

# CURRICULUM

## Novel Emergency Medicine Curriculum Utilizing Self-Directed Learning and the Flipped Classroom Method: Genitourinary Emergencies Small Group Module

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### ABSTRACT:

**Audience:** This curriculum, created and implemented at The Ohio State University Wexner Medical Center, was designed to educate our emergency medicine (EM) residents, PGY-1 to PGY-3, as well as medical students.

**Introduction:** In 2013, there were over 6 million Emergency Department visits in the United States which resulted in a primary diagnosis of the genitourinary system. This represents 5.2% of all Emergency Department visits.<sup>1</sup> Residents must be proficient in the differential diagnosis and management of the wide variety of genitourinary emergencies. This flipped classroom curricular model emphasizes self-directed learning activities completed by learners, followed by small group discussions pertaining to the topic reviewed. The active learning fostered by this curriculum increases faculty and learner engagement and interaction time typically absent in traditional lecture-based formats.<sup>2-4</sup> Studies have revealed that the application of knowledge through case studies, personal interaction with content experts, and integrated questions are effective learning strategies for emergency medicine residents.<sup>4-6</sup> The Ohio State University Wexner Medical Center EM Residency didactic curriculum recently transitioned to a “flipped classroom” approach.<sup>7-10</sup> We created this innovative curriculum aimed to improve our residency education program and to share educational resources with other EM residency programs. Our curriculum utilizes an 18-month curricular cycle to cover the defined emergency medicine content. The flipped classroom curriculum maximizes didactic time and resident engagement, fosters intellectual curiosity and active learning, and meets the needs of today’s learners.<sup>3,6,11</sup>

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**Objectives:** We aim to teach the presentation and management of genitourinary emergencies through the creation of a flipped classroom design. This unique, innovative curriculum utilizes resources chosen by education faculty and resident learners, study questions, real-life experiences, and small group discussions in place of traditional lectures. In doing so, a goal of the curriculum is to encourage self-directed learning, improve understanding and knowledge retention, and improve the educational experience of our residents.

**Methods:** The educational strategies used in this curriculum include: small group modules authored by education faculty and content experts based on the core emergency medicine content. This program also includes resident submitted questions that were developed during review of the content. The Socratic Method, used during small group sessions, encourages active participation; small groups also focus on the synthesis and application of knowledge through the discussion of real life experiences. The use of free open access medical education (FOAM) resources allows learners to work at their own pace and maximize autonomy.

**Topics:** Emergency medicine, flipped classroom, medical education, genitourinary emergencies, pedagogy, teaching.



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## Learner Audience:

Medical students, interns, junior residents, senior residents

## Length of Curriculum:

The entire didactic curriculum was developed to utilize an 18-month curricular cycle; therefore, resident learners experience each curricular topic twice in the course of their residency training. The genitourinary emergencies module consists of seven 45-60-minute small group sessions.

## Topics:

Emergency medicine, flipped classroom, medical education, genitourinary emergencies, pedagogy, teaching.

## Brief introduction:

The flipped classroom learning approach is becoming more commonly recognized as a preferred curricular model for mature learners, specifically those in medical education. This particular model is a natural fit for the hands-on, experiential emergency medicine learner.<sup>4</sup> The active learning fostered by this curriculum increases faculty and learner engagement and interaction time, which is typically absent in traditional lecture-based formats.<sup>5,12</sup> Education literature shows that resident learners prefer learning activities that involve small group discussion, are case/skill based, and emphasize the application of newly obtained knowledge.<sup>3,4</sup> This educational model also provides a clear channel for the incorporation of evidence-based medicine and increases opportunities for educator-learner conversations. A successful flipped classroom curriculum fosters learner accountability and provides robust opportunities for formal assessment in various emergency medicine milestones.<sup>4,9,12</sup> For these reasons, we developed a flipped classroom curriculum at The Ohio State University

Wexner Medical Center. This genitourinary emergencies curriculum is one of several topics in our overall didactic curriculum.

## Problem identification, general and targeted needs assessment:

Traditional lecture-based didactics may not be the most effective or preferred method for emergency medicine resident education.<sup>6</sup> Previously, we used a traditional lecture format in our residency curriculum despite overwhelming evidence for a more hands-on, “flipped classroom” approach.<sup>8,9</sup> From the perspective of resident learners, the chance to remain fully engaged through the asking of questions developed from personal experiences, and also by learning from the experiences of others, provides a manner of learning that makes a topic more difficult to forget.<sup>5</sup>

As current literature reveals, both educators and learners benefit from an interactive and collaborative classroom, leading to the creation and implementation of this proposed curricular model at our emergency medicine residency program.<sup>10</sup> This weekly small group curriculum has now replaced three hours of traditional lecture-based didactics. Since implementation, residents and educators are engaging in new, valuable flipped classroom learning communities at The Ohio State University Wexner Medical Center. Through the curriculum, we continually seek to foster self-directed learning and increased collaboration between resident learners and education faculty members. This ensures that resident time will be maximized and learning will be more efficient and effective. Similarly, self-directed learning is vital in continuing medical education; therefore, the development of this skill during residency training is important. Currently, minimal flipped classroom curricular materials dedicated to the core content of emergency medicine exist.

## Goals of the curriculum:

This curricular innovation was developed and implemented to promote self-directed/active learning and an environment of intellectual curiosity and learner accountability. This flipped classroom curriculum is specifically designed to cover the core content of emergency medicine; this module promotes the mastery of genitourinary emergencies. Secondary goals include increased interaction between educators and learners and the evaluation of resident small group teaching skills.

## Objectives of the curriculum:

Each chapter within our curriculum has individual objectives; however, educational objectives for the curriculum and more specifically, the Genitourinary Emergencies Module include:

1. Resident learners will learn the core content of emergency medicine in an 18-month curriculum utilizing self-directed learning and small group

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discussions based on the flipped classroom model.

2. After completing the Genitourinary Emergencies Module, resident learners will exhibit mastery within this content area and will critically discuss the pathophysiology, diagnosis, and treatment of various pediatric and adult genitourinary emergencies including:
  - a. Acid-Base Disorders
  - b. Acute Renal Failure and Hemolytic Uremic Syndrome
  - c. Chronic Renal Failure and Glomerular Disorders
  - d. Complications of Hemodialysis
  - e. Male Genitourinary Infections
  - f. Nephrolithiasis
  - g. Male Structural and Neoplastic Genitourinary Disorders
  - h. Urinary Tract Infections and Pyelonephritis

## Educational Strategies:

(See curriculum chart) Please refer to the curriculum chart of linked objectives and educational strategies.

## Evaluation and Feedback:

This innovative curriculum was literature-based and specifically designed to maximize active learning using the flipped classroom learning model. We overcame initial challenges and skepticism from both educators and learners to execute a successful, novel curricular model. Both resident learners and faculty educators provided an overwhelming amount of positive feedback. Additionally, a survey was administered to each resident prior to initiation of the curricular innovation, and repeated at the conclusion of the first 18-month cycle. Learners and educators were enthusiastic about the conference structure and expressed a preference for it rather than the previous, lecture-based didactics. Resident learner attendance at weekly emergency medicine didactics increased, presumably as a result of our curricular innovation and the associated increase in faculty engagement, active discussions, and learner perceived value of the sessions. The curriculum is critically evaluated annually via focus groups and surveys, and updated by education faculty members in order to ensure educational material remains current and consistent with the emergency medicine core content.

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# DIDACTICS AND HANDS-ON CURRICULUM

Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Acid Base Disorders	<p>-“Flipped” Classroom</p> <p>Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>-Indications for and Interpretations of venous and arterial blood gasses</p> <p>-Physiology of pH compensatory mechanisms</p> <p>-Presentation, Diagnosis and Management of common acid / base derangements</p>	<p>By the end of this session, learners will:</p> <p>Discuss indications for ABG vs VBG</p> <p>Discuss a stepwise approach to interpreting ABG</p> <p>Review calculation of the anion gap</p> <p>Review the calculation and application of Winter’s formula</p> <p>Discuss physiological compensatory mechanisms for acute acid / base disorders</p> <p>Critically discuss management of basic acid / base disorders</p> <p>Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable (instructor can pull up web images during session). Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



# DIDACTICS AND HANDS-ON CURRICULUM

Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Acute Renal Failure and Hemolytic Uremic Syndrome	<p>-“Flipped” Classroom</p> <p>Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>-Pathophysiology, diagnosis and therapies for typical and atypical hemolytic uremic syndromes</p> <p>-Contrast and NSAIDs use in acute renal failure</p> <p>-Indications for emergent hemodialysis</p>	<p>By the end of this session, learners will:</p> <p>Review diagnosis and treatment of typical and atypical hemolytic uremic syndromes</p> <p>Discuss the risks and benefits of NSAIDs and contrast use in ARF</p> <p>Review indications for emergent hemodialysis</p> <p>Discuss questions posed by residents in their pre-work assignments.</p> <p>Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Chronic Renal Failure and Glomerular Disorders	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>-Pathophysiology, Diagnosis, and Management of chronic renal failure</p> <p>-Pathophysiology, Diagnosis, and Management of complications of chronic renal failure</p> <p>-Pathophysiology, Diagnosis, and Management of glomerulonephritis</p>	<p>By the end of this session, learners will:</p> <p>-Review the most common causes of chronic renal failure</p> <p>-Discuss the clinical features of complications of chronic renal failure, including uremia</p> <p>-Identify strategies to treat bleeding in the dialysis patient</p> <p>-Discuss the presentation of glomerulonephritis</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Complications of Hemodialysis	<p>-"Flipped" Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>-Common complications of hemodialysis</p> <p>-Indications for emergent hemodialysis</p>	<p>By the end of this session, learners will:</p> <p>-Review diagnosis and treatment of common hemodialysis complications, including hyperkalemia</p> <p>-Describe techniques to treat bleeding AV fistulas</p> <p>-Discuss indications for emergent hemodialysis</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Male GU Infections	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>-Pathophysiology, Diagnosis, and Management of epididymitis</p> <p>-Pathophysiology, Diagnosis, and Management of Prostatitis</p> <p>-Guidelines for treatment of sexually transmitted infections</p> <p>-Pathophysiology, Diagnosis, and Management of Fournier’s Gangrene</p>	<p>By the end of this session, learners will:</p> <p>-Review pathophysiology, diagnosis and treatment of male GU infections</p> <p>-Discuss how age of the patient can affect treatment for infections such as epididymitis and prostatitis</p> <p>-Review recent CDC guidelines</p> <p>-Describe recommended treatment and evaluation of Fournier’s Gangrene</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation</p> <p>-Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Nephrolithiasis	<p>–“Flipped” Classroom</p> <p>Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>–Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>–15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>–Pathophysiology, differential diagnosis, diagnostic modalities, and treatment of kidney stones</p>	<p>By the end of this session, learners will:</p> <p>–Review the differential diagnosis for flank pain</p> <p>–Critically analyze the use of various imaging modalities in assessing renal stones</p> <p>–Review indications for emergent urological evaluation</p> <p>–Discuss treatment options for patients with renal stones</p> <p>–Summarize key learning points</p>	<p>PGY-1 PGY-2 PGY-3 Medical Students Faculty</p>	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation –Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Male GU Structural and Neoplastic Disorders	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>-Pathophysiology, differential diagnosis, diagnostic modalities, and treatment of testicular torsion</p> <p>-Pathophysiology, differential diagnosis, diagnostic modalities, and treatment of urinary retention</p> <p>-Pathophysiology, differential diagnosis, diagnostic modalities, and treatment of paraphimosis</p>	<p>By the end of this session, learners will:</p> <p>-Review the management of suspected testicular torsion</p> <p>- Describe how to perform emergent procedures such as manual de-torsion, reduction of paraphimosis, penile aspiration, and suprapubic catheter placement</p> <p>-Review a treatment algorithm for priapism in patients with and without sickle cell disease</p> <p>-Discuss strategies to communicate with a reluctant consultant</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation and -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, Resources Needed (Space, Instructors, Equipment, Citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Urinary Tract Infections and Pyelonephritis	<p>-“Flipped” Classroom</p> <p>Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p>	<p>-Pathophysiology, differential diagnosis, diagnostic modalities, and treatment of testicular torsion</p> <p>-Pathophysiology, differential diagnosis, diagnostic modalities, and treatment of pyelonephritis</p> <p>-Treatment variation between complicated and uncomplicated urinary infections</p>	<p>By the end of this session, learners will:</p> <p>-Accurately distinguish between lower and upper urinary tract infections and describe the proper treatment for both</p> <p>-Critically discuss treatment indications and options for pregnant patients</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable (instructor can pull up web images during session). Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Faculty Members or Content Experts. Predetermined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: MK</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



## Appendix A: Acid Base Disorders

Author: Geremiha Emerson, MD and Eric Adkins, MD

### Objectives

1. Discuss indications for arterial blood gas (ABG) vs venous blood gas (VBG)
2. Discuss a stepwise approach to interpreting ABG
3. Review calculation of the anion gap
4. Review the calculation and application of Winter's formula
5. Discuss physiological compensatory mechanisms for acute acid / base disorders

### Case Studies

**Case 1:** A 30-year-old male with history of Crohn's disease presents with increased pain and non-bloody diarrhea. He has had 3 days of diarrhea and noted some decreased urine output.

