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The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

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ACR–SIR–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF PERCUTANEOUS NEPHROSTOMY

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care¹. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of this document is to assist practitioners in achieving this objective.

¹ *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing*, ___ N.W.2d ___ (Iowa 2013) Iowa Supreme Court refuses to find that the *ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures* (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, *Stanley v. McCarver*, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

I. INTRODUCTION

This practice parameter was revised collaboratively by the American College of Radiology (ACR), the Society of Interventional Radiology (SIR), and the Society for Pediatric Radiology (SPR).

Percutaneous nephrostomy (PCN) is a well-established therapy for urinary drainage in patients with supravescical urinary tract obstruction; for urinary diversion, as in patients with urinary fistulae, leaks, or hemorrhagic cystitis; and for other indications [1-10]. The procedure is also performed to gain access to the urinary tract for ureteral stent placement, percutaneous stone removal, and other endoscopic procedures. The collecting system can be located with fluoroscopy or by using cross-sectional techniques such as ultrasonography (US) or computed tomography (CT). Fluoroscopic localization is especially useful if a radiopaque stone, indwelling ureteral stent, or contrast-opacified collecting system can serve as a target [11-25].

This practice parameter may be used in a quality improvement program that monitors percutaneous nephrostomies [26].

The most important processes of care are 1) patient selection, 2) procedure performance, 3) monitoring, and 4) patient follow-up. The outcome measures or indicators for these processes are 1) indications, 2) success rates, and 3) complication rates. Outcome measures are assigned threshold levels.

II. DEFINITIONS

Percutaneous nephrostomy: image-guided percutaneous placement of a catheter into the renal collecting system.

Technical success for percutaneous nephrostomy: placement of a catheter of sufficient size to provide adequate drainage of the collecting system or to allow successful tract dilation so that the planned interventional procedure can be successfully completed through the nephrostomy tract.

Endoscopic procedure: procedure performed through the nephrostomy tract under direct visualization, using rigid or flexible nephroscopes or ureteroscopes. Flexible endoscopes require a 12- to 16-French tract, while rigid nephroscopes require a 24- to 30-French tract. Examples of such procedures are incision of a strictured ureteropelvic junction (endopyelotomy) and resection or fulguration of upper tract transitional cell carcinomas.

Percutaneous nephrostolithotomy (PCNL): removal of calculi from the kidney or proximal ureter through a percutaneous tract that is dilated to sufficient size to allow placement of a rigid endoscope so that large stones can be fragmented under direct vision before removal. Smaller stones may be amenable to extraction without fragmentation. The targeted stones should be successfully removed through the percutaneous access tract. The placement of multiple nephrostomy tracts and the use of flexible instruments may be necessary for complete removal of stone material.

III. INDICATIONS AND CONTRAINDICATIONS

A. Indications include, but are not limited to:

1. Relief of urinary obstruction
 - a. Urosepsis or suspected infection
 - b. Acute renal failure
 - c. Intractable pain
2. Urinary diversion
 - a. Hemorrhagic cystitis
 - b. Traumatic or iatrogenic ureteral injury
 - c. Inflammatory or malignant urinary fistula
3. Access for endourologic procedure
 - a. Stone removal
 - b. Dilatation or stenting of a ureteral stricture

- c. Endopyelotomy
 - d. Foreign body retrieval (eg, fractured or malpositioned stent)
 - e. Ureteral occlusion for urinary fistula
 - f. Tumor fulguration
 - g. Delivery of medications
 - h. Biopsy of an urothelial lesion
4. Diagnostic testing
- a. Antegrade pyelography
 - b. Ureteral perfusion (Whitaker test)

The indications for percutaneous nephrostomy in renal transplants are largely the same as in native kidneys [27]. Occasionally, percutaneous nephrostomy drainage may be performed as a therapeutic trial to differentiate renal failures due to urinary obstruction from those related to rejection.

The threshold for these indications is 95%. When <95% of procedures are performed for one of these indications, the department will review the process of patient selection.

B. Absolute Contraindications

There are no absolute contraindications. As with all patients considered for invasive procedures, the relative risks of the procedure should be weighed carefully. If there is no safe pathway to the kidney on preprocedural imaging, percutaneous nephrostomy may not be feasible.

C. Relative Contraindications

1. Uncorrectable severe coagulopathy or bleeding diathesis (eg, thrombocytopenia, patient with liver or multisystem failure). Patients on oral anticoagulant therapy can safely undergo the procedure after correction of coagulation factors without increased risk of bleeding complications [28].
2. Severe uncorrectable hypertension. Patients with severe hypertension are at increased risk of bleeding complications [29].
3. Patients with severe hyperkalemia are at increased risk of complications related to moderate sedation or general anesthesia [29].
4. Terminally ill patient for whom death is imminent. The mean life expectancy in patients with end-stage malignancies is rather short. In these patients, nephrostomy may not contribute to an enhanced quality of life, and it often necessitates multiple hospital admissions for complications related to the nephrostomy drain or ureteral stents [5,6,9].
5. Fluoroscopically guided procedures are best avoided in pregnancy, particularly in the first trimester. Ultrasound-guided procedures are preferred in such patients, but limited fluoroscopy may be needed [30,31].

For the pregnant or potentially pregnant patient, see the [ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation](#) [32].

