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Dual Technique Percutaneous Nephrostomy: Experience from a Tertiary Care Centre

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Abstract

Aim: *To review the feasibility and performance of percutaneous nephrostomy (PCN) in a tertiary care teaching hospital and determine the success and complication rate and to compare it with the standard recommended by ACR-SIR-SPR guidelines.*

Materials and Methods: *We retrospectively reviewed 444 percutaneous nephrostomy in 344 patients performed from January 2010 to December 2012. All PCN performed in native kidney. Prophylactic antibiotic was given to all patients. Patients having coagulation abnormalities were corrected before the procedure. All cases had been carried out by experienced radiologists using a Seldinger technique under ultrasonography and fluoroscopy guidance. Percutaneous nephrostomy was considered successful if the catheter was placed in the pelvis and drained urine or the content of pelvicalyceal system. Indication, success rate and complication rate were noted.*

Results: *Most common indication was obstructive hydronephrosis (79.3%) due to various causes. Overall success rate was 98%; it was 98.2% for dilated system and 88.9% for non dilated system. Total complication rate was noted in 66 (14.9%) PCN, out of which 40 (9.01%) procedure related and 26 (5.9%) catheter related. Major complications were noted in 9 (2.03%).*

Conclusion: *Percutaneous nephrostomy using Seldinger technique under both ultrasonography and fluoroscopy guidance in the hands of experienced radiologists is a safe and effective minimally invasive procedure with high success rate and low rate of complications.*

Keywords: *Percutaneous nephrostomy, Seldinger technique, ultrasonography, fluoroscopy, pelvicalyceal system.*

Introduction

Percutaneous nephrostomy (PCN) is an established procedure for urinary diversion in infrarenal obstruction or prior to endourological procedure since 1955.[1,2] In percutaneous nephrostomy access to pelvicalyceal system of

kidney is obtained through the skin providing external drainage or a portal for minimally invasive procedures.[3] PCN is an effective and safe minimally invasive procedure in experienced hand. PCN is usually indicated for decompression of urinary obstruction, which may be secondary to nephrolithiasis, pelvicalyceal malignancy, retroperitoneal fibrosis and other urogenital and soft tissue tumors. It helps also in providing accesses for antegrade stenting and endourologic procedures. The preferred technique used is combined fluoroscopy and ultrasound guided with a technical success rate of 85-99% depending on degree of dilatation of obstructed system or complex renal stones.[4,5] The overall complication rate of PCN is usually below 10%.[6] Minor complications occur in about 15-28% and major complications occur in less than 4% patients.[7,8] The aim of the present study was to access the performance of percutaneous nephrostomy in a tertiary care teaching hospital and compare the success and complication rates with the ACR-SIR-SPR guideline and to identify areas for quality improvement.

Material and Methods

We retrospectively reviewed our data of all patients from radiology records and hospital information system who had a radiologically placed PCN at our institution between January 1, 2010, and December 31, 2012. PCN in transplant kidneys have been excluded from this study.

Patient Preparation

Coagulation parameters like prothrombin time (PT), activated partial thromboplastin time (aPTT) and platelet count of the patients were obtained before the procedure. As per our department protocol, International normalised ratio (INR) should be less than or equal to 1.4 and platelet counts more than 50,000 per mm^3. Abnormalities in PT and the partial thromboplastin time (PTT) were corrected by giving fresh frozen plasma and vitamin K prior to the procedure. Patients having platelet counts less than 50000 per mm^3 were given platelets transfusion. Repeat coagulation profile was obtained before the procedure.

All the patients were advised to be nil per orally 4-6 hours before the procedure and intravenous (I.V) access were maintained. Most of the patients were receiving antibiotics at the time of consultation. Those who are not receiving were given pre procedural intravenous 3rd generation cephalosporin antibiotics and subsequent antibiotics as per the treating physician discretion according to the urine culture and sensitivity. Informed consent was obtained from all patients.