#### Question Prompts:

1. What type of acid / base disorder would you expect to find?
  - a. This patient will likely show a metabolic alkalosis as a combination of chloride losses in diarrhea, as well as so called "contraction alkalosis" seen in early dehydration. Other common causes of primary metabolic alkalosis include vomiting, diuretics, endocrine derangements (excess aldosterone, corticosteroids), and exogenous bicarbonate intake (milk alkali syndrome, sodium bicarb administration).
2. Does this patient require an ABG or a VBG? In which clinical scenarios is each indicated?
  - a. blood gasses can accurately measure pH, pCO<sub>2</sub>, and bicarb. An arterial blood gas is indicated to measure pO<sub>2</sub> and the oxygen saturation. If this patient has an oxygen saturation > 92% on room air, there would be little benefit to obtaining an ABG as opposed to a VBG. This is however largely an area of personal practice preference, with some practitioners preferring to always obtain an ABG and others rarely ordering ABGs. An ABG is required to calculate an A-a gradient, if the patient is being assessed for such pathologies as acute respiratory distress syndrome (ARDS) and pneumocystis pneumonia.

**Case 2:** A 60-year-old female with history of chronic obstructive pulmonary disease (COPD) and lung cancer with metastases to the spine presents after family called emergency medical services due to decreased responsiveness. The patient has been taking oral narcotics at home for back pain. She has severe COPD and is on her typical home oxygen.



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## Question Prompts:

1. How can the cause of her mental status change be identified?
  - a. While the differential for this patient's altered mental status is broad and warrants a thoughtful workup, her presentation is suggestive of carbon dioxide (CO<sub>2</sub>) narcosis, likely as a result of the combination of her baseline severe COPD and over sedation from her opiate pain medications. A VBG would be indicated and could rapidly assess the patient's ventilatory status.
2. What acid base changes would you expect?
  - a. This patient would likely have an acute respiratory acidosis superimposed on a chronic respiratory acidosis with renal compensation.

Her initial ABG shows pH 7.20, pCO<sub>2</sub> 75, pO<sub>2</sub> 90, HCO<sub>3</sub> 32, oxygen saturation 98%.

3. What would you estimate her baseline pCO<sub>2</sub> to be?
  - a. In general, in acute respiratory acidosis, the patient's pH will drop by 0.08 for every 10mm Hg increase in pCO<sub>2</sub>. This patient has a pH of 7.2, or a drop of 0.2, which is 2.5 multiples of 0.08. This would be explained by an acute increase in the pCO<sub>2</sub> by 25 mmHg. This patient's total increase in pCO<sub>2</sub> was 35 (75 - 40). So, this patient likely chronically retains to a baseline pCO<sub>2</sub> of approximately 50mm Hg (10 + 40).

**Case 3:** A 50-year-old male presents with sudden onset of fever, cough, and dyspnea. A chest x-ray shows a right middle lobe and a left lower lobe pneumonia. BP is 90/60 with heart rate of 120. Respiratory rate of 30, and oxygen saturation of 85% on room air.

## Question Prompts:

1. Interpret the initial blood gas: pH 7.20, pCO<sub>2</sub> 20, pO<sub>2</sub> 60, HCO<sub>3</sub> 8, Na 138, Cl 110
  - a. This patient has an acidemia with a low pCO<sub>2</sub>, which defines a metabolic acidosis. Metabolic acidosis is divided into anion gap and non-anion gap acidosis. This patient's anion gap (Na - [HCO<sub>3</sub> + Cl]) is elevated at 20. Appropriate respiratory compensation can be assessed using the Winter's formula:  $(1.5 \times \text{HCO}_3) + 8 \pm 2$ . In this case, using the Winter's formula, the expected pCO<sub>2</sub> would be  $20 \pm 2$ , indicating that the patient is showing appropriate respiratory compensation. A higher than expected pCO<sub>2</sub> suggests inadequate ventilatory response, meaning the patient would have a mixed metabolic and respiratory acidosis.
2. What initial strategies for resuscitation should be started for IV fluids and vent settings?
  - a. This patient's anion-gap metabolic acidosis is likely secondary to lactic acidosis from sepsis and hypoperfusion. In addition to aggressive volume resuscitation, care should be taken to maintain the patient's ventilatory status. If intubation is indicated, it is important to remember that these patients require very high minute ventilations in order to maintain respiratory compensation of their severe metabolic derangements. If this is not taken into



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account, the patient can develop a rapid decline as the result of a superimposed respiratory acidosis.

**Case 4:** A recently discharged psych patient has returned via EMS after family became concerned that he might have ingested an unknown medication. The patient feels like there is a ringing in his ears, but otherwise has no complaints. You order a blood gas as part of your evaluation. It shows pH 7.52, pCO<sub>2</sub> 28, pO<sub>2</sub> 105, and HCO<sub>3</sub> 18.

## Question Prompts:

1. What is the acid base disorder afflicting this patient?
  - a. This patient is presenting with an alkalemia and low pCO<sub>2</sub>, which defines a respiratory alkalosis. The HCO<sub>3</sub> is lower than would be expected by normal acute compensation, indicating that this is a mixed respiratory alkalosis, metabolic acidosis. While this can be seen in early sepsis and trauma, this derangement is the hallmark of acute salicylate toxicity.
2. The patient's respiratory drive decreases and requires intubation. How would you manage the vent for this patient?
  - a. Similar to the above septic patient, salicylate toxicity induces a significant metabolic acidosis (lactic acidosis secondary to decoupling of oxidative phosphorylation). The tachypnea seen in these patients is, in part, an effort to compensate for this. As the patient becomes more ill, they may tire and/or lose their respiratory drive. If intubation becomes necessary, it is essential to maintain a high minute volume to compensate for the significant metabolic acidosis. Concurrent respiratory acidosis will likely lead to rapid decompensation.

## Suggested Readings:

Berend K, de Vries AP, Gans RO. Physiological approach to assessment of acid-base disturbances. *N Engl J Med.* 2014;371(15):1434-1445. doi: 10.1056/NEJMra1003327

Kaplan LJ, Frangos S. Clinical review: Acid–base abnormalities in the intensive care unit. *Crit Care.* 2005;9(2):198-203. doi: 10.1186/cc2912

Kelen GD, Nicolaou DD, Cline DM. Acid-base disorders. In: Tintinalli JE, Stapczynski J, Ma O, Yealy DM, Meckler GD, Cline DM, eds. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide.* 8<sup>th</sup> ed. New York, NY: McGraw-Hill; 2016:79-88.

## Additional References:

Bronfenbrenner R. Acid-base interpretation. Medscape. <http://emedicine.medscape.com/article/2058760-overview>. Updated October 30, 2015. Accessed April 12, 2017.



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Grogono AW. Acid-base tutorial. Acid-Base. <http://www.acid-base.com/index.php>. Published October 2016. Accessed April 12, 2017.

Strayer RJ. Acid-base disorders. In: Marx JA, Hockberger RS, Walls RM, et al. eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice*. 8<sup>th</sup> ed. Philadelphia, PA: Elsevier Saunders; 2014:1629-1635.

## Key Learning Points

1. Venous blood gas can be used to determine pH, pCO<sub>2</sub>, and bicarb. Accurate pO<sub>2</sub> is provided by ABG and is necessary in cases where calculation of an A-A gradient would change management, such as ARDS and pneumocystis pneumonia.
2. Develop a standard stepwise approach to interpreting the blood gas, being sure to assess the pH, pCO<sub>2</sub>, and bicarb, at a minimum.
3. Anion gap is calculated by the formula  $\text{Na}^- - (\text{Cl} + \text{HCO}_3)$ .
4. Winter's formula helps predict the expected pCO<sub>2</sub> for respiratory compensation in metabolic acidosis. The expected pCO<sub>2</sub> is equal to  $(1.5 \times \text{HCO}_3) + 8 \pm 2$ .
5. Metabolic acidosis often results in attempted respiratory alkalosis. Some patients may not be capable of mounting an adequate compensatory response.



## Appendix B:

# Acute Renal Failure and Hemolytic Uremic Syndrome

Author: Geremiha Emerson, MD and Jennifer Mitzman, MD

### Objectives

1. Review pathophysiology, diagnosis and therapies for typical and atypical hemolytic uremic syndromes.
2. Discuss risks and benefits of nonsteroidal anti-inflammatory drugs (NSAIDs) in the setting of acute renal dysfunction.
3. Discuss imaging risks as related to acute renal failure.
4. Discuss indications for emergent dialysis.
5. Review resident pre-work and answer questions written by residents.
6. Summarize the key learning points below.

### Case Studies

**Case 1:** A 4-year-old male patient presents with his parents to the emergency department with concern for dehydration. Parents report that their child has not urinated much today and did not wake up last night to use the bathroom which is very unusual. He has also been fatigued and slept most of the day. He has had a stomach bug for a few days and the parents are concerned that he has gotten dehydrated despite their efforts to get him to drink. On exam, he is pale with dry mucous membranes. He is not very active in the room but not toxic appearing either. He is tachycardic but vitals are otherwise appropriate.

### Question Prompts:

1. What is the most appropriate diagnostic evaluation for this child? What interventions would you want to initiate?
  - a. Diagnostic laboratory tests should be strongly considered in any pediatric patient presenting with oliguria/anuria. Urinalysis can be used to assist in assessing volume status (specific gravity), as well as assessing for evidence of glomerulonephritis (hematuria, red blood cell casts), nephrotic syndrome (proteinuria), infection (white blood cells, bacteria), and acute tubular necrosis (ATN) (hyaline casts). A basic metabolic panel will assess renal function and evaluate serum electrolytes. A complete blood count (CBC) is useful to identify hemolytic uremic syndrome (HUS) (anemia, thrombocytopenia), evidence of systemic infection/sepsis, and for evidence of interstitial nephritis (eosinophilia).
  - b. Aggressive volume resuscitation is essential for prevention and treatment of most causes of acute renal dysfunction, and particularly in cases of HUS, where the risk of developing anuric renal failure is 1.6 times higher in those patients who do not receive volume expansion.
2. What would your next steps be if his labs are normal?



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- a. Patients with reassuring laboratory values can be considered for discharge if they are able to tolerate adequate oral intake. Discharge home with antiemetics and close primary physician follow up is a reasonable option in these patients. While the correlation between antibiotic administration and HUS has been debated (particularly in adults), routine antibiotics should be avoided in most cases of pediatric diarrhea.
3. What would you do if his creatinine is 1.1 and platelets 90?
  - a. Thrombotic microangiopathies should be suspected in any patient with acute thrombocytopenia and anemia. In this patient who has acute thrombocytopenia and renal dysfunction — especially in the setting of prodromal diarrheal illness — the diagnosis of HUS should be considered to be likely. In addition to volume expansion, patients with suspected HUS should be admitted to the hospital for inpatient supportive care and close monitoring, particularly for worsening renal dysfunction that may require renal replacement therapy. In comparison to thrombotic thrombocytopenic purpura (TTP) and atypical HUS, patients with typical HUS (cases associated with prodromal bacterial diarrheal illness) do not respond to plasma infusions/plasmapheresis).