IV. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

A. Physician

Percutaneous nephrostomy should be performed under the supervision of and interpreted by a physician who has the following qualifications:

1. Certification in Interventional Radiology or Diagnostic Radiology by the American Board of Radiology (ABR), the American Osteopathic Board of Radiology, the Royal College of Physicians and Surgeons of Canada, or the Collège des Médecins du Québec and has performed (with supervision) a sufficient number of PCN procedures to demonstrate competency as attested by the supervising physician(s).

or

2. Completion of a residency program approved by the Accreditation Council for Graduate Medical Education (ACGME), the Royal College of Physicians and Surgeons of Canada (RCPSC), the Collège des Médecins du Québec, or the American Osteopathic Association (AOA) and has performed (with supervision) a sufficient number of PCN procedures to demonstrate competency as attested by the supervising physician(s).

or

3. Physicians whose residency or fellowship training did not include the above may still be considered qualified to perform PCN procedures provided that the physician can demonstrate having performed (with supervision) a sufficient number of PCN procedures to demonstrate competency as attested by the supervising physician(s). A physician who successfully completes an ACGME-approved radiology or nonradiology residency or fellowship training program that did not include the above may still be considered qualified to perform PCN providing the following can be demonstrated.

The physician must have at least 2 years of procedural experience during which the physician was supervised and during which he or she performed 15 PCNs as primary operator with outcomes within the quality improvement thresholds of this practice parameter.

and

4. Physicians meeting any of the qualifications in 1, 2, or 3 above must also have written substantiation that they are familiar with all of the following:
 - a. Indications and contraindications for the procedure
 - b. Periprocedural and intraprocedural assessment, monitoring, and management of the patient and potential complications
 - c. Pharmacology of moderate-sedation medications (if using moderate sedation), as well as recognition and treatment of adverse reactions and complications
 - d. Appropriate use and operation of fluoroscopic and radiographic equipment and other electronic imaging systems that may be used as guidance during percutaneous procedures
 - e. Principles of radiation protection, hazards of radiation, and radiation monitoring requirements as they apply to both patients and personnel
 - f. Pharmacology of contrast agents and intraprocedural medications, as well as recognition and treatment of potential adverse reactions
 - g. Percutaneous needle introduction techniques
 - h. Technical aspects of performing the procedure
 - i. Anatomy, physiology, and pathophysiology of the structures being considered for PCN

The written substantiation should come from the chief of interventional radiology, the chair of the department of radiology, or his or her designee at the institution in which the physician will be providing these services². Substantiation could also come from a prior institution in which the physician provided the services, but only at the discretion of the chair of the department of radiology or his or her designee who solicits the additional input.

Maintenance of Competence

Physicians must perform a sufficient number of PCNs to maintain their skills, with acceptable success and complication rates as laid out in this practice parameter. Continued competence should depend on participation in a quality improvement program that monitors these rates.

Continuing Medical Education

The physician's continuing education should be in accordance with the [ACR Practice Parameter on Continuing Medical Education \(CME\)](#) [33].

²At institutions in which there is joint (dual) credentialing across departments doing like procedures, this substantiation of experience should be done by the chairs of both departments to ensure equity of experience among practitioners when their training backgrounds differ [43].

B. Non-Physician Practitioners

Physician assistants and nurse practitioners can be valuable members of the interventional radiology team. These nonphysician practitioners can function as independent members of the team. See the [ACR–SIR–SNIS–SPR Practice Parameter for Interventional Clinical Practice and Management](#) [34].

C. Qualified Medical Physicist

A Qualified Medical Physicist should be responsible for overseeing the equipment quality control program and for monitoring fluoroscopy and other cross-sectional imaging equipment, both upon installation and routinely on an annual basis. Medical physicists assuming these responsibilities should meet the following qualifications:

A Qualified Medical Physicist is an individual who is competent to practice independently one or more of the subfields in medical physics. The American College of Radiology (ACR) considers certification, continuing education, and experience to demonstrate that an individual is competent to practice one or more of the subfields in medical physics and to be a Qualified Medical Physicist. The ACR strongly recommends that the individual be certified in the appropriate subfield(s) by the American Board of Radiology (ABR), the Canadian College of Physics in Medicine, or by the American Board of Medical Physics (ABMP).

A Qualified Medical Physicist should meet the [ACR Practice Parameter for Continuing Medical Education \(CME\)](#). (ACR Resolution 17, 1996 – revised in 2012, Resolution 42) [33]

The appropriate subfield of medical physics for this practice parameter is Diagnostic Medical Physics. (Previous medical physics certification categories including Radiological Physics, Diagnostic Radiological Physics, and Diagnostic Imaging Physics are also available.)

D. Registered Radiologist Assistant

A registered radiologist assistant is an advanced level radiographer who is certified and registered as a radiologist assistant by the American Registry of Radiologic Technologists (ARRT) after having successfully completed an advanced academic program encompassing an ACR/ASRT (American Society of Radiologic Technologists) radiologist assistant curriculum and a radiologist-directed clinical preceptorship. Under radiologist supervision, the radiologist assistant may perform patient assessment, patient management and selected examinations as delineated in the Joint Policy Statement of the ACR and the ASRT titled “Radiologist Assistant: Roles and Responsibilities” and as allowed by state law. The radiologist assistant transmits to the supervising radiologists those observations that have a bearing on diagnosis. Performance of diagnostic interpretations remains outside the scope of practice of the radiologist assistant. (ACR Resolution 34, adopted in 2006)

E. Radiologic Technologist

The technologist, together with the physician and nursing personnel, should have responsibility for patient comfort and safety. The technologist should be able to prepare and position³ the patient for the percutaneous procedure and, together with the nurse, monitor the patient during the procedure. The technologist should obtain the imaging data in a manner prescribed by the supervising physician. If intravenous contrast material is to be administered, qualifications for technologists performing the intravenous injection should be in compliance with