Technique

PCN was performed by an dedicated uroradiologist in the presence of nurse and radiographer. Ultra sonography examination was done to access location and anatomy of the target kidney, degree of hydronephrosis and to determine puncture site and entry angle. Patients were made to lie prone on fluoroscopy table for a trans retroperitoneal approach in native normally positioned kidney. The region of interest was prepared using surgical standard of disinfecting and draping. Pre procedural blood pressure was recorded in all patients. Blood pressure, pulse and oxygen saturation were continuously monitored throughout the procedure by pulse oxymetry. Local anaesthesia was administered at the desired site of needle entry. Intravenous sedation and analgesia was also given in apprehensive patients. Procedure in unstable, agitated and young patients was done under general anaesthesia in presence of anaesthetist.

Posterior calyx of lower or mid pole of kidney was preferred in majority of cases. The normally preferred posterior calyx along the relatively avascular Brodel line[2,10] is not always accessible. In cases where PCN was done before antegrade stenting or endo renal surgery, access through upper pole or mid pole calyx was preferred. Under constant real time sonographic guidance with the help of 3.5 MHz curvilinear probe and a free hand technique, the centre of target calyx was punctured with an 18 G needle (vygon needle).

Successful entry into calyx was considered if urine was coming out spontaneously or on aspiration after removal of stellate. In non dilated pelvicalyceal system Neff percutaneous set (22 G needle) was used to puncture the calyx. A jet of urine coming out of the needle indicates high pressure within the collecting system. In such situations, the system was decompressed by aspiration of urine equal to the amount of contrast to be injected. After focussing the needle tip under fluoroscopy, 10 ml of dilute iodinated contrast (urograffin 370mg Iodine/ml diluted in sterile normal saline in 1:1 ratio) was injected to delineate the collecting system (figure 1). Over distension of pelvi calyceal system was strictly avoided mainly in infected cases by prior aspiration of urine and minimization of the amount of contrast media injected to prevent the chance of bacteraemia. The hydrophilic terumo guide wire (0.035") was introduced through the puncture needle into the ureter or pelvis. Small skin and subcutaneous incision was given along the needle and the needle was removed. Dilator was passed coaxially over the 0.035 inch guide wire and the tract was dilated upto the calyx (figure 1). Serial dilatation of the tract was performed under fluoroscopy guidance to avoid false tract and injury to renal pelvis. Advancing the dilator upto the renal pelvis solves no purpose and can cause injury. Then malecot catheter was advanced over the guide wire under fluoroscopy upto the renal pelvis. The straightener of the catheter was withdrawn over the guide wire to open the flower of the catheter. After confirmation of the position of catheter tip, guide wire was removed (figure 1) . Catheter was sutured to the skin with 2-0 prolene (ethicone) suture and connected to drainage bag. Malecot catheters of different sizes were used depending on the content of renal pelvis. Catheters of 10 F were used as standard in adults where as 12 F catheters were used in cases of pyonephrosis. In very young patients 8 F catheter was used. Patients were checked daily by a member of interventional radiology until discharged from hospital. Special attention was given to monitor the vital signs and the nature and amount of drain output.

Result

A total of 344 patients underwent elective or emergency PCN, 114 (33.1%) were females and 230 (66.9%) males. The median age was 44 (range 2-82) years and 17 were children below 14 years. Systemic hypertension was present in 59 (17.2%) patients and diabetes mellitus with controlled sugar in 47 (13.7%) patients.

A total of 444 PCNs were performed in 344 patients, single PCN in 245 (71.2%), double in 98 (28.5%) and three PCN in 1 patient. The pelvi calyceal system was dilated in 435 (98%) and was not dilated in 9 (2%). A total of 224 (50.5%) PCNs were performed on the right kidney, 220 (49.5%) on the left kidney (table 1).

Most common indication for PCN was obstructive hydronephrosis. Urinary obstruction was found in 352 (79.3%) kidneys out of which calculus in 150 (33.8%), calculus with infection in 39 (8.8%), malignancy in 102 (23%), stricture in 20 (4.5%), pelvic ureteric junction obstruction in 35 (7.9%), retroperitoneal fibrosis in 6 (1.4%). Out of 102 malignancy related PCN, carcinoma of urinary bladder was an indication in 40 (9%), cervix 39(8.8%) and prostate 10(2.3%), rectum 8 (1.8%), lymphoma 2 (0.45%), pelvic germ cell tumor 2 (0.45%) and testicular carcinoma in one case. Infectious aetiology was an indication for PCN in 46(10.4%), fistula in 7(1.6%), pullout PCN in 10 (2.3%) and other unknown aetiology of hydronephrosis in 29(6.5%) kidneys. In our series of 344 patients, we found 5 duplex kidneys and 3 horse shoe kidneys. 8 cases of emphysematous pyelonephritis and 2 cases of xanthogranulo-matous pyelonephritis have been included in infection category (table 2).