**Case 2:** A 36-year-old male presents with colicky right flank pain and slight fever. He is known to have had small renal stones on that side in the past. He is well appearing but appears to have pain. On exam, he exhibits right costovertebral angle tenderness, right lower quadrant abdominal pain and a normal genitourinary exam. His creatinine is 1.8 and he has a WBC count of 15. Urinalysis is normal without evidence of infection.

## Question Prompts:

1. What imaging modalities could you consider in this patient?
  - a. The KUB x-ray lacks both sensitivity (29%-58%) and specificity (69%-74%) for kidney stones, but can be used to follow the progress of large, radiolucent stones. Computed tomography (CT) imaging is both highly sensitive and specific (mid 90%), allowing the practitioner to rapidly identify stone number, size, location, as well as evidence of obstruction. This information can be used to estimate the likelihood of success for conservative management, and/or assist in planning for operative management. In addition, it can identify other potential causes of flank pain/hematuria/etc, particularly when intravenous (IV) contrast is used. Disadvantages of helical CT include radiation dose and cost. Ultrasonography has reasonable accuracy, is relatively inexpensive, can be performed at bedside, and spares the patient from radiation. However, ultrasound lacks sensitivity (60s, particularly with smaller stones, as well as those in the middle 1/3 of the ureter).
2. How would your management change if the patient appeared ill or had significant vital sign abnormalities? Does this patient require emergent hemodialysis?
  - a. Sepsis with a urinary source should be considered in any ill-appearing patient presenting with fever, flank pain and abnormal vitals. As source control is a critical step in quality sepsis management, appropriate imaging and early urological consultation are key steps in addition to aggressive volume resuscitation and early antibiotics. Remember that the urinalysis may be misleading, particularly with obstructing stones, where the usual



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- indicators of infection (pyuria, bacteriuria) can be contained behind the stone. Practitioners should also maintain a broad differential and consider additional testing and/or management in patients presenting with flank pain and significant vital sign abnormalities. Consider AAA, biliary pathology, mesenteric ischemia, appendicitis, pancreatitis, ectopic pregnancy, PID/TOA, gonadal torsion, and retroperitoneal bleed.
- b. Based on the presented information, the patient likely does not require emergent hemodialysis. Conventional indications for emergent hemodialysis can be remembered with a helpful mnemonic: 'A-E-I-O-U.' Of note, there is no level of creatinine or BUN which is an absolute indication for hemodialysis.
    - i. A - Acidosis: significant acidosis that is refractory to medical management. Remember that metabolic acidosis secondary to organic acids, including ketoacids, will take longer to clear in patients with poor renal function.
    - ii. E - Electrolyte abnormalities: Hyperkalemia (rarely hypercalcemia, hyperphosphatemia)
    - iii. I - Ingestions: Salicylates, lithium, isoproterenol, methanol, ethylene glycol, valproic acid, barbiturates
    - iv. O - Volume overload: pulmonary edema that is refractory to medical care
    - v. U - Uremia: encephalopathy, pericarditis, bleeding
3. How would you manage this patient's pain?
- a. While renal colic does tend to respond well to NSAIDs, such as ibuprofen and ketorolac, these medications should be avoided in the setting of acute kidney injury and chronic kidney disease. One mechanism by which the kidneys maintain a sufficient glomerular filtration rate is by prostaglandin mediated afferent vasodilation. NSAIDs decrease cyclooxygenase which in turns decreases prostaglandin synthesis, resulting in decreased glomerular filtration rate (GFR). This patient's pain could be treated with acetaminophen, tramadol, or opioid medications

**Case 3:** A 62-year-old male presents with tearing chest pain. It was maximal at onset but is still quite severe. He looks unwell and in discomfort. He is diaphoretic. Vitals are significant for heart rate (HR) 120 and right arm blood pressure (BP) 200/100. A blood pressure taken in his leg is 120/80. You discuss with the patient your concern for aortic dissection and the need for CT angiography. His wife mentions that "he has some kidney problems. Are you sure the CT is ok for him?"

## Question Prompts:

1. Would you wait for labs in this case or proceed without them?
  - a. This patient is presenting with a constellation of symptoms that are highly suspicious for an acute thoracic aortic dissection, a condition that can be rapidly fatal. Rapid diagnosis and intervention are key to good outcomes. In cases such as this, angiography should be performed promptly, and should not be delayed based on underlying comorbidities or presence of acute renal dysfunction.
2. How would you have a risk and benefit discussion with this patient and his wife about imaging?



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- a. The risk-benefit conversation in this situation should focus on both the likelihood and severity of the potential worst-case outcomes. In this case, the patient and family need to balance the risk of decompensation and death from his likely aortic dissection (high) vs the true risk of contrast induced nephropathy (debated) and subsequent need for long-term renal replacement therapy (low). However, the high morbidity and costs associated with dialysis need to be considered.
3. What circumstances would make you more or less likely to scan this patient? How about others with less emergent pathology?
  - a. Contrast-induced nephropathy is a highly cited though poorly understood phenomenon, of which the incidence and clinical relevance is highly debated. In general, it is thought to be most significant in those patients presenting with acute on chronic renal insufficiency. While there is no absolute cutoff for those at highest risk, usual practice is to restrict contrast administration in those patients with creatinine of 1.5-2 or GFR < 45. The risk of contrast-induced nephropathy can be reduced by IV hydration, while early/prophylactic dialysis has not been shown to improve long-term outcomes.

## Suggested Readings:

Sreedharan R, Avener ED. Renal failure. In: Kliegman RM, Stanton BF, Schor NF, St. Geme JW, Behrman RE, eds. *Nelson Textbook of Pediatrics*. 19<sup>th</sup> ed. Philadelphia PA: Elsevier Saunders; 2011:1818-1826.

Why V, Avner ED. Hemolytic-uremic syndrome. In: Kliegman RM, Stanton BF, Schor NF, St. Geme JW, Behrman RE, eds. *Nelson Textbook of Pediatrics*. 19<sup>th</sup> ed. Philadelphia PA: Elsevier Saunders; 2011:1791-1794.

Wolfson AB. Renal failure. In: Marx JA, Hockberger RS, Walls RM, et al. eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice*. 8<sup>th</sup> ed. Philadelphia, PA: Elsevier Saunders; 2014:1291-1311.

## Additional Reading Options:

Lafrance JP, Miller DR. Selective and non-selective non-steroidal anti-inflammatory drugs and the risk of acute kidney injury. *Pharmacoepidemiol Drug Saf*. 2009;18(10):923-31. doi: 10.1002/pds.1798

McDonald RJ, McDonald JS, Carter RE, et al. Intravenous contrast material exposure is not an independent risk factor for dialysis or mortality. *Radiology*. 2014;273(3):714-745. doi: 10.1148/radiol.14132418

Picard C, Burtey S, Bornet C, Curti C, Montana M, Vanelle P. Pathophysiology and treatment of typical and atypical hemolytic uremic syndrome. *Pathol Biol (Paris)*. 2015;63(3):136-143. doi: 10.1016/j.patbio.2015.03.001

Rose TA Jr, Choi JW. Intravenous imaging contrast media complications: the basics every clinician needs to know. *Am J Med*. 2015;128(9):943-949. doi: 10.1016/j.amjmed.2015.02.018



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## Key Learning Points

1. There is currently no creatinine or GFR threshold which absolutely restricts IV contrast. Radiology practices commonly limited to a creatinine of 1.5-2 or GFR < 60.
2. In most, patients screening renal failure is not indicated.
3. Hydration is key to preventing contrast induced nephrotoxicity.
4. Initiating dialysis for patients other than those with traditional indications did not improve outcomes. Traditional indications are serum potassium >6, serum urea >30, serum pH < 7.25, serum bicarb <10, pulmonary edema, and uremic pericarditis or encephalopathy.
5. Classic triad of HUS is platelet consumption, mechanical erythrocyte destruction and acute renal insufficiency.
6. Typical HUS is preceded by a diarrheal illness and treated with supportive care including aggressive renal support. Atypical HUS is associated with complement deficiency and is treated with supportive care and eculizumab.



## Appendix C:

# Chronic Renal Failure and Glomerular Disorders Author: Geremiha Emerson, MD and Sorabh Khandelwal, MD

### Objectives

1. List the most common diseases responsible for end stage renal disease (ESRD) in adults and children.
2. Describe the pathophysiology of uremia (i.e., excretory failure, biosynthetic failure, regulatory failure).
3. Describe the clinical features of uremia (i.e., neurologic complications, cardiovascular complications, hematologic complications, gastrointestinal complications, renal bone disease).
4. Describe the epidemiology, differential diagnosis, and evaluation for acute glomerulonephritis.

### Case Studies

**Case 1:** A 56-year-old man with ESRD undergoing hemodialysis (HD) presents with altered mentation. He underwent dialysis earlier in the day but according to his wife was not feeling well. On exam there is no evidence of focal neurologic deficits.

#### Question Prompts:

1. What is the differential diagnosis for altered mentation in an ESRD patient undergoing hemodialysis?
  - a. Uremic encephalopathy, sepsis, hypotension, subdural hematoma, stroke, hypoglycemia, acute myocardial infarction (AMI) with acute heart failure, cardiogenic shock (AMI, congestive heart failure (CHF), bradycardia), dialysis disequilibrium, dialysis dementia.
2. What diagnostic studies should be ordered for this patient?
  - a. Complete blood count (CBC), complete metabolic panel (CMP), electrocardiogram (ECG), troponin, computed tomography (CT) of the head, chest radiograph, lactic acid, blood cultures (if concerned for sepsis), UA (if the patient still makes urine).
3. What are the most common causes of chronic kidney disease in adults?
  - a. Diabetic nephropathy, hypertensive nephropathy, lupus nephropathy, other autoimmune causes, polycystic kidney disease, and nephrotic syndrome.

**Case 2:** A 53-year-old woman with ESRD on HD presents with chest pain and shortness of breath. Her ECG demonstrates left ventricular hypertrophy without evidence of ischemia.

#### Question Prompts:

1. What is the differential diagnosis for chest pain and dyspnea in an ESRD patient undergoing HD?



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- a. Acute coronary syndrome, volume overload/CHF, pericarditis, hypertensive crisis, pulmonary embolism, aortic dissection, air embolism.
2. How do you interpret elevated levels of creatine phosphokinase and the MB isoenzyme, troponin I, and troponin T in ESRD patients undergoing regular dialysis?
  - a. Coronary artery disease affects approximately 40% of patients with chronic kidney disease. The mortality from cardiovascular disease is increased 10-30 times in patients who receive dialysis, and represents the most common cause of death in these patients. Cardiac biomarkers should not be expected to be significantly elevated in patients who receive regular dialysis. Elevations of cardiac biomarkers in these patients should be treated as acute myocardial necrosis. In those patients who have chronically elevated biomarkers, increases above the patient's personal baseline outperform usual laboratory cutoffs.
3. If pulmonary edema is seen on chest x-ray, what are the most appropriate management steps?
  - a. The approach to pulmonary edema in patients with ESRD is very similar to the general population. After considering alternative diagnosis (acute respiratory distress syndrome (ARDS), infection, alveolar hemorrhage), and securing the resuscitation ABCs, treatment should focus on improving oxygenation and off-loading the ventricles. Non-Invasive bi-level positive-pressure ventilation and high-dose nitroglycerin are the mainstays of treatment. If elevated blood pressures remain refractory to nitrates, blood pressure can be controlled with most medications, though ACE-inhibitors are considered first-line. If volume overload is a significant contributing factor, emergent hemodialysis should be performed, with phlebotomy as a potential temporizing measure.