³ The American College of Radiology approves of the practice of certified and/or licensed radiologic technologists performing fluoroscopy in a facility or department as a positioning or localizing procedure only, and then only if monitored by a supervising physician who is personally and immediately available*. There must be a written policy or process for the positioning or localizing procedure that is approved by the medical director of the facility or department/service and that includes written authority or policies and processes for designating radiologic technologists who may perform such procedures. (ACR Resolution 26, 1987 – revised in 2007, Resolution 12m)

*For the purposes of this parameter, “personally and immediately available” is defined in manner of the “personal supervision” provision of CMS—a physician must be in attendance in the room during the performance of the procedure. Program Memorandum Carriers, DHHS, HCFA, Transmittal B-01-28, April 19, 2001.

ACR policy statements⁴ and existing operating procedures or manuals at the interventional radiology facility and/or imaging facility. The technologist should also perform regular quality control testing of the equipment under the supervision of the physicist.

Technologists should be certified by the American Registry of Radiologic Technologists (ARRT) or have an unrestricted state license with documented training and experience in the imaging modality used for the percutaneous nephrostomy procedure.

F. Nursing Services

Nursing services, when deemed appropriate by the performing physician, are an integral part of the team for periprocedural and intraprocedural patient management and education and are recommended in monitoring the patient during the procedure.

V. SPECIFICATIONS AND PERFORMANCE OF THE PROCEDURE

Several technical requirements are necessary to ensure safe and successful PCNs. These include adequate imaging equipment and institutional facilities, physiologic monitoring equipment, and personnel.

A. Imaging Equipment and Facilities

The following are considered the minimum equipment requirements for performing PCN. In planning facilities for PCN, equipment and facilities more advanced than the minimum requirements outlined below may be desired to produce higher-quality studies with reduced risk and time of study. In general, the facility should have the following:

1. A high-resolution flat panel detector or image intensifier and television chain with adequate shielding and collimation. Ability to perform complex angle (eg, anteroposterior [AP], lateral, or oblique) views may facilitate fluoroscopically guided procedures in ensuring proper needle placement. Overhead fluoroscopic tube suites are less desirable because of increased radiation exposure to personnel during this procedure.
2. Availability of ultrasound. Proper transducer frequency is required to direct and monitor needle placement. Ultrasound equipment ideally should provide Doppler capabilities to avoid vascular injury.
3. Computed tomography (CT) capability when appropriate to better demonstrate anatomy, particularly in:
 - a. Patients with lesions in unusual or difficult-to-access locations
 - b. Locating the optimal access route to avoid transgressing vital structures
 - c. Patients with unusual anatomy
4. A suite that is large enough to allow easy transfer of the patient from the bed to the table and to allow room for the procedure table, monitoring equipment, and other hardware such as intravenous pumps, respirators, anesthesia equipment, and oxygen tanks. Ideally, there should be adequate space for the operating team to work unencumbered on either side of the patient and for the circulation of other technical staff in the room without contaminating the sterile conditions.
5. An area within the institution appropriate for patient preparation prior to the procedure and for observation of them after the procedure. At this location, there should be personnel to provide care as outlined in the Patient Care section below, and there should be immediate access to emergency resuscitation equipment.

B. Performance Guidelines

When using fluoroscopy for PCN, a facility should meet or exceed the following imaging practices:

1. Tight collimation should be used.
2. Radiation dose should be minimized.

⁴See the ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media.

3. Radiation dose estimates should also be recorded in the patient's medical record [35]. In accordance with the ALARA principle, a radiation dose reduction package including pulsed fluoroscopy and last image hold capabilities is recommended.

C. Physiologic Monitoring and Resuscitation Equipment

1. Equipment should be present in the procedure suite to allow for monitoring the patient's heart rate, cardiac rhythm, and blood pressure. If the patient is to receive moderate sedation, the [ACR–SIR Practice Parameter for Sedation/Analgesia](#) [36] should be followed.
2. Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications and/or procedural complications. The equipment should be maintained and medications inventoried for drug expiration dates on a regular basis. The equipment, medications, and other emergency support must also be appropriate for the range of ages and sizes in the patient population.

D. Surgical Support

Although complications of PCN only rarely require urgent surgery, it should be performed in an environment where operative repair can be instituted promptly. Ideally, this would be an acute-care hospital with adequate surgical, anesthesia, and ancillary support. If PCN is performed in a freestanding center, rapid transport or admission of patients to an acute-care hospital should be available. Procedures done in low-volume hospitals and by inexperienced operators may be associated with higher complication rates [37-39].

E. Anesthesia Support

Although indications for general anesthesia during percutaneous nephrostomy are rare, certain patients (including pediatric patients) may not tolerate the procedure with only moderate sedation. These patients may benefit from an anesthesia consult. These patients include, but are not limited to [36]:

1. Patients with chronic pain
2. Severe anxiety
3. Severe urosepsis requiring hemodynamic support
4. Patients managed by the anesthesiology or critical care service
5. Patients on mechanical ventilation
6. Patients who are ASA class IV and V

F. Patient Care

For additional information see the [ACR–SIR–SNIS–SPR Practice Parameter for Interventional Clinical Practice and Management](#) [34].

Percutaneous nephrostomy can be performed on an outpatient basis in selected patients. Patients who live alone or in whom the risk of complications is high (such as in those with urinary tract infection, staghorn calculi, uncorrected hypertension, or a coagulopathy) are best treated in an inpatient setting or a short-stay unit so they can be appropriately monitored [40-42].

