

Percutaneous Nephrostomy Audit: Evaluating Quality and Technical Proficiency

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ABSTRACT

Objective: The objective of this clinical audit was to assess the quality and technique of percutaneous nephrostomy (PCN) procedures in accordance with international standards in order to identify deficiencies in existing practices, adopt standardized quality improvement protocols, and evaluate their effects by a re-audit to optimize procedural outcomes and minimize problems.

Study design and setting: This retrospective cross-sectional clinical audit conducted in the Urology Department of Allied Hospital, Faisalabad. Study included 50 patients who underwent PCN and was carried out in two phases: an initial audit (January–February 2023) to assess baseline compliance with international PCN guidelines, followed by the implementation of quality improvement interventions and a re-audit (May–June 2023) to evaluate improvements in procedural quality and technique.

Methodology: Procedures were assessed via an audit proforma based on European Association of Urology (EAU), Society of Interventional Radiology (SIR), and Smith and Tanagho's guidelines, grading outcomes as Good, Moderate, or Poor. After identifying common errors, quality improvement measures were implemented. A re-audit of another 50 patients was conducted.

Results: The preliminary audit revealed suboptimal PCN quality and technique. Following the implementation of quality improvement measures, the re-audit demonstrated substantial enhancements in all grades, with a significant increase in good quality protocols.

Conclusion: This clinical audit and quality improvement initiative significantly enhanced the quality and technique of PCN. Regular training sessions, dissemination of guidelines and ongoing evaluations are recommended to reduced complications and improved patient experience.

Keywords: Clinical Audit, Hydronephrosis, Nephrostomy, Percutaneous, Patient Safety, Quality Improvement, Ultrasonography, Interventional

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INTRODUCTION:

PCN was pioneered by Dr. Willard Goodwin in 1955 as a image-guided minimally invasive procedure, offering a temporary or permanent alternative to surgical intervention for patients with hydronephrosis.¹ The procedure gained widespread acceptance in the late 1970s, facilitated by advancements in ultrasound (US) imaging technology, which enabled cross-sectional visualization of the kidneys, and is now commonly performed by urologists and radiologists. Based on current literature and guidelines, indications of PCN have been grouped into three main categories: urinary drainage, urinary diversion, and provision of access to the pelvicalyceal system.²

The primary indication for PCN is the relief of urinary obstruction, accounting for 85-90% of all nephrostomy placements. Complete obstruction is not considered as an emergency even after one-week, complete recovery is very likely. The longer the obstruction beyond one week, the lower the eventual recovery rate. After 12 weeks of complete outlet obstruction, very little recovery of renal function in

that kidney can be expected.^{3,4} Diversion of urine away from the inflamed area via nephrostomies can potentially expedite the healing of injured urinary tract tissue. Additionally, bilateral nephrostomies may be beneficial in severe and refractory cases by eliminating the bleeding-promoting effects of urinaryurokinase.⁵ Percutaneous access to the pelvicalyceal system is essential for various therapeutic and diagnostic interventions. This approach enables antegrade stenting to facilitate healing, targeted delivery of concentrated medications to treat refractory infections, and assessment of the degree of obstruction and permanent changes in renal musculature via Whittaker's test.⁶⁻⁷

Guidelines to perform PCN have been mentioned by European Association of Urology (EAU) and Society of Interventional Radiology (SIR). PCN is classified as a level 3 procedure. For level 3 procedures, guidelines recommend specific coagulation parameters to ensure safe performance of percutaneous procedures. These include an International Normalized Ratio of 1.5 or less, an Activated Partial Thromboplastin Time of no more than 1.5 times the hospital's normal standard, and a platelet count of at least 50,000 cells per cubic centimeter. There is a list of anticoagulants that should be withheld to reduce bleeding risks. Performing PCN on a non-dilated system may be temporarily deferred if there's a possibility that the calyces will dilate with a short delay, making the procedure easier and potentially safer. In patients with obstructive renal failure, hyperkalaemia can develop, posing a risk of life-threatening arrhythmias. In cases of severe hyperkalaemia or significant renal dysfunction, dialysis should be performed prior to attempting PCN to stabilize the patient's condition. Patient should be aware of the likelihood of having a tube in the body that requires maintenance for weeks or months. It may require prolonged nursing or family medical support with limited lifestyle functionality.⁸⁻⁹

