists who perform their own access is low. According to the UK Nephrostomy Study <0.5% of the PCNs were placed by urologists.\textsuperscript{18} This rate was reported as 11% in another published study.\textsuperscript{19} Increasingly, many urologists in Europe and throughout the world perform their own renal access for percutaneous procedures and nephrostomy tube placements when required.\textsuperscript{10} According to some publications, urologist-directed PCN placement under ultrasound guidance is very safe and effective.\textsuperscript{11,12} In Mahaffey’s study, 100 consecutive ultrasonography-guided percutaneous access procedures showed success and complication rates similar to those documented by radiologists.\textsuperscript{11}

The calyx puncture under ultrasound guidance needs very good ultrasonography experience and its learning curve is long. But according to the results of Skolarikos et al., this is not difficult and urologists perform it easily.\textsuperscript{12} They used a free hand technique as far as we understand. Free hand technique allowed direct visualization of the needle, but the operator has to make sure that the position of the needle remains confined to the slice thickness of the transducer. To further aid needle visualization, instead of moving the needle in and out, it was preferred to move the stylet back and forth within the needle.\textsuperscript{10} Needle directors which can be attached to a convex ultrasound probe also prevent loss of needle visualization. The 12th costa may give rise to an image artefact and in some cases the gap between the 12th costa and iliac crest may be narrow; therefore, renal imaging with a convex abdominal ultrasound probe might be difficult.

At the beginning we failed with the free hand technique and also with the needle director which was attachable to the convex probe. We noticed that the short grooved needle director is not sufficient for safe directing of the needle to the targeted calyx. According to our previous limited experiences we believed that PRA and PCN insertion with convex ultrasound probe without aid of radiologist was very difficult. And we agreed that nobody can say that ‘we are surgeons, we can easily place the needle to the renal calyx when we see the kidney by ultrasonography’. We also believed that the training period of PCN insertion which is performed with convex probe must be conducted by an experienced radiologist’s supervision. In our study, we could not establish a consensus among radiology and urology clinics about PCN insertion training.

In January 2007, when we were performing prostate biopsy, we noticed that the needle could be reached directly to the target, and the needle line could be seen easily. And then we hypothesized that a small probe placed on the flank or intercostal region and a long grooved needle director that never allows for needle movement would be useful. In this manner, we considered that TRUS probe was suitable for solving the problems of needle direction. In imaging the kidney with the TRUS probe and choosing the renal calyx for access, we did not encounter a problem in subjects whose BMI was lower than 30 kg/m\textsuperscript{2}, and grade 1 hydronephrosis was sufficient for renal access with TRUS probe.

Currently, a microconvex probe with frequency of 3.5 MHz was presented to the physicians. It seems less expensive than the TRUS probe and easy to use for the novice. This device may have a great influence on surgical outcome for all types of patients. As the kidney is located in the deep region of the human body, the superficial probe such as TRUS probe is inappropriate for obese patients. But we already excluded these patients. One year ago we tried to purchase that probe from two different hospitals. Despite its low price, hospital managements refused to sell this device.

We performed PRA under ultrasound guidance in three different hospitals. The TRUS probe was used for calyx puncture and we also used modified dilators adapted by us for safe dilation of the tract. Our success rate of PRA (calyx puncture with needle) in each group was 100%. The primary success rate of PCN insertion was 69.1% in the LA group and 95.8% in the DS group. The results of the DS group are comparable with the 90% to 100% success rates demonstrated by other studies.\textsuperscript{3,12,21,23}

According to the literature, the use of the TRUS probe and modified dilators for facilitating PRA and PCN insertion
are first reported by us; our fully ultrasound-guided percutaneous nephrolithotomy experiences in 43 patients were published recently.14 In that study we performed PRA using a TRUS probe at the beginning of percutaneous nephrolithotomy.

In the first 42 cases, all procedures were applied solely under local anesthesia. We achieved 100% success rate in the stage of calyx puncture, but the rate of successful tube insertion was 69.1%. According to the literature, our success rate was low and it might have been derived from the local anesthesia. We noticed that when patients suffered pain and had anxiety, it caused frequent and deep breathing and body movement. As a result, tube placement into the kidney was impossible in some cases. Thus, we applied deep sedation with remifentanil and propofol after local anesthesia in order to reduce fear, anxiety, and pain and to increase tolerability and comfort in the subsequent 71 cases. Indeed, we benefited a lot from this anesthesia procedure; consequently, our successful tube insertion rate increased.

No major vascular injury and adjacent organ injury was seen in any patients. No patients showed hemodynamic instability necessitating surgical exploration and blood transfusions. The number of collecting system perforations was 3 in the LA group and 2 in the DS group. Leukocytosis with fever (defined as bacteremia not septicemia) was seen in 3 cases in the LA group and in 5 cases in the DS group. Our complication rates were comparable with the results of other published studies.4,25,16

We cannot postulate definite conclusions about the learning curve of our technique because our study was not prospective and was not controlled by another study which might have been conducted with convex probe under the supervision of an experienced radiologist or urologist. In our study, each urologist can perform it easily after mean 2.1 cases for PRA and mean 3.3 cases for PCN insertion in DS group. These data were not recorded for the LA group. These findings may give an idea about the learning curve of our technique.

This study had some limitations; for example, it was not a prospective, randomized, and controlled study, the subjects were selected by means of BMI not above 30 kg/m², and the number of cases might not be enough for a full assessment. Even though it was a retrospective study, we believe that our findings will give a presumption to the urologists who are keen on PCN insertion.

Conclusion

Guidance of TRUS probe, deep sedation, and modified dilators may offer a high success rate. The urologists who have little experience in PCN insertion will find it difficult to perform.

Targeted calyx puncture could be achieved easily by using the biopsy attachment as needle director and by imaging with the TRUS probe in selected cases whose BMIs are lower than 30 kg/m².

According to our experience, PCN insertions under deep sedation can be performed safely and effectively by urologists via TRUS probe and modified dilators. The results of our technique should be confirmed by prospective randomized studies before use in future routine urologic practice.

Conflict of interest

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.acuroe.2012.02.006.

References

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