In patients with severe uncorrected metabolic imbalance such as hyperkalemia or metabolic acidosis, correction of these imbalances may be necessary prior to the PCN in order to decrease the risk of complications such as arrhythmias or cardiac arrest related to the profound electrolyte abnormality.

1. Preprocedure Care

The physician performing the procedure must have knowledge of the following:

- a. Clinically significant history, including indications for the procedure

- b. Clinically significant physical examination findings, including an awareness of clinical or medical conditions that may necessitate specific care, such as administration of prophylactic antibiotics
- c. Any relevant preprocedure imaging studies or findings at cystoscopy
- d. Possible alternative methods, such as surgical or medical treatments, to obtain the desired therapeutic result

Informed consent must be in compliance with all state laws and the [ACR–SIR–SPR Practice Parameter on Informed Consent for Image-Guided Procedures](#) [43].

2. Procedural Care

- a. Adherence to the Joint Commission’s Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery™ is required for procedures in nonoperating room settings, including bedside procedures.
The organization should have processes and systems in place for reconciling differences in staff responses during the “time-out.”
- b. The physician performing fluoroscopy should have knowledge of exposure factors, including kVp, mA, magnification factor, and dose rate, and should consider additional parameters such as collimation, field of view, and last image hold.
- c. Nursing personnel, technologists, and those directly involved in the care of patients undergoing PCN should have protocols for use in standardizing care. These protocols should include, but are not limited to, the following:
 - i. Equipment needed for the procedure
 - ii. Patient monitoring

Protocols should be reviewed and updated periodically.

3. Postprocedure Care

- a. The operating physician or a qualified designee should evaluate the patient after the procedure, and these findings should be summarized in a progress note. If moderate sedation was administered prior to and during the procedure, complete recovery from sedation must be documented. The physician or designee should be available for continuing care during hospitalization and after discharge. The designee may be another physician, a physician’s assistant, or a nurse (see the [ACR–SIR Practice Parameter for Sedation/Analgesia](#) [36]). Postprocedure documentation should be in accordance with the [ACR–SIR–SPR Practice Parameter for the Reporting and Archiving of Interventional Radiology Procedures](#) [44].
- b. The patient’s vital signs and clinical status should be monitored until stable.
- c. The quality and quantity of tube drainage should be monitored at frequent intervals and charted by appropriately trained personnel.
- d. Care to prevent tube dislodgement or contamination must be exercised.
- e. Routine tube care including follow-up evaluation at coordinated intervals is recommended.

VI. DOCUMENTATION

Reporting should be in accordance with the [ACR–SIR–SPR Practice Parameter for the Reporting and Archiving of Interventional Radiology Procedures](#) [44].

VII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, “as low as reasonably achievable” (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification,

optimization and the use of dose reference levels) http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf.

Nationally developed guidelines, such as the ACR's [Appropriateness Criteria®](#), should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Facilities should have and adhere to policies and procedures that require varying ionizing radiation examination protocols (plain radiography, fluoroscopy, interventional radiology, CT) to take into account patient body habitus (such as patient dimensions, weight, or body mass index) to optimize the relationship between minimal radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available at the Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org) websites. These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR technical standards. Regular auditing of patient dose indices should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry, the NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends. (ACR Resolution 17 adopted in 2006 – revised in 2009, 2013, Resolution 52).

The [ACR–AAPM Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures](#) provides additional information on radiation dose management during fluoroscopy [45]. Radiation safety deserves particular attention when fluoroscopically guided procedures are performed on children. The Image Gently coalition has provided useful guidance in this regard [46].

VIII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (<http://www.acr.org/guidelines>).

IX. QUALITY IMPROVEMENT

While practicing physicians should strive to achieve perfect outcomes (ie, 100% success, 0% complications), in practice all physicians will fall short of this ideal to a variable extent. Therefore, indicator thresholds may be used to assess the efficacy of ongoing quality improvement programs. For the purpose of these parameters, a threshold is a specific level of an indicator that should prompt a review.

Individual complications may also be associated with complication-specific thresholds. When measures such as indications or success rates fall below a minimum threshold or when complication rates exceed a maximum threshold, a review should be performed to determine causes and to implement changes, if necessary. Thresholds may vary from those listed here; for example, patient referral patterns and selection factors may dictate a different threshold value for a particular indicator at a particular institution. Thus, setting universal thresholds is very difficult, and each department is urged to alter the thresholds as needed to higher or lower values to meet its own quality improvement program needs. There are relatively few reports of success rates and complication rates in children. The thresholds given below apply to adults.

A. Success Rates and Threshold

The technical success rates for percutaneous nephrostomy may vary depending on the clinical scenario, as follows:

<u>Clinical Scenario</u>	<u>Reported Success</u>	<u>Threshold</u>
Obstructed dilated system (with or without small stones)	98%	95%
Obstructed system in renal transplant	98%	95%
Nondilated collecting system (with or without small stones)	85%	80%
Complex stone disease, staghorn calculi	85%	75%

Overall, the ability to render a patient stone-free depends on factors beyond the placement of an optimal PCN tract. Variables such as the composition of the stones, whether the stone is a staghorn calculus or a solitary renal calculus, the anatomy of the patient, patient body habitus, whether multiple access tracts are placed or not, whether flexible instruments are used or not, and whether extracorporeal shock wave lithotripsy is combined with the percutaneous methods for complete removal of stone material [39,47-49] all contribute to the stone-free rate. The success of other endoscopic procedures is similarly affected by factors other than the creation of an optimal nephrostomy tract.