**Case 3:** A 76-year-old man with ESRD on hemodialysis presents with epistaxis.

## Question Prompts:

1. Besides the normal treatment algorithm, what additional agents could be used and why?
  - a. Desmopressin, 0.3 microgram/kg intravenous (IV), can be used to counteract the uremia-induced platelet dysfunction seen in patients with ESRD. Treatment effect usually takes ~1 hour, so this should not be considered in isolation for patients with significant bleeding.
  - b. Protamine, 1 mg/100 units of heparin received; heparin is often used during hemodialysis. If a bleeding patient presents within 4 hours after receiving heparin, they would likely benefit from protamine reversal.

**Case 4:** A 12-year-old girl presents with fatigue and lethargy. As part of the work up, a triage urinalysis reveals macroscopic or microscopic hematuria, red cell casts, and proteinuria.

## Question Prompts:

1. What questions would you ask to help with your differential diagnosis?
  - a. Acute glomerulonephritis in an inflammatory process affecting the glomerulus characterized by deposition of immune complexes in the glomeruli. The most common



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- cause is sequela of group A  $\beta$ -hemolytic streptococci infections. Other etiologies include hereditary nephropathies, hemolytic uremic syndrome, Henoch-Schönlein purpura (HSP), IgA nephropathy, and autoimmune disorders (lupus, polyarteritis). History should focus on prodromal symptoms/illness (sore throat, cough, upper respiratory infection symptoms, rash), as well as associated symptoms including joint pains, abdominal pain, rash, fever, and vomiting. Family history of renal and/or autoimmune diseases may suggest hereditary causes.
2. How would you focus your physical exam?
    - a. There are no specific physical exam findings for glomerulonephritis. Exam should focus on evaluating for any potential underlying cause. Evaluate for evidence of volume overload (respiratory distress, crackles/rhonchi, peripheral edema), rash (palpable purpura, scarlatiniform rash, ecchymosis), joint effusions, oropharyngeal erythema and exudates.
  3. What additional diagnostic testing would you ask for?
    - a. A basic metabolic panel should be ordered to evaluate for renal function and electrolyte abnormalities, and a CBC should be ordered to evaluate platelet and RBC counts. Consider serum albumin levels, complement levels, and antistreptolysin titers, as well as testing for immune-mediated causes including lupus, polyarteritis, and HSP. Renal biopsy is often ultimately required.

## Suggested Readings:

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## Key Learning Points:

1. Stroke occurs in approximately 6% of HD patients, with 52% of cases caused by ICH. Subdural hematomas occur 10 times more frequently in dialysis patients than in the general population.
2. Levels of creatine protein kinase and the MB isoenzyme, troponin I, and troponin T are not significantly elevated in ESRD patients undergoing regular dialysis and are specific markers of myocardial ischemia in these patients.
3. Congestive heart failure most commonly results from hypertension, followed by coronary artery disease and valvular defects. Causes of CHF unique to ESRD include uremic cardiomyopathy, fluid overload, and arteriovenous (AV) fistula-related high-output failure. Treatment of CHF is similar to non-ESRD patients. Lasix is helpful.



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4. Patients with ESRD and tamponade rarely present with the classic signs of Beck's triad. Instead, signs of cardiac tamponade in these patients include changes in mental status, hypotension, or shortness of breath.
5. Pericarditis in ESRD patients is usually due to uremia. One of the unique features of uninfected uremic pericarditis is that the inflammatory cells do not penetrate into the myocardium, so typical ECG changes of acute pericarditis are absent. The other etiology of pericarditis is dialysis-related pericarditis. Dialysis-related pericarditis is most common during periods of increased catabolism (trauma and sepsis) or inadequate dialysis due to missed sessions or vascular access problems – not common due to improved dialysis techniques. Management of uremic and dialysis-related pericarditis in patients in hemodynamically stable condition is intensive dialysis.
6. Due to platelet dysfunction seen in ESRD patient, desmopressin can be used to mitigate bleeding (benefit in one hour).

### Pediatrics:

1. Chronic renal failure is divided into four stages. The asymptomatic stage, or stage 1, is associated with a GFR of 50% to 75% of normal for age. In stage 2, or chronic renal insufficiency, the GFR is 25% to 50% of normal for age. In this stage urine protein level is >1000 milligrams/d, and blood urea nitrogen, creatinine, and parathyroid hormone levels increase. Stage 3 is chronic renal failure, and the GFR is 10% to 25% of normal. This stage is characterized by anemia, acidosis, hypocalcemia and rickets. Stage 4, or ESRD, occurs when the GFR is <10% of normal for age.
2. Congenital renal disease is the most common cause of chronic renal failure in young children, whereas glomerulonephritis and reflux nephropathy predominate in older children.
3. Acute glomerulonephritis has many causes which can be differentiated by history, physical examination and laboratory evaluation (post-streptococcal, HUS, HSP, Immunoglobulin A Nephropathy, lupus, Alport syndrome)



## Appendix D:

# Complications of Hemodialysis

Author: Geremiha Emerson, MD and Diane Gorgas, MD

### Objectives

1. Review pathophysiology, diagnosis and treatment of various hemodialysis related complications including hyperkalemia, bleeding AV fistula, and pulmonary edema.
2. Review indications for emergent hemodialysis in patients with chronic renal failure.
3. Critically discuss various strategies for achieving hemostasis in bleeding arteriovenous fistulas (AVF or AV fistulas).

### Case Studies

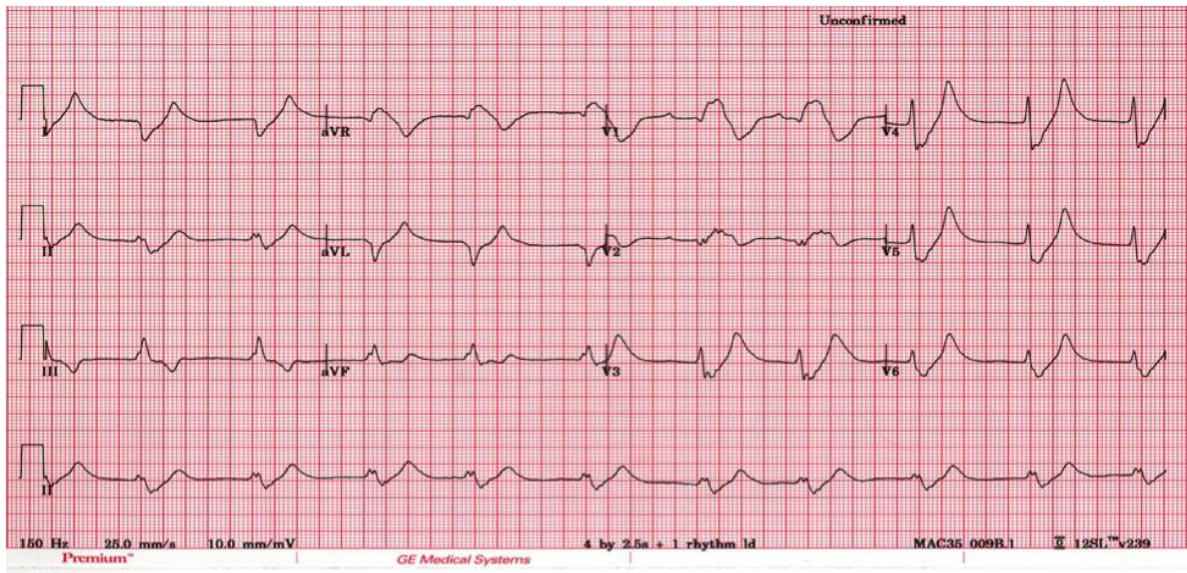
**Case 1:** A 32-year-old woman with insulin dependent diabetes mellitus and chronic renal failure on routine hemodialysis presents to the emergency department with nausea, vomiting and abdominal pain. She has not taken insulin for 24 hours because of anorexia. On presentation, she had marked ketotic halitosis with Kussmaul's respirations. Her vital signs include a temperature of 36.0°C, heart rate of 94 beats/min, respiratory rate of 20 breaths/min, blood pressure of 178/108, and oxygen saturation of 93%. Clinical examination was unremarkable apart from bilateral lung crackles, an S4 gallop, and distended jugular veins. Her hematocrit was 25.5, and total white blood cell count was  $7.2 \times 10^9/L$ . Table 1 summarizes serum biochemistry and arterial blood gas results. Other relevant results included a  $\beta$ -hydroxy butyrate level of 9.1 mmol/L, calcium of 2.73 mmol/L, phosphate of 1.69 mmol/L, and lipase of 1084 units/L.

Type of Test	On arrival
Sodium	110
Potassium	9.8
Chloride	74
CO <sub>2</sub>	4
Glucose	782
Urea	224
Creatinine	6.72
Pao <sub>2</sub>	123
Paco <sub>2</sub>	19
pH	7.2
HCO <sub>3</sub>	7.1



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ECG on Arrival:



## Question Prompts:

1. Critically describe the findings on this electrocardiogram (ECG). What is the cause?
  - a. This ECG shows a regular wide-complex bradycardia with sinusoidal characteristics. These findings are suggestive of marked hyperkalemia. Classic ECG findings of hyperkalemia (in order of appearance) include: peaked T-waves, PR prolongation, loss of P-wave, QRS widening, sine-wave pattern. Hyperkalemia should be considered in any patient presenting with unstable and/or wide-complex bradycardia
2. Describe the acute management of this patient given the labs and ECG findings.
  - a. This is a critically ill patient presenting with evidence of diabetic ketoacidosis (DKA), pancreatitis, and marked hyperkalemia. Focus should be on securing the ABCs, including intravenous (IV) access and *judicious* volume resuscitation, supplemental oxygen, and aggressive management of the acute hyperkalemia.
  - b. Treatment of severe hyperkalemia includes:
    - i. Stabilization of the cardiac membranes: intravenous calcium (for QRS >120)
    - ii. Movement of potassium back into the cell: Insulin (+ dextrose if glucose <250), B-agonists (Albuterol nebs), and Sodium bicarbonate (if acidotic)
    - iii. Removal of potassium from the body: emergent hemodialysis
3. Discuss fluid management, pharmacologic interventions, and plan for reassessment of this patient.
  - a. Fluid status can be tenuous in end-stage renal disease (ESRD) patients, particularly given the high incidence of comorbid congestive heart failure (40%). However, patients presenting with DKA and/or sepsis frequently have significant volume deficits that warrant aggressive volume resuscitation. Care should be taken that this is done *judiciously*. Given the absence of osmotic diuresis in ESRD patients, the total volume losses are typically less than those seen in patients with normally functioning kidneys. Common recommendations are for



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frequent small boluses (250-500ml), with frequent reassessment of the patient’s clinical status and hemodynamic parameters.

- b. In this patient, once the hyperkalemia has been addressed, focus should shift towards treating the underlying causes of this patient’s decompensation. Diabetic ketoacidosis should be addressed with IV insulin drip, judicious volume resuscitation, serial electrolytes with appropriate supplementation, and close hemodynamic monitoring. Consider underlying etiologies/inciting factors of DKA, particularly ischemia (MI) and infection. Consider underlying sepsis in these immunocompromised patients and treat aggressively with early antibiotics if there is a concern. This patient is likely suffering from underlying pancreatitis, which should be treated with aggressive pain control, as well as consideration of further workup with a right upper quadrant ultrasound and/or computed tomography scan of the abdomen. Once the patient has received appropriate stabilization and pain control, re-evaluation of the elevated blood pressure should take place and be addressed accordingly.