Guidelines explain that before performing PCN patient should be explained about the procedure in sufficient detail. The unwillingness of a patient to accept this or to accept the risks of the procedure is a contraindication to the procedure. It's essential to inform patients that having a nephrostomy tube may require prolonged maintenance, potentially lasting weeks or months. This can impact their lifestyle, necessitating ongoing nursing or family support. If a patient is unwilling to accept the responsibilities and risks associated with the procedure, it is considered a contraindication. Patient positioning and marking the site is highly supportive of less chances of associated intrabdominal visceral injuries. US is a popular tool for PCN due to accessibility, portability, real-time imaging and no radiation risk. The technical success rate may vary depending on the clinical scenario i.e. degree of hydronephrosis or pyonephrosis, patient anatomy, number of access tracts but staying stuck to the guidelines provides benefit as it covers almost the outcomes. Sufficient time after injecting the LA

provides makes the procedure pain free for the patient and convenient for the surgeon. Incision at the marked site is made initially, 18-gauge or 21-gauge needle is then introduced at the incised area and advanced into the deeper planes. This step is confirmed by US as well as needle aspiration. Entry point should be carefully selected to minimize complications. Ideally, the entry point should be below the 12th rib to reduce the risk of pleural and diaphragmatic trauma. Additionally, the tube should be placed to avoid medial insertion, which can cause discomfort and kinking due to the paraspinal muscles, and lateral insertion, which increases the risk of accidental colon trauma. Later after removing the plunger of needle, guidewire enters the needle lumen. An 18-gauge needle can easily transmit a 0.035-inch guidewire. Serial dilatation causes significantly less pain than single-step dilatation. After the tract is dilated, nephrostomy tube is passed and its placement is confirmed, later secured with stitching and aseptic dressing. Post-procedure the patient is kept under observation for 6 hours and vitals are monitored half hourly. Bedrest is advised and nephrostomy tube is checked for its patency periodically and if blocked can be gently washed with diluted 5 mL N/S solution.¹⁰⁻¹²

PCN offers numerous benefits, making it a valuable treatment option. By immediately relieving obstruction, PCN can help preserve kidney function and potentially save nephrons. Additionally, it provides effective pain relief from obstruction and creates a better opportunity to treat infected urine compared to medication alone. PCN is also a safer and less invasive alternative to surgery, reducing the risk of abdominal organ injury, muscle damage, and post-procedure pain, while also resulting in a significantly smaller scar. Furthermore, PCN allows for the use of larger tubes for improved drainage, reduces the need for ureteral stone manipulation, and provides rapid relief from symptoms of pyonephrosis and urosepsis, typically within one to two days. It reduces the septic load, thereby creating a more favourable environment for other treatments to take effect. A successful PCN procedure can also help restore deranged renal functions, potentially preventing the need for dialysis and significantly improving the patient's overall condition.¹³⁻¹⁵

To ensure continuous quality improvement in patient-focused care, it is essential to audit and evaluate the local practices and techniques employed by doctors and healthcare assistants involved in PCN procedures. This audit aims to observe, assess, and enhance the quality and techniques of PCN procedures within the Department of Urology & Renal Transplantation at Allied Hospital Faisalabad. By doing so, we strive to provide the best possible healthcare outcomes while minimizing complications and unnecessary procedures.

The objective of this clinical audit is to evaluate the quality and technique of PCN procedure performed in the department of Urology & Renal transplantation, Allied Hospital Faisalabad, using a 3-tiered grading system; Good, Moderate and Poor.