B. Complication Rates and Threshold

Complications can be stratified on the basis of outcome. When minor and major complications are considered together, they occur in approximately 10% of patients [50-85]. The specific complications and their thresholds are given below. The departmental thresholds apply to all complications that occur in the department. The individual thresholds apply to all the complications that each practitioner encounters. For the purposes of this document, the following thresholds are for major complications only (see Appendix A):

<u>Complication</u>	<u>Reported Rate</u>	<u>Threshold</u>
Septic shock (fever, chills with hypotension, requiring major increase in level of care)	1% to 3%	4%
Septic shock (in setting of pyonephrosis)	7% to 9%	10%
Hemorrhage (requiring transfusion)		
PCN alone	1% to 4%	4%
With PCNL	12% to 14%	15%
Bowel transgression	0.2%	<1%
Pleural complications (pneumothorax, empyema, hydrothorax, hemothorax)		
PCN alone	0.1% to 0.2%	<1%
with PCNL or endopyelotomy via intercostal puncture or upper pole puncture	8.7% to 12%	15%
Individual threshold*	4% to 7%	5%

*Complications that result in unexpected transfer to an intensive care unit, emergency surgery, or delayed discharge from the hospital

Note: PCN = percutaneous nephrostomy
PCNL = percutaneous nephrostolithotomy

Published rates for individual types of complications are highly dependent on patient selection and are in some cases based on series comprising several hundred patients, which is a volume larger than most individual practitioners are likely to treat. It is also recognized that a single complication can cause a rate to cross above a complication-specific threshold when the complication occurs in a small volume of patients, eg, early in a quality improvement program.

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Collaborative Committee – members represent their societies in the initial and final revision of this practice parameter

ACR

Stephen P. Reis, MD, Chair
Noor Ahmad, MD
J. Damien Grattan-Smith, MBBS
Sean R. Dariushnia, MD

SIR

Drew M. Caplin, MD
Jason W. Mitchell, MD
Naganathan B. Mani, MD

SPR

G. Peter Feola, MD
Manish N. Patel, DO
Shellie C. Josephs, MD

Committee on Practice Parameters – Interventional and Cardiovascular Radiology

(ACR Committee responsible for sponsoring the draft through the process)

Aradhana M. Venkatesan, MD, FSIR, Chair
Clayton K. Trimmer, DO, FACR, Vice-Chair
Drew M. Caplin, MD
Sean R. Dariushnia, MD
Jeremy L. Friese, MD, MBA
Joshua A. Hirsch, MD, FACR, FSIR
Elizabeth A. Ignacio, MD
Sanjeeva P. Kalva, MD, FSIR
Minhajuddin S. Khaja, MD, MBA
Margaret Hsin-Shung Lee, MD
Susan K. O'Horo, MD, FSIR
Stephen P. Reis, MD
Wael Saad, MD, FSIR
Beth A. Schueler, PhD, FACR, FAAPM
Timothy L. Swan, MD, FACR, FSIR
Sanjit Tewari, MD
Joan C. Wojak, MD, FACR, FSIR

Committee on Practice Parameters – Pediatric Radiology

(ACR Committee responsible for sponsoring the draft through the process)

Beverley Newman, MB, BCh, BSc, FACR, Chair

Lorna P. Browne, MB, BCh

Timothy J. Carmody, MD

Brian D. Coley, MD, FACR

Lee K. Collins, MD

Monica S. Epelman, MD

Lynn Ansley Fordham, MD, FACR

Kerri A. Highmore, MD

Sue C. Kaste, DO

Tal Laor, MD

Terry L. Levin, MD

Marguerite T. Parisi, MD, MS

Sumit Pruthi, MBBS

Nancy K. Rollins, MD

Pallavi Sagar, MD

Philip S. Cook, MD, FACR, FSIR, Chair, Commission on Interventional and Cardiovascular Radiology