Type of Test	After ED Interventions
Sodium	122
Potassium	6.3
Chloride	81
CO <sub>2</sub>	16
Glucose	66
Urea	231
Creatinine	6.86

#### 4. What are the prompts for emergent hemodialysis?

- a. Conventional indications for emergent hemodialysis can be remembered with a helpful mnemonic: ‘A-E-I-O-U’
  - i. A - Acidosis: significant acidosis that is refractory to medical management. Remember that metabolic acidosis secondary to organic acids, including ketoacids, will take longer to clear in patients with poor renal function.
  - ii. E - Electrolyte abnormalities: Hyperkalemia (rarely hypercalcemia, hyperphosphatemia).
  - iii. I - Ingestions: Salicylates, lithium, isoproterenol, methanol, ethylene glycol, valproic acid, barbiturates.
  - iv. O - Volume overload: pulmonary edema that is refractory to medical care.
  - v. U - Uremia: encephalopathy, pericarditis, bleeding.

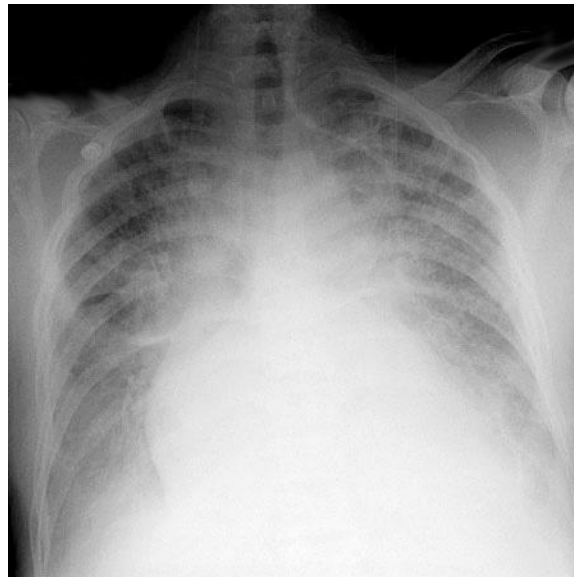
Type of Test	After Hemodialysis
Sodium	138



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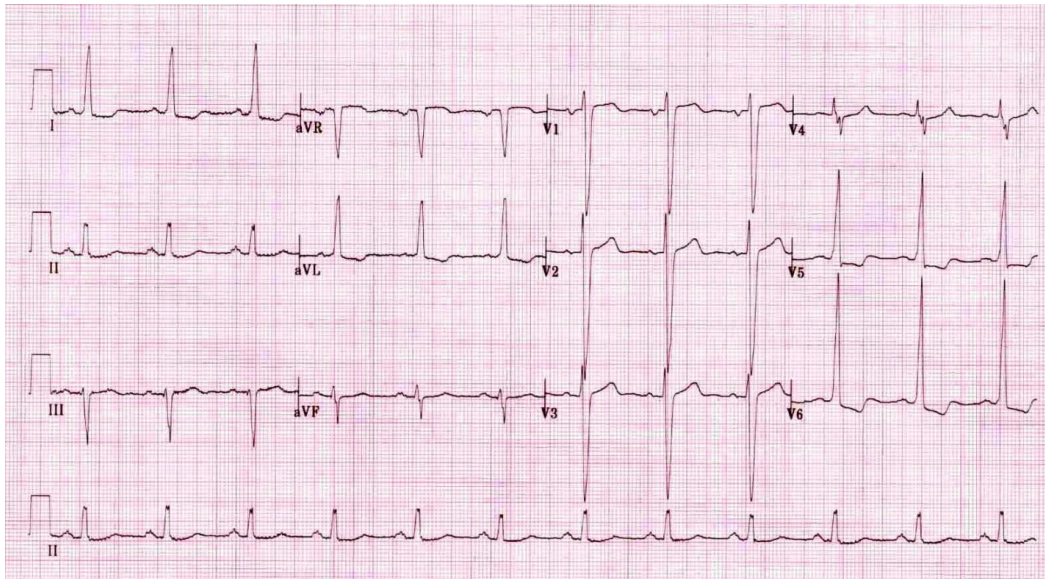
Potassium	3.7
Chloride	101
CO <sub>2</sub>	29
Glucose	235
Urea	81
Creatinine	2.72

**Case 2:** A 51-year-old African American female presents to the emergency department with shortness of breath and chest pain. She states that her blood pressure has been difficult to control for the past 20 years and is noted to be high even after hemodialysis. She denies use of tobacco, alcohol, or drugs and is compliant with all of her medications. She does not exercise but strictly adheres to a low-sodium diet. The patient has a history of diabetes mellitus, uncontrolled hypertension, and ESRD secondary to hypertension on hemodialysis for 1 year. Physical examination shows a healthy appearing woman in slight respiratory distress. Blood pressure is 246/131, heart rate is 94 bpm, and pulse oximetry (on room air) is 75%. On 100% non-rebreather her oxygen saturation increased to 90%. Neck examination reveals jugular venous distention to 10 cm. Heart auscultation is notable for S3 and S4 gallops, and lung examination reveals crackles up to mid-lung fields. Abdominal examination does not reveal organomegaly or renal bruit. Pitting edema (2+) up to mid-shin is appreciated in both lower extremities. Chest X-ray and ECG are shown below.





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Echocardiogram shows left ventricular hypertrophy with an ejection fraction of 45%, notable for diastolic dysfunction.

### Question Prompts:

1. Critically discuss management and stabilization measures including pharmacologic interventions, fluid management, patient re-assessment, and management of respiratory status.
  - a. This patient is presenting with acute pulmonary edema, likely secondary to her marked hypertension and underlying congestive heart failure (CHF), with a component of volume overload contributing given her history of ESRD. Treatment should focus on securing the ABCs with early and aggressive use of bi-level non-invasive positive pressure ventilation (which will lower preload and afterload), as well as aggressive blood pressure control with IV nitrates, typically with a high-dose nitroglycerine drip (100mcg/min titrated by 25mcg/min Q5 min, with a goal reduction in SBP by 25%). It is recommended to start at doses of at least 100mcg/min because these are the doses required to achieve afterload reduction. Emergent/urgent dialysis is required in ESRD patients with refractory pulmonary edema, and should be considered in all ESRD patients presenting with respiratory distress regardless of response to therapy. In cases of refractory hypertension, IV ace inhibitors (enalaprilat) should be considered, though all antihypertensive agents are effective in hemodialysis (HD) patients. Low-volume phlebotomy (150-500ml) may be beneficial in some patients with refractory pulmonary edema, particularly those with obvious volume overload.



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**Case 3:** A 76-year-old man with ESRD on hemodialysis presents with epistaxis.

## Question Prompts:

2. Besides the normal treatment algorithm, what additional agents could be used and why?
  - a. Desmopressin, 0.3 microgram/kg intravenous (IV), can be used to counteract the uremia-induced platelet dysfunction seen in patients with ESRD. Treatment effect usually takes ~1 hour, so this should not be considered in isolation for patients with significant bleeding.
  - b. Protamine, 1 mg/100 units of heparin received; heparin is often used during hemodialysis. If a bleeding patient presents within 4 hours after receiving heparin, they would likely benefit from protamine reversal.

**Case 4:** A 57-year-old Caucasian man with a past medical history of benign essential hypertension, dyslipidemia, coronary artery disease status post coronary artery bypass grafting x1, systolic congestive heart failure secondary to ischemic cardiomyopathy, type 1 diabetes mellitus with associated complications of diabetic retinopathy, neuropathy and nephropathy, h/o ischemic stroke, Human Immunodeficiency Virus (HIV) positivity since 1992, and end-stage renal disease on hemodialysis through a right arm brachiocephalic AV fistula (AVF) created approximately five years ago presents to the emergency department with bleeding from his AVF. No significant dialysis access issues were observed until two weeks before the current presentation when dialysis nurses observed aneurysmal dilatation of his AV fistula and recurrent prolonged bleeding from the cannulation site. His home medications included aspirin 81 mg, clopidogrel 75 mg, lamivudine, atazanavir, lanthanum carbonate, carvedilol, amlodipine, valsartan, levothyroxine, insulin aspart, and lantus. On the day of presentation, an uncomplicated hemodialysis treatment concluded at 11 AM and the patient drove himself home. About 30 minutes after his dialysis treatment ended, he called a friend and complained of bleeding from his AVF. The friend arrived half an hour later and called 911. The patient was coherent and conscious but complaining of generalized weakness, fatigue, and shortness of breath. Emergency medical services responded and applied a pressure dressing to his AVF. Upon arrival in the emergency department, his blood pressure was 117/98 mmHg, pulse 79 and regular, respiratory rate 18, temperature 98.6 F, SpO<sub>2</sub> 92% on room air. He was pale and there was an area of aneurysmal dilatation of the right AVF with a pinpoint area of bleeding which had largely stopped with pressure. Patient's AVF is shown below. A short arm cast was on the right wrist (wrist fracture had occurred three weeks earlier). There were no obvious signs and symptoms of infection of the AVF and no recent antibiotic use. Initial labs were remarkable for Hgb 6.7 gm/dL and Hct of 21.8%. Of note, his hemoglobin the prior month was 13.2 gm/dL. His partial thromboplastin time (PTT), INR (international normalized ratio), and platelets were normal.



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## Question Prompts:

1. Critically discuss the pros and cons of utilizing direct pressure to control AV fistula graft bleeding
  - a. Direct pressure is the easiest method of hemorrhage control, and is often effective. Direct pressure with 1 or 2 fingers directly over a bleeding site (with or without proximal compression of the fistula) is often effective. However, given the high flow of AV fistulas, as well as the hypocoagulative state of most dialysis patients, manual compression is often time consuming, requiring a minimum of 15-30 minutes. In addition, direct compression of the AV fistula may lead to thrombosis or stenosis. All patients presenting with bleeding at the fistula site should be observed 1-2 hours for re-bleeding.
2. Discuss the appropriate threshold to consult or refer to vascular surgery.
  - a. Any prolonged bleeding requiring more than simple short term compression should warrant discussion with vascular surgery. Bleeding related to new/worsening true or pseudo-aneurysm, local infection, or bleeding that is refractory to direct pressure, or is life-threatening, warrants surgical consultation.
3. What are methods to manage bleeding from AV fistulas?
  - a. Direct pressure
  - b. Topical pro-thrombotic agents: Gelfoam, QuikClot, HemCon, topical thrombin.
  - c. Intravenous protamine (to reverse heparin-induced coagulopathy): 0.01 mg/unit heparin given during dialysis, usually 10-20 mg.
  - d. Intravenous desmopressin (to correct uremia-induced platelet dysfunction): 0.3mcg/kg.
  - e. Suture: 5.0 prolene suture with a non-cutting (round-body) needle through skin *and* fistula/(pseudo)aneurysm/graft. Usually figure-of-eight or purse-string stitch.
  - f. Tourniquet proximal to vascular access: temporizing measure in refractory and/or life-threatening bleeding. Should be done in parallel with emergent vascular surgery consultation



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## Key Learning Points:

1. Assume hyperkalemia in any anuric patient regardless of serum concentration.
2. Fluid status for DKA in renal failure should be carefully managed – can complicate with fluid overload. Ketoacidosis will take longer to clear in renal failure.
3. Search for etiologies of DKA, specifically myocardial ischemia and infection.
4. Congestive heart failure or fluid overload despite adequate HD treatments is the most common manifestation of HTN emergency in HD patients. All standard anti-hypertensive agents with the exception of diuretics have therapeutic benefits in HD patients.
5. Dialysis access site hemorrhage typically occurs in the setting of aneurysms, anastomosis rupture, or over-anticoagulation.
6. Control of bleeding can be best attained by pin point pressure (like with a capped 18 g needle sheath) applied to the area of bleeding, allowing maintenance of collateral flow and preservation of graft function. Can also consider lidocaine with epinephrine, sutures, etc.



## Appendix E:

# Male Genitourinary Infections

Author: Geremiha Emerson, MD and Nicholas Kman, MD

### Objectives

1. Review pathophysiology, differential diagnosis, diagnostic modalities, and treatment of male genitourinary (GU) infections
2. Utilize the revised Center for Disease Control (CDC) 2010 sexually transmitted disease (STD) treatment guidelines to select the appropriate antibiotics for gonococcal, chlamydial, and non-gonococcal urethritis
3. Emphasize the clinical presentation and differences in treatment regimens depending on patient age for epididymitis and prostatitis.
4. Describe the presentation and management of Fournier's Gangrene
5. Educate on the reemergence of syphilis and describe the presentation, diagnosis, and treatment of primary syphilis.