Ethical Approval: This audit was conducted with ethical exemption from the Allied Hospital/Faisalabad Medical University Ethical Review Committee. All research activities were performed in strict compliance with international ethical standards and institutional guidelines. To ensure complete patient privacy and data protection, all personally identifiable information was removed from the dataset prior to analysis. A rigorous anonymization protocol was implemented; whereby patient names were systematically replaced with unique alphanumeric codes. This coding system was securely maintained with restricted access to protect participant confidentiality throughout all stages of data collection, analysis, and reporting, in accordance with HIPAA-equivalent data protection standards.

METHODOLOGY

This retrospective cross-sectional audit was carried out from 1st January 2023 to 28th February 2023. This audit was granted ethical exemption by the Allied Hospital/Faisalabad Medical University Ethical Review Committee, with additional review and approval from the local departmental review body of Urology and Renal Transplantation, given the time-sensitive nature of PCN procedures, which often require immediate intervention in emergency situations. This study included 50 adult patients aged 18–60 years presenting with acute hydronephrosis or pyonephrosis secondary to obstructive etiologies such as urolithiasis, ureteral strictures, malignant compression, or iatrogenic injury. Eligible patients exhibited clinical indications for emergency percutaneous nephrostomy (PCN), including severe pain, fever ($>38^{\circ}\text{C}$), leukocytosis ($\text{WBC} >11,000/\text{iL}$), or deteriorating renal function (elevated creatinine/BUN), necessitating urgent urinary drainage, diversion, or upper tract access. Patients were excluded if they had non-obstructive hydronephrosis without acute symptoms, uncorrected coagulopathy ($\text{INR} >1.5$ or platelets $<50,000/\text{iL}$), advanced renal impairment (creatinine $>4 \text{ mg/dL}$), terminal illness with limited life expectancy, or local contraindications such as active skin infection at the puncture site. These criteria ensured the selection of appropriate candidates while prioritizing patient safety and procedural feasibility. Based on 95% confidence interval ($\alpha=0.05$) and 80% study power ($\beta=0.20$), the calculation utilized the standard formula and sample size of 50 patients was computed using the Open-Epi online calculator, validated against parameters from the benchmark study "Audit of percutaneous nephrostomy in Rabat Urological Centre". [16] This approach ensured methodological rigor while accounting for real-world clinical variability observed in PCN outcomes. The calculation intentionally mirrored comparable audit designs to facilitate meaningful audit and re-audit comparisons while maintaining statistical reliability. Prior to the procedure, patients provided verbal consent after receiving a thorough explanation of the procedure. Patients were then positioned comfortably in a room with sufficient lighting and comfortable environment.

Presence of an assistant was observed. The patient was positioned in either a prone or oblique position. The operative field was meticulously prepared, maintaining sterility and disinfecting the skin. Sterile gloves and sheets were utilized to minimize the risk of infection. Subsequently, US guidance was employed, utilizing a probe with a frequency range of 3.5–5.2 MHz. The PCN procedure was performed using a Coloplast® PCN set, comprising a J-tip 6Fr PCN tube, 0.035-inch guidewire, 18G Chiba needle, and serial dilators (6–10Fr). Following, nephrostomy tube is carefully inserted up to the predetermined marked area. To ensure accurate placement, the position of the tube was then confirmed using US as well as by aspirating urine through the tube. The insertion site was secured with 2/0 Prolene suture. The entire procedure was carried out in accordance with established guidelines. Audit proforma was present in the procedure room. The audit proforma was meticulously designed in accordance with the evidence-based PCN techniques outlined in the European Association of Urology (EAU) Guidelines and the Society of Interventional Radiology (SIR) Guidelines, as well as the standardized PCN protocol detailed in Smith and Tanagho's General Urology (19th Edition). The PCN protocols were assessed using a standardized audit proforma, which evaluated the outcome in terms of Good, Moderate, and Poor quality techniques. The proforma was completed by the performing physician, ensuring anonymity of both the doctor and patient to the auditor. Once filled, the proforma was deposited in a designated secured area. Upon completion of the audit, the findings were analysed, and common errors were identified. A quality improvement plan was developed later, incorporating a set of recommendations and guidelines aimed at enhancing the overall quality of PCN procedures. For effective implementation, fortnightly journal club meetings took place in ward to facilitate discussion, critical analysis, and dissemination of recent research findings and best practices in PCN and related fields. Weekly presentations were conducted to educate and update the team. The recommended changes were then applied and monitored over a period of 2 months. A re-audit was conducted 2 months after the implementation of quality improvement measures, spanning from 1st May 2023 to 30th June 2023. This re-audit included 50 patients, adhering to the same inclusion criteria and protocols as the initial audit, to assess the efficacy of the implemented changes.