The needle puncture was commonly performed in middle pole calyx in 250 (56.3%) kidneys. The lower pole calyx was approached in 130 (29.3%), upper pole in 62 (14%) kidneys. Pelvic puncture was done in 2 kidneys as the pelvicalyceal system

were deformed and calyx not clearly appreciable (table 1).

The procedure was successful in 435 (98%) PCN, which was defined by catheter placed in the renal pelvis and draining urine or contents of pelvicalyceal system. In 8 cases the catheter could not be advanced upto the pelvis and kept in the calyx. Four of these had complex calculus disease or staghorn calculi, one had PUJ obstruction and the calyces are not communicating with the pelvis. One case was post PCNL pseudoaneurysm located at mid and lower pole, so catheter kept at upper pole. Remaining two cases had pyonephrosis. In one case procedure was failed due to unsuccessful puncture in a non dilated system.

Complications

Total complications were found in 66 (14.9%) PCNs. The procedure related complications were found in 40 (9%) cases. The major complication was found in 9 (2%) cases (table 3). The major complications included the patients requiring blood transfusion for haemorrhage which was found in 3 (0.6%) cases and sepsis requiring prolonged hospitalisation in 6 (1.4%) cases. Out of 6 patients of sepsis; 5 were having pyonephrosis including one xanthogranulomatous pyelonephritis with pyonephrosis; one diabetic patient developed septic shock and could not be revived (Table 4). Minor complications were noted in 31 (7%), which includes transient post PCN hematuria in 23 (5.2%), perinephric collection in 6(1.4%), piled off terumo in 1 (0.2%), pain in 1 (0.2%) patient. These minor complications were self limited or managed conservatively.

Catheter related complications were found in 26 (5.9%) cases. In 11 (2.5%) cases the PCN catheter was accidentally pulled out, mostly by the patients themselves. Repeat PCN was done in 10 patients; one patient underwent nephrectomy for non functioning pyonephrotic kidney. In 5 (1.1%) cases catheter was displaced from the pelvis to one of the calyces within 7 days of procedure and repositioning done under fluoroscopy guidance. In 10 (2.3%) cases catheter was blocked due to thick pus or hemorrhage that was managed by flushing with normal saline (table 3).

Post PCN patients developing complications after undergoing further urological intervention have been excluded. There was no association of increased morbidity or mortality in diabetics and hypertensive patients in our study (table 4).

Table 1: Demography and procedure characteristics

Parameters	N=344 (%)
Age (in years)	43.30±16.38 (median 44, range 2-82)
Children (<14 years)	17 (4.9%)
Older (>70 years)	12 (3.5%)
Female	114 (33.1%)
Diabetes mellitus	47 (13.7%)
Hypertension	59 (17.2%)
Pelvi calyceal system	N=444 (%)
Dilated	435 (98%)
Non dilated	9 (2%)
Site of PCN	
Right kidney	224 (50.5%)
Left kidney	220 (49.5%)
Punctured Calyx	
Lower	130 (29.3%)
Middle	250 (56.3%)
Upper	62 (14%)
Pelvis	2 (0.45%)

Table 2: Indications of PCN

Indications	N=444 (%)
Calculus	150 (33.8%)
Calculus and infection	39 (8.8%)
Malignancy	102 (23 %)
Ca urinary bladder	40 (9%)
Ca cervix	39 (8.8%)
Ca prostate	10 (2.3%)
Ca rectum	8 (1.8%)
Ca testis	1 (0.2%)
Lymphoma	2 (0.45%)
Pelvic giant cell tumor	2 (0.45%)
Stricture	20 (4.5%)
PUJO	35 (7.9%)
RPF	6 (1.4%)
Infection	46 (10.4%)
Fistula	7 (1.6%)
Pullout PCN	10 (2.3%)
Others	29 (6.5%)