### Case Studies

**Case 1:** A 24-year-old man presents to the emergency department with dysuria. He has no past medical history and denies any discharge, scrotal pain, or scrotal swelling. He is heterosexual and has recently had unprotected sex with 2 different partners.

### Question Prompts:

1. What treatment regimen should this patient receive and should his partners receive treatment?
  - a. Treatment should be initiated as soon as possible after diagnosis. Azithromycin and doxycycline are highly effective for chlamydial urethritis; however, infections with *M. genitalium* respond better to azithromycin. Ceftriaxone is effective against *Neisseria gonorrhoeae*. Single-dose regimens have the advantage of improved compliance and directly observed treatment. These patients are generally treated with a single dose of ceftriaxone and either a one-time dose of azithromycin or a 7-day course of doxycycline. To maximize compliance with recommended therapies, medications should be dispensed on-site in the clinic, and the first dose should be directly observed.
  - b. Recommended Regimens  
Azithromycin 1 g orally in a single dose  
OR  
Doxycycline 100 mg orally twice a day for 7 days
  - c. Alternative Regimens



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Erythromycin base 500 mg orally four times a day for 7 days

OR

Erythromycin ethylsuccinate 800 mg orally four times a day for 7 days

OR

Levofloxacin 500 mg orally once daily for 7 days

OR

Ofloxacin 300 mg orally twice a day for 7 days

2. What other organisms should be considered if the patient fails treatment?
  - a. Objective signs of urethritis should be present before the initiation of antimicrobial therapy. In persons who have persistent symptoms after treatment without objective signs of urethritis, the value of extending the duration of antimicrobials has not been demonstrated. Persons who have persistent or recurrent urethritis can be retreated with the initial regimen if they did not comply with the treatment regimen or if they were re-exposed to an untreated sex partner. Persistent urethritis after doxycycline treatment might be caused by doxycycline-resistant *U. urealyticum* or *M. genitalium*. *T. vaginalis* is also known to cause urethritis in men; a urethral swab, first void urine, or semen for culture can be performed. If compliant with the initial regimen and re-exposure can be excluded, the following regimen is recommended while awaiting the results of the diagnostic tests.
  - b. Recommended Regimens  
Metronidazole 2 g orally in a single dose  
OR  
Tinidazole 2 g orally in a single dose  
PLUS  
Azithromycin 1 g orally in a single dose (if not used for initial episode)
3. Does failure to treat the above condition put the patient at risk for any other specific infections?
  - a. Infection with Gonococcal urethritis, chlamydial urethritis, and nongonococcal, nonchlamydial urethritis might facilitate Human Immunodeficiency Virus (HIV) transmission. Patients who have non-gonococcal urethritis and also are infected with HIV should receive the same treatment regimen as those who are HIV negative.

**Case 2:** A 24-year-old man presents complaining of left testicular pain for the past 3 days. He denies any trauma. No urinary symptoms or penile discharge. He is sexually active with both men and women and has had 4 partners in the past year. On exam, his left testicle is slightly swollen without discoloration, and he has moderate tenderness over the epididymis. You also note a painless ulcer on the head of his penis.

## Question Prompts:

1. Does this patient require any testing specifically for his testicular pain?
  - a. While his history and physical exam seems most consistent with epididymitis, testicular torsion is also in the differential. With variable presentations and high morbidity, missing testicular torsion is a common area for litigation for the emergency physician. Therefore, a



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- testicular ultrasound should be obtained to assess for blood flow to the testicle. The patient should also be tested for gonorrhea and chlamydia, for epidemiological purposes.
2. The ultrasound shows good flow to the testicle and inflammatory changes consistent with epididymitis; what is the best treatment for this patient? Would your treatment regimen change if he were 53-years-old?
    - a. The bacterial etiology of epididymitis depends on the age of the patient. Patients younger than age 40 are frequently infected with Gonorrhea or Chlamydia and should be treated with Ceftriaxone 250mg intramuscularly and Doxycycline 100mg orally twice daily for 10 days. In patients older than 40, Epididymitis is typically due to common urinary pathogens like E. coli or Klebsiella and is often secondary to urethral stricture or BPH. Treatment consists of levofloxacin 500mg daily for 10 days, ciprofloxacin 500mg orally twice daily for 14 days, or trimethoprim/sulfamethoxazole orally twice daily for 14 days. These guidelines however are generalizations. A sexually active 53-year-old is still at risk for sexually transmitted pathogens and a young patient with known anatomical abnormalities such as strictures may be more at risk for urinary pathogens.
  3. How should the patient be evaluated for his painless penile ulcer?
    - a. In a patient with multiple sexual partners, and particularly men who have sex with men, a painless genital ulcer should raise the suspicion for syphilis. The incidence of syphilis is increasing and patients (especially the immunocompromised) presenting with painless penile chancre or a dull red papular rash that began on the trunk and spread to the palms and soles should be tested. A non-treponemal test such as RPR or VDRL can be sent from the emergency department; however syphilis testing is notoriously difficult with both false positive and false negatives common. Therefore, the patient should be referred either to the health department or their primary care physician for confirmatory testing or retesting should symptoms persist. Empiric treatment with Penicillin G can be considered in high risk patients. HIV testing should also be considered in any patient you are considering testing for syphilis.

**Case 3:** A 44-year-old man reports pelvic pain, dysuria, and urinary urgency for the past 2 weeks. He has had several similar episodes over the past 2 years and gained temporary relief with antibiotics. He is sexually active and notes frequent discomfort after ejaculation. He has no other past medical history and he denies fever or chills.

## Question Prompts:

1. Discuss the risk factors that predispose to this condition and the workup that should be performed.
  - a. Chronic bacterial prostatitis has been associated with risk factors for urinary tract infection, including urethral catheterization or instrumentation. A history of recurrent urinary tract infections documented by cultures suggests the diagnosis of chronic bacterial prostatitis.
2. Discuss treatment options for this patient.
  - a. The initial treatment for chronic bacterial prostatitis involves the use of a prostate-penetrating antimicrobial agent (e.g., a fluoroquinolone or trimethoprim/sulfamethoxazole)



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that is effective against the pathogen identified by prostatic localization cultures. Alpha blockers, such as tamsulosin, can also be used to improve symptoms. The usual course of therapy is 4-6 weeks.

3. If the patient’s symptoms remain constant and urinalysis does not show evidence of urinary tract infection (UTI), what condition does this patient have?
  - a. Chronic pelvic pain syndrome is characterized by symptoms of chronic pelvic pain and urinary symptoms, such as difficulty voiding, in the absence of urinary tract infection.

**Case 4:** A 55-year-old diabetic male presents to the hospital with a red, swollen scrotum and perineal pain. He is noted to have fever, tachycardia, an elevated respiratory rate, and an elevated blood sugar.

### Question Prompts:

1. What are your imaging choices to confirm your suspected diagnosis?
  - a. Computed tomography or ultrasonography can be helpful, but definitive diagnosis of Fournier’s Gangrene is obtained by exploratory surgery at the infected sites.
2. Discuss your treatment plan.
  - a. Management of the infection begins with broad-spectrum antibiotics, but early and aggressive drainage and meticulous debridement constitute the mainstay of treatment. Antibiotics started in the emergency department should cover for gram positive, gram negative, and anaerobic organisms. Regimens such as vancomycin, piperacillin-tazobactam, and clindamycin are common. The patient should also receive aggressive fluid resuscitation while in the emergency department. Postoperative management of the surgical wound is also important for the patient’s survival, along with proper nutrition. The vacuum-assisted closure system has proved to be helpful in wound management, with its combined benefits of continuous cleansing of the wound and the formation of granulation tissue.
3. How would you risk stratify this patient and are there any validated measures to assist in the stratification?
  - a. The Fournier’s Gangrene Severity Index (FGSI) is a numerical score obtained from a combination of physiological hospital admission parameters that include temperature, heart rate, respiration rate, sodium, potassium, creatinine, leukocytes, haematocrit and bicarbonate. It was concluded that an FGSI score above 9 is sensitive and specific as a mortality predictor in these patients.

Physiological variables	High abnormal values			Normal values			Low abnormal values		
Assigned numerical score	4+	3+	2+	1+	0	1+	2+	3+	4+
Temperature °C	>41	39-40.9	-	38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	<29.9
Heart rate	>180	140-179	110-139	-	70-109	-	56-59	40-54	<39
Respiratory rate	>50	35-49	-	25-34	12-24	10-11	6-9	-	<5
Serum sodium (mmol/l)	>180	160-179	155-159	150-154	130-149	-	120-129	111-119	<110
Serum potassium (mmol/l)	>7	6-6.9	-	5.5-5.4	3.5-4	3-3.4	2.5-2.9	-	<2.5
Serum creatinine (mg/100 ml)	>3	2-3.4	1.5-1.9	-	0.6-1.4	-	<0.6	-	-
Haematocrit %	>60	-	50-59.9	46-49	30-45.9	-	20-29.9	-	<20
Leukocytes (total/mm <sup>3</sup> ×1000)	>40	-	20-39.9	15-19.9	3-14.9	-	-	1-2.9	-
<1 Serum bicarbonate	>52	41-51.9	-	32-40.9	22-31.9	-	18-21.9	15-17.9	<15 (Venous, mmol/l)



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## Suggested Readings:

Davis JE. Male genital problems. In: Tintinalli JE, Stapczynski J, Ma O, Yealy DM, Meckler GD, Cline DM, eds. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*. 8<sup>th</sup> ed. New York, NY: McGraw-Hill; 2016:601-608.

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Centers for Disease Control and Prevention. Epididymitis. <https://www.cdc.gov/std/treatment/2010/epididymitis.htm>. Updated: January 28, 2011. Accessed: April 16, 2015.

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## Key Learning Points

1. Symptoms of urethritis include mucopurulent or purulent discharge, dysuria, or urethral pruritus. Patients with one of these symptoms or a known exposure should be treated with ceftriaxone 250mg IM and azithromycin 1000mg orally. Failure to respond to this treatment should prompt consideration of non-gonococcal infection by *Trichomonas Vaginalis* or *Mycoplasma Genitalium*
2. The bacterial etiology of epididymitis depends on the age of the patient. Patients younger than 40 are frequently infected with Gonorrhea or Chlamydia and should be treated with Ceftriaxone 250mg IM and Doxycycline 100mg orally twice daily for 10 days. In patients older than 40, Epididymitis is typically due to common urinary pathogens like *E. coli* or *Klebsiella* and is often secondary to urethral stricture or BPH. Treatment consists of levofloxacin 500mg daily for 10 days, ciprofloxacin 500mg orally twice daily for 14 days, or trimethoprim/sulfamethoxazole orally twice daily for 14 days



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3. E. coli is the most common pathogen in acute prostatitis followed by Pseudomonas and Klebsiella. Treatment consists of IV ceftriaxone for the hospitalized patient and 4-6 weeks of Cipro 500mg orally twice daily or trimethoprim/sulfamethoxazole orally twice daily.
4. Males presenting with repeated episodes of pelvic pain, dysuria, and urinary urgency along with culture positive urinalyses growing the same pathogen should be worked up for chronic prostatitis. This workup includes looking for structure or other functional abnormalities of the urinary tract by CT and measurement of post-void residuals. Some men may progress to chronic pelvic pain syndrome characterized by constant pain in the perineum, rectum, prostate, or testicles without evidence of infection on urinalysis.
5. Risk scoring systems for Fournier's gangrene can be helpful but are not validated. Any patient with suspected Fournier's should receive gram +, gram -, and anaerobic coverage as well as an emergent urology consult.
6. The incidence of syphilis is increasing and patients (especially the immunocompromised) presenting with painless penile chancre or a dull red papular rash that began on the trunk and spread to the palms and soles should be tested.