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REFERENCES

1. Farrell TA, Hicks ME. A review of radiologically guided percutaneous nephrostomies in 303 patients. *J Vasc Interv Radiol.* 1997;8(5):769-774.
2. Hausegger KA, Portugaller HR. Percutaneous nephrostomy and antegrade ureteral stenting: technique-indications-complications. *Eur Radiol.* 2006;16(9):2016-2030.
3. Laurin S, Sandstrom S, Ivarsson H. Percutaneous nephrostomy in infants and children. *Acad Radiol.* 2000;7(7):526-529.
4. Millward SF. Percutaneous nephrostomy: a practical approach. *J Vasc Interv Radiol.* 2000;11(8):955-964.
5. Nariculam J, Murphy DG, Jenner C, et al. Nephrostomy insertion for patients with bilateral ureteric obstruction caused by prostate cancer. *Br J Radiol.* 2009;82(979):571-576.
6. Romero FR, Broglio M, Pires SR, Roca RF, Guibu IA, Perez MD. Indications for percutaneous nephrostomy in patients with obstructive uropathy due to malignant urogenital neoplasias. *Int Braz J Urol.* 2005;31(2):117-124.
7. Shokeir AA, El-Diasty T, Eassa W, et al. Diagnosis of ureteral obstruction in patients with compromised renal function: the role of noninvasive imaging modalities. *J Urol.* 2004;171(6 Pt 1):2303-2306.
8. Stables DP. Percutaneous nephrostomy: techniques, indications, and results. *Urol Clin North Am.* 1982;9(1):15-29.
9. Wilson JR, Urwin GH, Stower MJ. The role of percutaneous nephrostomy in malignant ureteric obstruction. *Ann R Coll Surg Engl.* 2005;87(1):21-24.
10. Zagoria RJ, Hodge RG, Dyer RB, Routh WD. Percutaneous nephrostomy for treatment of intractable hemorrhagic cystitis. *J Urol.* 1993;149(6):1449-1451.
11. Barbaric ZL, Hall T, Cochran ST, et al. Percutaneous nephrostomy: placement under CT and fluoroscopy guidance. *AJR Am J Roentgenol.* 1997;169(1):151-155.
12. Basiri A, Mehrabi S, Kianian H, Javaherforooshzadeh A. Blind puncture in comparison with fluoroscopic guidance in percutaneous nephrolithotomy: a randomized controlled trial. *Urol J.* 2007;4(2):79-83; discussion 83-75.
13. Basiri A, Ziaee AM, Kianian HR, Mehrabi S, Karami H, Moghaddam SM. Ultrasonographic versus fluoroscopic access for percutaneous nephrolithotomy: a randomized clinical trial. *J Endourol.* 2008;22(2):281-284.
14. Basiri A, Ziaee SA, Nasseh H, et al. Totally ultrasonography-guided percutaneous nephrolithotomy in the flank position. *J Endourol.* 2008;22(7):1453-1457.
15. Egilmez H, Oztoprak I, Atalar M, et al. The place of computed tomography as a guidance modality in percutaneous nephrostomy: analysis of a 10-year single-center experience. *Acta Radiol.* 2007;48(7):806-813.
16. El-Ghar ME, Shokeir AA, El-Diasty TA, Refaie HF, Gad HM, El-Dein AB. Contrast enhanced spiral computerized tomography in patients with chronic obstructive uropathy and normal serum creatinine: a single session for anatomical and functional assessment. *J Urol.* 2004;172(3):985-988.
17. Hosseini MM, Hassanpour A, Farzan R, Yousefi A, Afrasiabi MA. Ultrasonography-guided percutaneous nephrolithotomy. *J Endourol.* 2009;23(4):603-607.
18. Mahmood T, Younus R, Ahmad F, Memon S, Moavia A. Ultrasound as a reliable guidance system for percutaneous nephrostomy. *J Coll Physicians Surg Pak.* 2007;17(1):15-18.
19. Matlaga BR, Shah OD, Zagoria RJ, Dyer RB, Stroom SB, Assimos DG. Computerized tomography guided access for percutaneous nephrostolithotomy. *J Urol.* 2003;170(1):45-47.
20. Osman M, Wendt-Nordahl G, Heger K, Michel MS, Alken P, Knoll T. Percutaneous nephrolithotomy with ultrasonography-guided renal access: experience from over 300 cases. *BJU Int.* 2005;96(6):875-878.
21. Patel U, Hussain FF. Percutaneous nephrostomy of nondilated renal collecting systems with fluoroscopic guidance: technique and results. *Radiology.* 2004;233(1):226-233.
22. Patel U, Walkden RM, Ghani KR, Anson K. Three-dimensional CT pyelography for planning of percutaneous nephrostolithotomy: accuracy of stone measurement, stone depiction and pelvicalyceal reconstruction. *Eur Radiol.* 2009;19(5):1280-1288.
23. Skolarikos A, Alivizatos G, Papatsoiris A, Constantinides K, Zervas A, Deliveliotis C. Ultrasound-guided percutaneous nephrostomy performed by urologists: 10-year experience. *Urology.* 2006;68(3):495-499.
24. Sood G, Sood A, Jindal A, Verma DK, Dhiman DS. Ultrasound guided percutaneous nephrostomy for obstructive uropathy in benign and malignant diseases. *Int Braz J Urol.* 2006;32(3):281-286.