Table 3: Complications of PCN

Procedure related	40 (9%)
Transient post PCN hematuria	23 (5.2%)
Major hemorrhage	3 (0.6%)
Sepsis	6 (1.4%)
Perinephric collection	6 (1.4%)
Piled off terumo	1 (0.2%)
Pain	1 (0.2%)
Catheter related	26 (5.9%)
Displaced	5 (1.1%)
Obstructed	10 (2.3%)
Pulled out	11 (2.5%)

Table 4: Details of major Complications

Sl. no	Diagnosis	Clinical sepsis	Pcn output	Coagulopathy	Diabetic	Hypertensio	Successful Pcn	Prophylactic antibiotic	Complication
1	Left PUJO with pyonephrosis	Yes	Pus	No	No	No	Yes	Yes	Sepsis
2	Right ureteric calculus with pyonephrosis	Yes	pus	No	Yes	No	Yes	Yes	Sepsis
3	Right xanthogranulomatous pyelonephritis with pyonephrosis	Yes	Pus	No	No	No	Yes	Yes	Sepsis
4	Carcinoma urinary bladder	No	Clear urine	No	No	No	Yes	Yes	Sepsis
5	Right pyonephrosis	Yes	Candida on culture	No	Yes	Yes	Yes	Yes	Septic shock, Death
6	Staghorn calculus	No		No	No	No	Yes	Yes	Sepsis
7	Benign enlargement of prostate with obstructive uropathy with right HDN	No	Haemorrhagic	No	No	Yes	Yes	Yes	haemorrhage
8	Ca prostate	No	Hemorrhagic	No	No	Yes	Yes	Yes	Haemorrhage
9	Left renal calculus	No	hemorrhagic	No	No	No	Yes	Yes	haemorrhage