Adherence to sterile techniques during PCN procedures was evaluated among doctors using a standardized audit proforma, both before and after the implementation of recommendations for standardizing PCN. The evaluation was based on adherence to established guidelines from the EAU, SIR, and Smith and Tanagho's standards. The auditor collected the completed proformas on a weekly basis, ensuring a systematic and ongoing evaluation of the procedure's quality. Statistical analysis was performed using a one-sample T-test. A P-value

of less than 0.05 was considered statistically significant. All relevant data was entered into SPSS version 25 for analysis.

RESULTS

This retrospective cross-sectional clinical audit, conducted at the Urology and Renal Transplantation Department of Allied Hospital Faisalabad, enrolled 50 patients who met the predefined inclusion criteria between January 2023 and February 2023. The results exhibited that, among the 50 patients assessed, the quality and technique of PCN varied significantly. Specifically, 21 patients (42%) had poor (score =6), 17 patients (34%) had moderate (score 7-9), and only 12 patients (24%) had good quality and technique (score =10), highlighting substantial opportunities for quality improvement in PCN procedures. (Table. 1 & Figure. 1)

Following the implementation of a quality improvement plan, a re-audit was conducted over a 2-month period, from May 2023 to June 2023. The re-audit results demonstrated significant enhancements across all grades. Among the 50 patients assessed, the quality and technique of PCN was classified as poor (score =6) in 13 patients, moderate (score 7-9) in 19 patients, and good (score =10) in 18 patients. This translates to 26% of PCN being categorized as poor, 38% as average, and 36% as good, indicating notable improvements in the quality of care and technique of procedure. (Table. 2 & Figure. 2)

Quality improvement measures have also led to a significant reduction in post-PCN complications. Notably, tube malfunction, the most common complication, decreased from 42% to 16%, with the number of cases dropping from 21 to 8. Other complications also showed a decline in frequency. The number of patients experiencing severe pain requiring continuous painkillers decreased from 18 to 8, representing a drop from 36% to 16%. Similarly, haemorrhage requiring transfusion decreased from 8 to 3 cases, from 16% to 6%. Other complications, such as urine leakage, and hypotension, also showed a decline in frequency. Particularly, pneumothorax was completely eliminated, and there were no reported deaths in both pre- and post-quality improvement periods.

This re-audit demonstrated a statistically significant improvement in the quality and technique of PCN protocols, characterized by a substantial increase in good quality protocols (from 24% to 36%) and a marked decrease in poor quality protocols (from 42% to 26%). Aligning practices with international guidelines for PCN can bring numerous benefits.

Before the recommendations were implemented, several components showed suboptimal performance. For instance, only 28% of patients received a proper explanation before the procedure, and just 40% had tract dilatation performed sequentially. Sterility maintenance (72%) and ultrasound (US)-guided marking (74%) were relatively better adhered to, while assistant availability (56%) and appropriate

positioning (60%) had moderate compliance. Notably, waiting for local anesthetic (LA) efficacy showed no improvement, remaining at 60% post-implementation. After implementing the recommendations, significant improvements were observed in most components. Patient explanations increased to 42%, and sequential tract dilatation improved to 60%. Sterility maintenance rose to 82%, and US-guided marking reached 84%. Confirmation of PCN placement by US and urine aspiration saw the highest post-implementation compliance at 92%. Post-procedure care also improved from 60% to 74%. However, some components, such as skin disinfection (68%) and needle entry confirmation (66%), showed only modest improvements.