25. Thanos L, Mylona S, Stroumpouli E, Kalioras V, Pomoni M, Batakis N. Percutaneous CT-guided nephrostomy: a safe and quick alternative method in management of obstructive and nonobstructive uropathy. *J Endourol*. 2006;20(7):486-490.
26. Chalmers N, Jones K, Drinkwater K, Uberoi R, Tawn J. The UK nephrostomy audit. Can a voluntary registry produce robust performance data? *Clin Radiol*. 2008;63(8):888-894.
27. Aytekin C, Boyvat F, Harman A, Ozyer U, Colak T, Haberal M. Percutaneous therapy of ureteral obstructions and leak after renal transplantation: long-term results. *Cardiovasc Intervent Radiol*. 2007;30(6):1178-1184.
28. Kefer JC, Turna B, Stein RJ, Desai MM. Safety and efficacy of percutaneous nephrostolithotomy in patients on anticoagulant therapy. *J Urol*. 2009;181(1):144-148.
29. Stokes LS, Meranze SG. Percutaneous nephrostomy, cystostomy, and nephroureteral stenting. In: Mauro MA, Murphy KPJ, Thompson KR, Venbrux AC, Morgan RA., eds. *Image-Guided Interventions* 2nd ed. Philadelphia, PA: Elsevier Saunders; 2014:1077.
30. ACR ASRT joint statement. Radiologist assistant roles and responsibilities. *Digest of Council Actions*. Reston, Va: American College of Radiology; 2008:147.
31. Khoo L, Anson K, Patel U. Success and short-term complication rates of percutaneous nephrostomy during pregnancy. *J Vasc Interv Radiol*. 2004;15(12):1469-1473.
32. American College of Radiology. ACR-SPR practice parameter for imaging pregnant or potentially pregnant adolescents and women with ionizing radiation. 2013; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Pregnant-Pts.pdf>. Accessed June 19, 2015.
33. American College of Radiology. ACR practice parameter for continuing medical education (CME). 2011; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CME.pdf>. Accessed June 19, 2015.
34. American College of Radiology. ACR-SIR-SNIS-SPR practice parameter for interventional clinical practice and management. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/IRClin-Prac-Mgmt.pdf>. Accessed June 19, 2015.
35. Miller DL, Balter S, Wagner LK, et al. Quality improvement guidelines for recording patient radiation dose in the medical record. *J Vasc Interv Radiol*. 2004;15(5):423-429.
36. American College of Radiology. ACR-SIR practice parameter for sedation/analgesia. 2015; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Sed-Analgesia.pdf>. Accessed June 19, 2015.
37. 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(2):327-330.
38. Lewis S, Patel U. Major complications after percutaneous nephrostomy-lessons from a department audit. *Clin Radiol*. 2004;59(2):171-179.
39. Morris DS, Wei JT, Taub DA, Dunn RL, Wolf JS, Jr., Hollenbeck BK. Temporal trends in the use of percutaneous nephrolithotomy. *J Urol*. 2006;175(5):1731-1736.
40. Cochran ST, Barbaric ZL, Lee JJ, Kashfian P. Percutaneous nephrostomy tube placement: an outpatient procedure? *Radiology*. 1991;179(3):843-847.
41. Gray RR, So CB, McLoughlin RF, Pugash RA, Saliken JC, Macklin NI. Outpatient percutaneous nephrostomy. *Radiology*. 1996;198(1):85-88.
42. Hogan MJ, Coley BD, Jayanthi VR, Shiels WE, Koff SA. Percutaneous nephrostomy in children and adolescents: outpatient management. *Radiology*. 2001;218(1):207-210.
43. American College of Radiology. ACR-SIR practice parameter on informed consent for image-guided procedures. 2016; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/InformedConsent-ImagGuided.pdf>. Accessed January 8, 2015.
44. American College of Radiology. ACR-SIR-SPR practice parameter for the reporting and archiving of interventional radiology procedures. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Reporting-Archiv.pdf>. Accessed June 19, 2015.
45. American College of Radiology. ACR-AAPM technical standard for management of the use of radiation in fluoroscopic procedures. 2013; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MgmtFluoroProc.pdf>. Accessed June 19, 2015.
46. Sidhu MK, Goske MJ, Coley BJ, et al. Image gently, step lightly: increasing radiation dose awareness in pediatric interventions through an international social marketing campaign. *J Vasc Interv Radiol*. 2009;20(9):1115-1119.
47. Al-Kohlany KM, Shokeir AA, Mosbah A, et al. Treatment of complete staghorn stones: a prospective randomized comparison of open surgery versus percutaneous nephrolithotomy. *J Urol*. 2005;173(2):469-473.

48. Bird VG, Fallon B, Winfield HN. Practice patterns in the treatment of large renal stones. *J Endourol.* 2003;17(6):355-363.
49. Desai M, Jain P, Ganpule A, Sabnis R, Patel S, Shrivastav P. Developments in technique and technology: the effect on the results of percutaneous nephrolithotomy for staghorn calculi. *BJU Int.* 2009;104(4):542-548; discussion 548.
50. Cadeddu JA, Arrindell D, Moore RG. Near fatal air embolism during percutaneous nephrostomy placement. *J Urol.* 1997;158(4):1519.
51. Camunez F, Echenagusia A, Prieto ML, Salom P, Herranz F, Hernandez C. Percutaneous nephrostomy in pyonephrosis. *Urol Radiol.* 1989;11(2):77-81.
52. Carrafiello G, Lagana D, Mangini M, et al. Complications of percutaneous nephrostomy in the treatment of malignant ureteral obstructions: single-centre review. *Radiol Med.* 2006;111(4):562-571.
53. Chichakli R, Krause R, Voelzke B, Turk T. Incidence of perinephric hematoma after percutaneous nephrolithotomy. *J Endourol.* 2008;22(6):1227-1232.
54. El-Nahas AR, Shokeir AA, El-Assmy AM, et al. Colonic perforation during percutaneous nephrolithotomy: study of risk factors. *Urology.* 2006;67(5):937-941.
55. el-Nahas AR, Shokeir AA, Mohsen T, et al. Functional and morphological effects of postpercutaneous nephrolithotomy superselective renal angiographic embolization. *Urology.* 2008;71(3):408-412.
56. Gonen M, Turan H, Ozturk B, Ozkardes H. Factors affecting fever following percutaneous nephrolithotomy: a prospective clinical study. *J Endourol.* 2008;22(9):2135-2138.
57. Hegarty NJ, Desai MM. Percutaneous nephrolithotomy requiring multiple tracts: comparison of morbidity with single-tract procedures. *J Endourol.* 2006;20(10):753-760.
58. Hopper KD, Sherman JL, Williams MD, Ghaed N. The variable anteroposterior position of the retroperitoneal colon to the kidneys. *Invest Radiol.* 1987;22(4):298-302.
59. Hopper KD, Yakes WF. The posterior intercostal approach for percutaneous renal procedures: risk of puncturing the lung, spleen, and liver as determined by CT. *AJR Am J Roentgenol.* 1990;154(1):115-117.
60. Hosseini MM, Basiri A, Moghaddam SM. Percutaneous nephrolithotomy of patients with staghorn stone and incidental purulent fluid suggestive of infection. *J Endourol.* 2007;21(12):1429-1432.
61. Kaskarelis IS, Papadaki MG, Malliaraki NE, Robotis ED, Malagari KS, Piperopoulos PN. Complications of percutaneous nephrostomy, percutaneous insertion of ureteral endoprosthesis, and replacement procedures. *Cardiovasc Intervent Radiol.* 2001;24(4):224-228.
62. Lee WJ, Patel U, Patel S, Pillari GP. Emergency percutaneous nephrostomy: results and complications. *J Vasc Interv Radiol.* 1994;5(1):135-139.
63. Martin JH, Rosser CJ, Linebach RF, McCullough DL, Assimios DG. Are coagulation studies necessary before percutaneous nephrostomy? *Tech Urol.* 2000;6(3):205-207.
64. Marx MV. The radiation dose in interventional radiology study: knowledge brings responsibility. *J Vasc Interv Radiol.* 2003;14(8):947-951.
65. Michel MS, Trojan L, Rassweiler JJ. Complications in percutaneous nephrolithotomy. *Eur Urol.* 2007;51(4):899-906; discussion 906.
66. Miller DL, Balter S, Cole PE, et al. Radiation doses in interventional radiology procedures: the RAD-IR study: part II: skin dose. *J Vasc Interv Radiol.* 2003;14(8):977-990.
67. Miller DL, Balter S, Cole PE, et al. Radiation doses in interventional radiology procedures: the RAD-IR study: part I: overall measures of dose. *J Vasc Interv Radiol.* 2003;14(6):711-727.
68. Miller GL, Summa J. Transcolonic placement of a percutaneous nephrostomy tube: recognition and treatment. *J Vasc Interv Radiol.* 1997;8(3):401-403.
69. Ng CK, Yip SK, Sim LS, et al. Outcome of percutaneous nephrostomy for the management of pyonephrosis. *Asian J Surg.* 2002;25(3):215-219.
70. Pearle MS, Pierce HL, Miller GL, et al. Optimal method of urgent decompression of the collecting system for obstruction and infection due to ureteral calculi. *J Urol.* 1998;160(4):1260-1264.
71. Radecka E, Magnusson A. Complications associated with percutaneous nephrostomies. A retrospective study. *Acta Radiol.* 2004;45(2):184-188.
72. Ramchandani P, Cardella JF, Grassi CJ, et al. Quality improvement guidelines for percutaneous nephrostomy. *J Vasc Interv Radiol.* 2003;14(9 Pt 2):S277-281.
73. Rana AM, Zaidi Z, El-Khalid S. Single-center review of fluoroscopy-guided percutaneous nephrostomy performed by urologic surgeons. *J Endourol.* 2007;21(7):688-691.