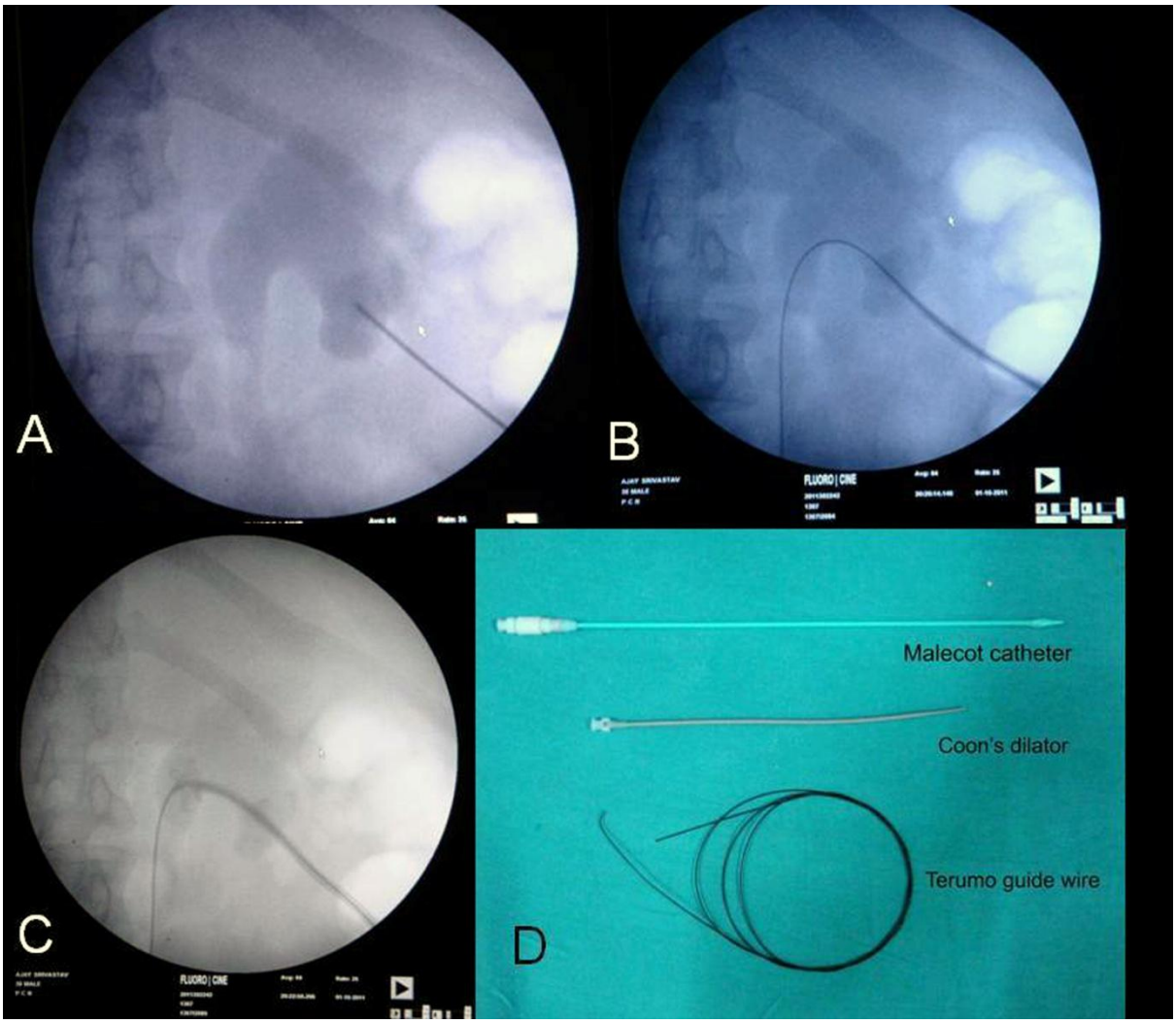

figure: 1 (A) Pelvicalyceal system has been opacified through 18 G access needle (B) Dilator has been introduced over the guide wire upto the calyx (C) After removal of dilator 10F malecot catheter has been introduced over the guide wire and straightener removed, opening the flower of malecot catheter. Position in pelvis is confirmed (D) Terumo guide wire, Coon's dilator and Malecot catheter commonly used in our department.

Discussion

PCN can be performeds under USG and/ or fluoroscopy guidance. Needle access into the pelvic alyceal system can be done as (i) one step technique under USG guidance (ii) two step technique using USG guided renal pelvic access followed by definitive fluoroscopy guided needle access or (iii) two step technique using fluoroscopy guided renal pelvic access followed by definitive fluoroscopy guided needle access.[3] In all cases of our study needle access was done in one step technique under USG guidance. After puncture of the calyx the remaining steps were performed under fluoroscopy guidance. The advantage of this technique is that it can be performed in patients with renal failure and patients allergic to iodinated contrast media and it requires less fluoroscopy time.[11] As puncture of the calyx is done under real time USG guidance, it has less risk of damage to kidney and adjacent organs.

Needle access below the level of 11th rib reduces the risk of pleural complication.[8,2] Far lateral approach has a risk of bowel transgression. In most cases, a posterolateral approach with the needle directed to the mid-to lower calyx provides optimal results.[8] In our study needle access has been done in lower pole in 130(29.3%), middle pole in 250 (56.3%) and in upper pole in 62(14%).

All cases were approached lateral to paraspinal muscles and below the level of 11th rib.

In our study, 352 (79.3%) PCN has been done for urinary obstruction, most commonly due to calculus with or without infection that accounted for 189 (42.6%) of total. Malignancy related indication accounted for 102 (22.9%) PCNs. In a study by Farell et al (396 PCN) 87.2% of PCN were indicated due to obstruction out of which (186 patients) 61 % were malignancy related. However they have excluded patients in whom PCN was done prior to PCNL.[4]

The technical success rate of PCN is >90%, except for the study in which blind puncture technique was used.[12] Success rate in most recent series under fluoroscopy guidance alone or in combination of USG and fluoroscopy ranges from 98 to 100%.[13,4,14,15] Success rate using USG only is 91-92%.[16,17] The lower success rate using USG alone may be due to difficulty in visualisation of guidewire and catheter. In our study the overall success rate is 98%, it was (98.2%) for dilated system and (88.9%) for undilated system) that is significantly higher than the recommended threshold by ACR-SIR.[18]