PCN is a critical procedure commonly performed in urology wards worldwide. However, faulty and unsterilized techniques can lead to severe complications, including haematuria, pain, haemorrhage, injury to the kidney, infection, sepsis, and allergic reactions. Moreover, mispositioning and PCN dislodgement are frequent issues if it is not properly secured with sutures and dressing. This can cause ongoing discomfort for the patient, emphasizing the importance of adhering to strict sterilization and technique protocols to ensure optimal outcomes. Complying with evidence-based PCN guidelines from the EAU, SIR, and Smith and Tanagho's techniques ultimately leads to improved patient outcomes. It ensures effective urinary drainage, reduces the risk of long-term kidney damage, and leads to shorter hospital stays. Optimal PCN technique reduces patient discomfort and pain during and after the procedure. Reduced complications lead to higher patient satisfaction rates. Consequently, implementation of PCN guidelines not only enhances patient safety and satisfaction but also reduces healthcare costs associated with managing complications. Ultimately, prioritizing high-quality PCN techniques is crucial for delivering exceptional patient care and achieving superior clinical outcomes.

This clinical audit and successive implementation of quality improvement measure yielded significant enhancements in the quality and technique of PCN in the Urology ward of Allied Hospital. Notably, the project improved patient experience and substantially reduced PCN-associated complications, thereby demonstrating the effectiveness and value of this quality improvement initiative.

DISCUSSION

The clinical audit conducted in the Urology ward of our tertiary-care hospital aimed to evaluate and improve the quality and technical proficiency of PCN. The findings of this audit and then reaudit highlight areas of excellence and identify opportunities for quality improvement. The existing literature underscores the importance of adhering to all scoring steps of this clinical audit, as they are crucial in ensuring the successful execution of PCN.

Field sterility is a crucial aspect of infection prevention in

Table 1: PCN: Grades, Scores, and percentage with Mean±SD

Grading of PCN	Scoring of PCN	n=Number	Percentage %	Mean±SD	p-Value
Poor	<6	21	42%	4.714±1.27	<0.001
Moderate	7-9	18	36%	8±0.935	<0.001
Good	>10	11	22%	11±0.73	<0.001

Figure. 1 – Graphical representation of PCN: Patient distribution by grade

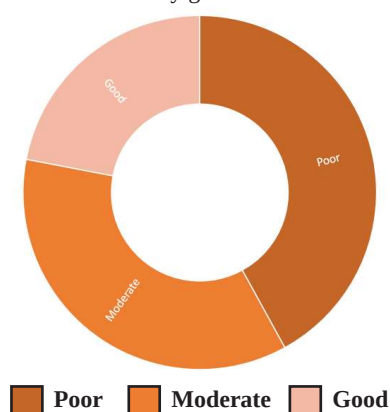


Figure. 2 – Graphical representation of PCN after quality improvement measures: Patient distribution by grade

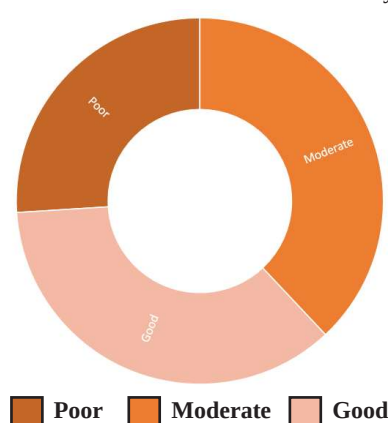


Table 2: PCN after quality improvement measures: Grades, Scores, and percentage with Mean±SD

Grading of PCN	Scoring of PCN	n=Number	Percentage %	Mean±SD	p-Value
Poor	<6	13	26%	5±1.3	<0.001
Moderate	7-9	19	38%	8.1±0.87	<0.001
Good	>10	18	36%	11.38±0.69	<0.001

Table 3: Exhibiting the number of patients and percentage of post PCN complications before and after implementation of the recommendations