74. Richstone L, Reggio E, Ost MC, et al. First Prize (tie): Hemorrhage following percutaneous renal surgery: characterization of angiographic findings. *J Endourol*. 2008;22(6):1129-1135.
75. Ryan JM, Ryan BM, Smith TP. Antibiotic prophylaxis in interventional radiology. *J Vasc Interv Radiol*. 2004;15(6):547-556.
76. Safak M, Olgar T, Bor D, Berkmen G, Gogus C. Radiation doses of patients and urologists during percutaneous nephrolithotomy. *J Radiol Prot*. 2009;29(3):409-415.
77. Schaeffer AJ, Handa SE, Lingeman JE, Matlaga BR. Transsplenic percutaneous nephrolithotomy. *J Endourol*. 2008;22(11):2481-2484.
78. Shaban A, Kodera A, El Ghoneimy MN, Orban TZ, Mursi K, Hegazy A. Safety and efficacy of supracostal access in percutaneous renal surgery. *J Endourol*. 2008;22(1):29-34.
79. Sharifi Aghdas F, Akhavadegan H, Aryanpoor A, Inanloo H, Karbakhsh M. Fever after percutaneous nephrolithotomy: contributing factors. *Surg Infect (Larchmt)*. 2006;7(4):367-371.
80. Srivastava A, Singh KJ, Suri A, et al. Vascular complications after percutaneous nephrolithotomy: are there any predictive factors? *Urology*. 2005;66(1):38-40.
81. Tefekli A, Ali Karadag M, Tepeler K, et al. Classification of percutaneous nephrolithotomy complications using the modified clavien grading system: looking for a standard. *Eur Urol*. 2008;53(1):184-190.
82. Turna B, Nazli O, Demiryoguran S, Mammadov R, Cal C. Percutaneous nephrolithotomy: variables that influence hemorrhage. *Urology*. 2007;69(4):603-607.
83. Vorrakitpokatorn P, Permtongchuchai K, Raksamani EO, Phetongkam A. Perioperative complications and risk factors of percutaneous nephrolithotomy. *J Med Assoc Thai*. 2006;89(6):826-833.
84. Watterson JD, Soon S, Jana K. Access related complications during percutaneous nephrolithotomy: urology versus radiology at a single academic institution. *J Urol*. 2006;176(1):142-145.
85. Yoder IC, Lindfors KK, Pfister RC. Diagnosis and treatment of pyonephrosis. *Radiol Clin North Am*. 1984;22(2):407-414.

APPENDIX A

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Classification of Complications by Outcome

Minor Complications

- A. No therapy, no consequence
- B. Nominal therapy, no consequence; includes overnight admission for observation only

Major Complications

- C. Require therapy, minor hospitalization (<48 hours)
- D. Require major therapy, unplanned increase in level of care, prolonged hospitalization (>48 hours)
- E. Permanent adverse sequelae
- F. Death

*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

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