Most of the cases were performed using 18G needle except 4 cases of non dilated system where 22G needle (neff percutaneous set) was used. Small bore (22G needle) access systems were not safer in terms of lower risk of bleeding or pain than 18 G needle in one study.[19] Large calibre needles are stiffer and maintain a straight path towards the target calyx. 18 G needle accepts 0.035 inch guide wire over which the dilator and definitive access nephrostomy catheter can be passed directly. In contrast to 22 G needle that accepts only 0.018 inch guide wire, requires a composite/telescoped access system to allow a 0.035 inch wire over which the dilator and catheter can be passed.[3]

Overall complication rate in our study is 14.9% (in 66 PCN). Total rate of major complication is 2% (9 patients). Major hemorrhage requiring blood transfusion was found in 0.6 (3 cases) and severe sepsis in 1.4% (6 cases) that is within the limit described by ACR-SIR guideline. Severe sepsis was found in 6 patients (1.4%) including one patient of septic shock. In a study 97% patients were given prophylactic antibiotic, 4 (1.3%) patients developed sepsis and required ICU care.[4] According to ACR-SIR-SPR practice guideline, recommended threshold for septic shock without pyonephrosis is 4% and with pyonephrosis is 10%.[18] Other studies have reported sepsis as a major complication in 0.7 to 3.6%.[11,4,20] Lower rate of sepsis in our study may be due to administration of prophylactic antibiotics in all cases and maintaining standard asepsis during the procedure. Reported incidence of sepsis is 50% in patients not receiving antibiotics and 9% in patients receiving antibiotics in high risk group (i.e. patients having positive urine culture, struvite stone or urinary ostomy).[21] Many authors suggest use of prophylactic intravenous antibiotics for all patients undergoing PCN. [22,23,21]

Most common minor complication was transient hematuria found in 23 (5.2%) patients that were self limited and did not require any treatment. Other minor complications were perinephric collection 6 (1.4%), pain 1 (0.2%) and piled off terumo guide wire in 1 (0.2%) case. Although not a life threatening condition piled off terumo guidewire can be a nidus for subsequent stone formation. So inadvertent guidewire manipulation should be avoided while the needle is still within the pelvicalyceal system. In our series none of the patients developed pneumothorax or colon transgression.

Catheter dislodgement noted in 16 (3.6%) cases; in 11 it was accidentally pulled out and in 5 it was displaced from pelvis. The rate of catheter dislocation has been reported ranging from 0.9 to 18%.[4] Catheter dislodgement in early post procedural period occurs in less than 1% of patients, 2% by the end of 1st month and 11-30% after prolonged follow up.[14,16] In our study 7 out of 11 patients with pulled out catheter were above the age of 50 years. Catheter block due to hemorrhage or debris were found in 10 (2.3%) patients that were managed by flushing with

sterile normal saline. None of the blocked catheter needed repeat procedure. Catheter blockage occurs in approximately 1% of patients.[24] One patient (0.2%) developed septic shock and expired. Mortality rate following PCN has been reported ranging from 0.04 to 0.3%. [22,3]

Conclusion

Percutaneous nephrostomy using seldinger technique with the USG and fluoroscopy guidance is an effective and safe minimally invasive procedure with a high success rate and low morbidity. The threshold limits given by SCVIR and ACR can be achieved by a well staffed department and experienced radiologists.