## Appendix F: Nephrolithiasis

Author: Geremiha Emerson, MD and Robert Cooper, MD

### Objectives

1. Review the pathophysiology, differential diagnosis, diagnostic modalities, and treatment of kidney stones.
2. Discuss questions posed by residents in their self-assessment assignments.
3. Utilize available evidence-based literature and best practices to discuss imaging for patients presenting to the ED with renal colic.
4. Critically discuss the medications available to treat nephrolithiasis and specifically evaluate the literature on the use of alpha-blocking agents.
5. Summarize key learning points.

### Case Studies

**Case 1:** A 61-year-old patient presents to the emergency department with ten hours of right flank and lower abdominal pain. The patient reports nausea but no vomiting. The pain is episodic. Movement does not increase the pain. Nonsteroidal anti-inflammatory drugs (NSAIDs) slightly decrease the pain. The patient has mild mid- to lower-abdominal tenderness on the right. He does not have costovertebral angle tenderness. His vital signs show hypertension and tachycardia. He has a medical history of hypertension, hyperlipidemia and diabetes.

### Question Prompts:

1. List a prioritized differential diagnosis for this patient.
  - a. The differential diagnosis for acute flank pain that radiates into the groin includes but is not limited to renal colic, pyelonephritis, retroperitoneal hematoma, aortic dissection and/or rupture, mesenteric ischemia, renal infarction, pancreatitis, enterocolitis, biliary pathology, splenic pathology, appendicitis, gonadal torsion, and ectopic pregnancy.
2. Explain the differences in history, physical exam findings, and vital signs for the top four diagnoses of your differential list.
  - a. The top four diagnoses for this patient include renal colic, appendicitis, abdominal aortic aneurysm (AAA), aortic dissection, and colitis. Renal colic tends to be intermittent and sharp in nature, migratory in location with radiation into the groin, and severe in onset. Patients tend to appear very uncomfortable during these episodes, and often find it difficult to get into a position of comfort. The abdomen may be tender, though this is not a reliable finding.
  - b. In contrast, intra-abdominal pathology including appendicitis and colitis tends to present initially with more vague pain that is initially more difficult to locate. As the peritoneum



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- becomes irritated, patients present with focal pain that is well-located and readily reproducible with palpation. Patients tend to lay still, as movement commonly exacerbates the pain
- c. Patients with aortic pathology typically present with constant pain that is centrally located, radiates to the back and flanks, and is unrelenting. Neurovascular deficits may be present, as may a palpable pulsatile mass.
3. What is the most important laboratory test to order?
    - a. Urinalysis is a highly useful test in any patient with acute flank pain, with sensitivity of ~90% for acute renal colic (RBCs). Additionally, a urinalysis (UA) can evaluate for infectious causes including pyelonephritis.
  4. What imaging would you obtain in this patient?
    - a. Imaging is indicated in patients with first time suspected renal colic, as physician gestalt has shown to be suboptimal in predicting this pathology. Commonly utilized imaging modalities include helical computed tomography (CT) and renal ultrasound (US). Helical CT offers sensitivity and specificity that exceed 95%, and provides information regarding stone number and size. In addition, CT provides great value in evaluating for alternative diagnosis, including pathology in the abdomen, pelvis and retroperitoneum.
    - b. Ultrasound is a useful tool for evaluating patients where pretest probability for renal colic is high, particularly in those patients with a known history of kidney stones. US offers several advantages over CT in that it is fast, can be performed at bedside, and spares the patient from radiation, though the sensitivity is relatively poor (60%-85%), particularly with small and non-obstructing stones. Bedside US performed by EM physicians has been shown to be an effective tool in identifying renal colic patients that are likely to require intervention.

**Case 2:** A 47-year-old patient presents to the emergency department with right flank pain. She describes the pain as radiating to her groin. She is experiencing nausea and vomiting. The patient has a history of kidney stones. She also notes that her urine has been darker. Her vital signs show mild tachycardia and hypertension.

## Question Prompts:

1. Does this patient require blood work?
  - a. Otherwise well-appearing and hemodynamically stable patients with a history of renal colic presenting with typical symptoms may not require imaging or blood work. They can often be managed conservatively with pain management and close urology follow-up.
2. What historical factors would influence your imaging decision?
  - a. Pain that is atypical for renal colic or refractory to conventional management may benefit from imaging to assess for stone size and location. In patients in which there is little to no diagnostic uncertainty based on history, infectious symptoms would warrant further investigation.
3. Which imaging test would you choose?
  - a. Either CT or ultrasound can be helpful, though CT is more likely to provide information on stone size and location.



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4. What is the specificity and sensitivity of hydronephrosis detection when bedside ultrasound is performed by an upper level emergency medicine resident?
  - a. Among all clinicians bedside ultrasound had a sensitivity of 72.6% and a specificity of 73.3%. Among ultrasound fellowship trained clinicians sensitivity was 92.7% with a negative likelihood ratio (LR) of 0.08.

**Case 3:** In the case above, renal ultrasound has detected a 6mm stone in the proximal ureter. There is mild hydronephrosis.

## Question Prompts:

1. Discuss analgesia options for the patient.
  - a. While opiates certainly provide useful pain relief in renal colic patients, NSAIDs have been shown to outperform opiates, likely related to suppression of the production of the inflammatory mediators that lead to ureteral spasm.
2. Does intravenous (IV) fluid hydration improve outcomes?
  - a. IV hydration has not been shown to improve pain or likelihood stone passage, nor has it been proven to worsen pain.
3. When dispositioning the patient, what factors would lead to a urological consult versus discharge?
  - a. Any patient presenting with hemodynamic instability and/or evidence of systemic infection/sepsis require emergent urologic consultation for intervention. In well-appearing patients, the decision to discharge vs consult should be based on the ability to achieve reasonable symptom control in the emergency department, as well as the likelihood of success for conservative management. Stone size is the most important factor, with high success rates in small stones (<5mm). Stones >8mm require intervention in >95% of cases.
4. If the decision is made to discharge the patient, would you prescribe an alpha-blocker?
  - a. There is mixed data on the use of medical expulsion therapy with alpha blockers (typically tamsulosin). These may be beneficial in larger stones (4-8mm), but the evidence is far from conclusive. These medications can be expensive, and financial constraints should be taken into consideration

## Suggested Readings:

Manthey DE, Nicks BA. Urologic stone disease. In: Tintinalli JE, Stapczynski J, Ma O, Yealy DM, Meckler GD, Cline DM, eds. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*. 8<sup>th</sup> ed. New York, NY: McGraw-Hill; 2016: 609-612.

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## Additional Resources

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## Key Learning Points

1. The differential diagnosis for renal colic should include pyelonephritis, AAA, papillary necrosis, renal infarction, and biliary colic. In elderly patients with flank pain, hypertension, or hemodynamic instability a CT scan should be ordered.
2. A UA should be obtained in all patients with suspected kidney stone. Blood on UA is 89% sensitive but only 23% specific. Other labs tests including kidney function are not necessary unless that patient has underlying kidney disease as the non-obstructed kidney will continue to keep BUN and Cr within normal limits.
3. Patients presenting with a known stone history and typical renal colic do not need any imaging. In patients where imaging is deemed necessary, ultrasound rather than CT scan has not been shown to lead to more adverse outcomes or greater duration or intensity of pain.
4. The ability to detect CT proven hydronephrosis on bedside ultrasound varies with the amount of ultrasound training. Among all clinicians bedside ultrasound had a sensitivity of 72.6% and a specificity



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of 73.3%. Among ultrasound fellowship-trained clinicians sensitivity was 92.7% with a negative LR of 0.08.

5. NSAIDs and Opioids are first line treatment for nephrolithiasis. IV fluids and diuretics have not been shown to improve stone clearance or pain scores.
6. The evidence for the use of alpha blockers for treating nephrolithiasis is mixed. Some studies show a shorter expulsion time and a reduced number of painful episodes with alpha blockers like Tamulosin. Other studies show no improvement in outcomes. Finally, some studies show improvement in outcomes for stones 4mm or greater in size. As generic Flomax costs 140\$ for 30 capsules, patient's capacity to pay should be taken into account.
7. Pediatric patients are increasingly suffering from kidney stones with the incidence of renal colic increasing by 86% over a ten-year period. The interquartile range for age was 13-17 years and 61% of patients were female.
8. Disposition of patients with kidney stones depends on stone size, evidence of infection, and symptom control. Stones less than 5mm will pass 95% of the time while stones greater than 8mm will require intervention 95% of the time. Infection with an obstructed stone is a urological emergency while patients with stones greater than 5mm in size should have close follow-up.



## Appendix G: Male Genitourinary Structural and Neoplastic Disorders

Author: Geremiha Emerson, MD and Christopher Paul, MD

### Objectives

1. Review pathophysiology, diagnosis, and treatment of pediatric and adult male genitourinary structural and neoplastic disorders including testicular torsion, acute urinary retention, and penile disorders.
2. Discuss questions posed by residents during their self-assessment activity.
3. Critically discuss the management of acute urinary retention and the various strategies to alleviate the obstruction depending on the cause.
4. Summarize key learning points.

### Case Studies

**Case 1:** A 17-year-old adolescent boy arrives at the emergency department (ED) after he developed the acute onset of severe right testicular pain about 4 hours ago while at soccer practice. The patient does not recall any recent trauma to the area and denies any fever, dysuria, or penile discharge. Although he is nauseous, he does not have any abdominal pain or vomiting. On examination, his temperature is 99.5°F, blood pressure 138/84 mm Hg, heart rate 104 beats per minute, and respiratory rate of 22 breaths per minute. He is in acute distress due to pain. His abdomen is benign. On visual inspection, he has right scrotal erythema and swelling although no penile lesions or discharge. Because his scrotum is so diffusely tender, it is difficult to examine it more closely. However, there is no testicular rise when his inner thigh is stroked. His urinalysis shows 3 to 5 white blood cells (WBCs)/high power field (hpf).

### Question Prompts:

1. What is the appropriate step-wise management algorithm in regards to consultation and imaging?
  - a. This patient is presenting with acute severe testicular pain with a testicle that is swollen, tender, and lacks a cremasteric reflex. This is highly suggestive of testicular torsion, an acute surgical pathology that is time-sensitive (excellent outcomes when managed within 6 hours), and warrants immediate urology consultation for swift operative management. Any imaging ordered should be done in parallel with immediate consultation. Manual detorsion can be attempted by rotating the affected testicle 1.5 turns in an “open-book” fashion (clockwise for left testicle; counter-clockwise for right), with any pain relief being a positive endpoint.
2. What could be done if you worked in a community emergency department with no urologic back-up?



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- a. In the community setting without urology back-up, the emergency practitioner should immediately work towards facilitating transfer to a center with emergency urology capabilities. Attempts can be made at manual detorsion. Imaging can be considered, though this should not be performed if it will delay transfer.
3. How would you manage a urologist who refuses to evaluate the patient until an ultrasound is complete?
  - a. Situations like these can be challenging. A gentle reminder of the time-sensitive nature of the pathology, and that ultrasound is only 88% sensitive (and 90% specific), may be helpful. Escalation to the department chair is another option. Ultimately, the end-point of the emergency management of potential testicular torsion is evaluation by a urologist. In a hypothetical situation where the above techniques are unsuccessful, the patient may require transfer to another facility where his needs can be accommodated.

**Case 2:** A 64-year-old man presents to the emergency department (ED) because of an inability to urinate for the past 24 hours. In addition, he complains of an unintentional weight loss of 20 pounds over the past 6 months, night sweats, and generalized fatigue. On examination, he is thin and in moderate distress. His blood pressure is 168/92 mm Hg, heart rate is 102 beats per minute, temperature is 37.7°C (98.8°F), and respiratory rate is 22 breaths per minute. The abdominal examination reveals a tender mass in the suprapubic area. On rectal examination, the prostate is firm, non-tender, and somewhat irregular.