Post PCN complications	Pre-quality PCN complications (n)	Post-quality PCN complications (n)	Pre-quality PCN complications (%)	Post-quality PCN complications (%)
Severe pain requiring continues painkiller	18	8	36%	16%
Haemorrhage – requiring transfusion	8	3	16%	6%
Tube malfunction	21	8	42%	16%
Urine leakage	11	2	22%	4%
Hypotension	9	8	18%	16%
Pneumothorax	2	0	4%	0%
Death	0	0	0%	0%

ambulatory settings minor minimal invasive procedures as well as image-guided procedures. Yu J and colleagues provided a comprehensive explanation that the implementation of sterility practices, including the use of skin disinfectants and patient draping significantly reduces the risk of infection. When performed actively, field sterility in image-guided procedures ensures a sterile environment, minimizing the introduction of microorganisms and subsequent infection.¹⁷ Nyhsen CM and team exhibited that decontamination of US transducers and related components along with the use of sterile gel is essential to prevent infection transmission even on intact skin and ensure patient safety during US guided procedures. The improper

decontamination can pose a significant risk of infection transmission to patients. The cost of an infection after a procedure is exceedingly high, not only in terms of patient quality of life but also in terms of healthcare system resources. Results in prolonged recovery times, increased healthcare costs, and decreased patient satisfaction, all stressing need for strict adherence to sterility protocols.¹⁸ Jaraith explains in his study that patient positioning and marking the site is highly supportive of less injuries. US is preferred for PCN due to portability and real-time imaging. Sufficient time after injecting the LA and incision at the marked site needle introduction, confirmed by US and aspiration, these steps in a pattern provide ease. After dilatation, nephrostomy tube

is passed later secured. Adherence to these guidelines is beneficial. Pig-tail PCN tubes are effective and safe approach, with recorded technical success 99%. PCN enables precise catheter placement under radiological guidance and ensuring continuous urine drainage. The self-retention mechanism of the catheter reduces the risk of dislodgement or blockage, resulting in low complications including decreased pain leading to lower analgesia requirements, with a positive impact on hospital expenses.²⁻¹⁹ Overall, in-situ nephrostomies significantly improve the renal drainage, relieve obstruction, and preserve renal function in patients with hydronephrosis or pyonephrosis.²⁰⁻²¹ Although the percentage of good PCN scores improved significantly after implementing quality improvement measures, the results still fell short of expectations, largely due to the brief time span in which the recommendations were implemented.

This major limitations of this study is the small sample size, which restricts generalizability. The absence of a control group complicates the validation of whether the enhancements were exclusively attributable to the intervention. Furthermore, a long-term follow-up was not performed to evaluate sustainability. A randomized trial may yield more robust findings. Notwithstanding these constraints, the results underscore possible avenues for procedural enhancement.

Clinical audits are essential for maintaining and improving quality and techniques in healthcare facilities, particularly in developing nations like Pakistan where basic care is often compromised due to shortage of hospitals, unavailability of equipment, poor doctor-to-patient ratio, doctors, nurses, and paramedical staff. Conducting multiple clinical audits fosters a thorough understanding of clinical practice, driving systemic enhancements. Our study's findings indicate significant potential for improvement, underscoring the need for hospital-based workshops engaging doctors, nurses, and paramedical staff to refine procedure execution, supplemented by recurring presentations, lectures, and simplified educational methods to facilitate ongoing betterment.

CONCLUSION

A comparative analysis of before and after implementation of quality improvement plan for PCN procedures reveals a statistically significant enhancement across the majority of assessed parameters. The implementation and stringent adherence to standardized PCN protocols are paramount, as efficacious management of these guidelines can potentially optimize procedural quality and patient outcomes. A follow-up audit should be conducted six months after implementing the suggested changes to evaluate the level of quality improvement. The findings should be presented at national conferences to share best practices and enhance the standards of this commonly performed procedure worldwide.

LIMITATION

The key limitations include the small sample size from a single center and the short implementation period for the

quality improvement measures. The study design also lacked a control group and long-term follow-up, which are necessary to robustly confirm causality and the durability of the observed improvements.

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