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References

1. Goodwin WE, Casey WC,Woolf W. Percutaneous trocar (needle) nephrostomy in hydronephrosis. J Am Med Assoc 1955;157(11):891–4.
2. Hausegger KA, Portugaller HR. Percutaneous nephrostomy and antegrade ureteral stenting: technique–indications–complications. Eur Radiol 2006;16(9):2016–30.
3. Saad WE, Moorthy M, Ginat D. Percutaneous nephrostomy: native and transplanted kidneys. Tech Vasc Interv Radiol. 2009;12(3):172-92.
4. Farrell TA, Hicks ME: A review of radiologically guided percutaneous nephrostomies in 303 patients. J Vasc Interv Radiol 1997; 8:769-774
5. Radecka E, Magnusson A: Complications associated with percutaneous nephrostomies. A retrospective study. Acta Radiol 2004;45:184-188
6. Ramchandani P, Cardella JF et al. Quality improvement guidelines for percutaneous nephrostomy. J Vasc Interv Radiol. 2003 14(9 Pt 2): S277-281.
7. Stables DP. Percutaneous nephrostomy: techniques, indications, and results. Urol Clin North Am. 1982; 9(1): 15-29.
8. Dyer RB, Regan JD, Kavanagh PV, Khatod EG, Chen MY, Zagoria RJ. Percutaneous nephrostomy with extensions of the technique: step by step. Radiographics. 2002;22(3):503-25.
9. Rameysh D. Mahmood, Lee Yizhi and Mark Tan M.L. (2012). Percutaneous Nephrostomy in Chronic Kidney Disease, Prof. Monika Göőz (Ed.), ISBN: 978-953 51-0171-0, InTech, DOI: 10.5772/25162. 297-314. Available from: http://www.intechopen.com/books/chronic-kidney-disease/percutaneous nephrostomy
10. Montanari E, Serrago M, Esposito N, Rocco B, Kartalas-Goumas I, Del Nero A, Zanetti G, Trinchieri A, Pisani E. Ultrasound-fluoroscopy guided access to the intrarenal excretory system. Ann Urol (Paris). 1999;33(3):168-81
11. Agostini S, Dedola GL, Gabbrielli S, Masi A. A new percutaneous nephrostomy technique in the treatment of obstructive uropathy. Radiol Med. 2003;105(5-6):454 61
12. Montvilas P, Solvig J, Johansen TE. Single-centre review of radiologically guided percutaneous nephrostomy using "mixed" technique: success and complicat-ion rates. Eur J Radiol. 2011;80(2):553-8.
13. Lee WJ, Mond DJ, Patel M, Pillari GP. Emergency percutaneous nephrostomy: technical success based on level of operator experience. J Vasc Interv Radiol 1994; 5:327–330.
14. Lee WJ, Patel U, Patel S, Pillari GP. Emergency percutaneous nephrostomy: results and complications. J Vasc Interv Radiol. 1994;5(1):135-139

15. Gray RR, So CB, McLoughlin RF, Pugash RA, Saliken JC, Macklin NI. Outpatient percutaneous nephrostomy. Radiology 1996; 198:85–88.
16. Gupta S, Gulati M, Uday Shankar K, Rungta U, Suri S. Percutaneous nephrostomy with real-time Sonographic guidance. Acta Radiol 1997; 38:454–457.
17. von der Recke P, Nielsen MB, Pedersen JF. Complications of ultrasound-guided nephrostomy: a 5-year experience. Acta Radiol 1994; 35:452–454.
18. ACR–SIR–SPR practice guideline for the performance of Percutaneous nephrostomy. http://www.acr.org/./media/ACR/Documents/PGTS/guidelines/Percutaneous nephrostomy;2011 [accessed 7.3.2013]
19. Clark TW, Abraham RJ, Flemming BK. Is routine micropuncture access necessary for percutaneous nephrostomy? A randomised trial. Canad Assoc Radiol J 2002;53:87—91.
20. Lewis S, Patel U. Major complications after percutaneous nephrostomy – lessons from a department audit. Clin Radiol 2004;59(2):171–9.
21. Cochran ST, Barbaric ZL, Lee JJ, Kashfian P. Nephrostomy tube placement: an outpatient procedure? Radiology 1991; 179:843–847.
22. Zagoria RJ, Dyer RB. Do's and don't's of percutaneous nephrostomy. Acad Radiol 1999; 6:370–377.
23. Ferral H, Stackhouse DJ, Bjarnason H, Hunter DW, Castaneda-Zu´n˜ iga WR. Complications of percutaneous nephrostomy tube placement. Semin Intervent Radiol 1994; 11:198–206.
24. Mahaffey KG, Bolton DM, Stoller ML. Urologist directed percutaneous nephrostomy tube placement. J Urol 1994; 152:1973–1976.