## Question Prompts:

1. What is the most appropriate diagnostic evaluation for this man?
  - a. This patient is presenting from acute urinary retention, likely secondary to obstruction at the level of the prostate. Bedside ultrasound is the most appropriate diagnostic modality in this situation, as it can be performed rapidly, accurately, is relatively pain free, and carries a relatively low cost.
2. Describe the management algorithm for this patient's presentation.
  - a. If initial attempts to catheterize with a standard urinary catheter fail, consider using a Coude catheter, which has a more rigid and angulated tip that can assist in traversing an enlarged prostate and/or ureteral stricture. Be sure the angulated tip is pointing anteriorly.
  - b. If any attempt at catheterization results in gross hematuria, the catheter should be removed (after the balloon is deflated), as this is likely secondary to the creation of a false passage.
  - c. Attempts at standard catheterization should not be made in patients who recently underwent a urological surgery. Urology consultation is warranted in these patients.
  - d. Once a catheter is successfully placed, the patient may be discharged home with urological follow up. He should be provided with catheter care instructions and supplies. A retrograde urethrogram can be performed on a non-emergent basis to identify the size and location of any urethral strictures and/or other urethral abnormalities. The patient can also be worked up for possible prostatic neoplasm as an outpatient.
3. Discuss the management strategies if initial attempts at decompression failed.



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- a. If initial attempts are unsuccessful, urology consultation should be considered. If urology is unavailable, suprapubic catheterization can be considered.
- b. A suprapubic catheter can be inserted at bedside under ultrasound guidance with low complication rates. Insert a 22-gauge needle angled caudally (30-degrees from true vertical) — at the midline 3-4cm above the pubic symphysis — until urine is aspirated and the needle can be seen in the bladder. A guide wire can then be inserted through the needle and into the bladder. This wire can be used to guide a cystostomy catheter and obturator assembly into proper position. The obturator is then removed, leaving the functional catheter in place.

**Case 3:** An 8-month-old male presents to the emergency department accompanied by his parents for the evaluation of increased irritability. Parents state that the child has been intolerant of diaper changes in the past several hours. He is an otherwise healthy child with no medical problems and he was born full-term. He is uncircumcised and fussy when you examine his genitalia. You see a retracted swollen foreskin (instructors can search the internet for an example image to show learners)

## Question Prompts:

1. What is the diagnosis affecting this child?
  - a. This is a paraphimosis, a urologic emergency characterized by the inability of retracted foreskin to return over the head of the penis. This can result in ischemia and gangrene to the glans penis.
  - b. In contrast, a phimosis is characterized as the inability to retract the foreskin over the head of the penis. This is rarely a true urologic emergency, though it can rarely result in balanitis (inflammation of the glans), as well as urinary retention.
    - i. Always consider paraphimosis, as well as other pathology to the penis and scrotum, in the undifferentiated, fussy male infant.
2. What is the appropriate treatment for this child? Describe what you would do if urology were not available.
  - a. Paraphimosis warrants emergent urology consultation for possible operative management. In situations where a urologist is not immediately available, manual reduction can be attempted by applying direct pressure to the glans penis for up to 5-10 minutes. Consider anesthesia with a dorsal penile block prior to reduction. Consider applying osmotic agents (mannitol, granulated sugar) to help reduce glans edema. If manual reduction fails, a dorsal slit can be performed.

**Case 4:** A 56-year-old male presents with a persistent erection. The patient took a single dose of sildenafil approximately 6 hours ago, and has had a persistent erection for the past 5 hours. It has become progressively more painful, which is what prompted him to come to the Emergency Department.



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## Question Prompts:

1. What is the diagnosis affecting this child?
2. What are the different classifications of priapism and what are the etiologies for each?
  - a. High Flow Priapism is rare, often painless, and is generally caused by a traumatic fistula between cavernosal artery and the corpus cavernosum.
  - b. Low Flow Priapism is the common presentation of priapism and is generally very painful. In children, sickle cell disease is the predominant causative etiology. Adults are more likely to have priapism that is idiopathic or caused by the patient's medication, such as oral and injectable medications for erectile dysfunction, hypertensive medications (hydralazine, prazosin, or calcium channel blockers), and/or psychiatric medications (chlorpromazine, trazodone, thioridazine).
3. What are the treatment options for this patient?
  - a. This patient is experiencing low flow priapism as a result of his sildenafil use. This is a urological emergency as prolonged priapism can cause significant morbidity with erectile dysfunction. He should receive prompt pain control, and consider performing a penile block before initiating any local treatments. Some physicians start with an IM systemic injection of terbutaline. Others proceed directly to aspiration of blood from the corpus cavernosum followed by irrigation with either normal saline or an alpha-adrenergic agonist such as phenylephrine. It is generally advised to approach the corpus cavernosum from either lateral aspect of the penis, avoiding the neurovascular bundle on the dorsum of the penis and the urethra on the ventral surface. This process of aspiration and irrigation can be repeated every 5 minutes. If, however, it fails to produce detumescence, the patient requires emergent urological evaluation for possible shunting procedure. If this cause of the priapism is thought to be from sickle cell crisis, the patient should be treated with fluids and pain control. They may also benefit from aspiration and irrigation, but before undergoing a shunt procedure, a transfusion or exchange transfusion should be considered.

## Suggested Readings:

Davis JE. Male genital problems. In: Tintinalli JE, Stapczynski J, Ma O, Yealy DM, Meckler GD, Cline DM, eds. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*. 8<sup>th</sup> ed. New York, NY: McGraw-Hill; 2016:601-608.

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## Additional Reading:

Lippert S, Wang NE. Pediatric genitourinary and renal disorders. In: Adams JG, Barton ED, Collings JL, DeBlieux PMC, Gisondi MA, Nadel ES, eds. *Emergency Medicine: Clinical Essentials*. 2<sup>nd</sup> ed. Philadelphia, PA: Elsevier/Saunders; 2013:167-176.

Liu DR. Pediatric urologic and gynecologic disorders. In: Tintinalli JE, Stapczynski J, Ma O, Yealy DM, Meckler GD, Cline DM, eds. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*. 8<sup>th</sup> ed. New York, NY: McGraw-Hill; 2016:875-880.

## Key Learning Points:

1. After initial attempts to pass a 14/16/18 french Foley catheter fail, a Coude catheter should be attempted. If any of these attempts produce gross hematuria the balloon should be deflated and the catheter removed because a false passage may have been created.
2. Suprapubic catheterization under US guidance has a low complication rate. The procedure should attempt to advance a 22gauge spinal needle 30 degrees caudally from the true vertical at a point 3-4cm above the pubic symphysis in midline. Then use an obturator to dilate the tract before placing the catheter in the bladder.
3. Urethral strictures are becoming more prevalent secondary to rising incidence of STI's.
4. Abnormal residual bladder volumes are 150cc-200cc.
5. Retrograde urethrography (RUG) is indicated to define location and extent of urethral stricture.
6. If 2-3 attempts to place a catheter past a stricture fail, urologic consultation is indicated. For emergency bladder decompression, a suprapubic cystostomy using the Seldinger technique can be performed in the ED.
7. For testicular torsion, urologic consultation should precede scrotal US. Manual detorsion can be attempted using open-book method with adequate analgesia.
8. Paraphimosis is a urologic emergency due to the possibility of penile necrosis.
9. For the fussy infant, consider penile or scrotal pathology.
10. Priapism can often be treated by the emergency physician through aspiration and irrigation of the corpus cavernosum. If, however, this is unsuccessful, the patient should undergo emergent urological evaluation.



## Appendix H:

# Urinary Tract Infections – Cystitis and Pyelonephritis

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### Objectives

1. Review pathophysiology, diagnosis and treatment of urinary tract infections in pediatrics and adult patients.
2. Review pathophysiology, diagnosis and treatment of pyelonephritis in pediatrics and adult patients.
3. Discuss questions posed by residents in their pre-work assignments.
4. Evaluate the role of advanced imaging studies for further evaluation of patients with urinary tract infections.
5. Summarize key learning points.

### Case Studies

**Case 1:** A 17-year-old female presents to the emergency department (ED) with a primary complaint of burning with urination. The patient has no significant complaints of nausea, vomiting, fevers or chills.

### Question Prompts:

1. What characteristics in patients define the difference between cystitis and pyelonephritis?
  - a. Cystitis manifests as focal symptoms of irritation to the bladder, including suprapubic pain and urinary frequency, occasionally accompanied by hematuria. Infection of the urethra results in dysuria. In contrast, pyelonephritis, which can manifest as flank or costovertebral angle pain, commonly causes systemic signs and symptoms, including fever, malaise, nausea and vomiting.
2. What are the possible findings in a urinalysis for possible infection?
  - a. The urinalysis can be divided into two major components: dipstick and microscopy. On the dipstick, the major indicators of infection are the leukocyte esterase reaction (LE) and nitrite reaction. Leukocyte esterase is an enzyme produced by neutrophils, and its presence indicates pyuria. Nitrites are a byproduct of fixation of nitrates by coliform bacteria. Positive nitrite reaction on dipstick is highly specific for urinary tract infection (UTI), though it is poorly sensitive (~50%), since many urinary pathogens do not convert nitrates into nitrites (Pseudomonas, Enterococcus, Staph, Acinetobacter). LE has reasonable sensitivity and marginal specificity.
  - b. Microscopic evaluation of a urine sample is performed on a centrifuged sample. White blood cell count is highly sensitive, with a sensitivity of 90%-96% at WBC of >5/hpf, though the specificity is relatively poor. The presence of bacteria and/or hematuria, in the presence



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- of signs and symptoms of active infection, are highly specific for UTI (~90%). The presence of squamous epithelial cells can be used to identify poorly acquired/contaminated samples.
3. Describe the management algorithm if this patient was a child.
    - a. In general, children are less likely to manifest systemic symptoms with upper UTIs. The treatment algorithm for children is based on age and presentation. All children under the age of 28 days with a fever or findings of a UTI should be admitted for intravenous (IV) antibiotics and a full septic workup. Children >28 days but less than 2 years old can be managed at home if they are clinically well, typically with an initial dose of ceftriaxone, followed by a 2-week course of oral antibiotics with 24 hour follow up for reassessment. In well children >2 years of age, typical courses are for 7 days of oral antibiotics, with the option of a standard 3-day course for females >13 years old with otherwise uncomplicated UTIs. Urology evaluation for structural abnormalities should be considered in all pediatric patients who present with UTI.
  4. What types of collection methods are possible in children and adults?
    - a. A midstream voiding specimen is the most preferred sample for adults and children that can void on command. With proper sample collection — including adequate cleansing — these samples perform as well as those obtained via catheterization, which carries a 1%-2% iatrogenic UTI rate/catheterization. In children who cannot spontaneously void, suprapubic needle aspiration is an additional option in patients where catheterization is not an option or proves difficult. Perineal bags are another option, though these are generally considered suboptimal as their specificity is quite poor, owing to high rates of contamination.

**Case 2:** A 23-year-old individual presents with flank pain. The patient reports fevers and chills as well, but has been tolerating oral intake well at home. She has already been evaluated by her primary care physician and prescribed a 2-week course of ciprofloxacin.

## Question Prompts:

1. Describe the potential issues/reasons for the patient's presentation.
  - a. This patient is presenting with symptoms suggestive of pyelonephritis despite 2 weeks of oral antibiotics. There are several considerations as to why this has occurred. Non-compliance with the antibiotics is certainly a consideration, though this should be a diagnosis of exclusion. Bacterial resistance to ciprofloxacin should be considered. While local resistance patterns will vary, rates of resistance to ciprofloxacin and trimethoprim/sulfamethoxazole, the most commonly-prescribed antibiotics for UTI, have been rising and are as high as 30% nationally. Though not applicable to this patient, it is important to also remember to avoid nitrofurantoin in patients with suspected "upper" UTIs, as this drug only achieves therapeutic levels with concentration in the bladder. Alternative pathogens to the typical enteric coliforms, including staph species and sexually transmitted infections (STIs), should also be considered, since these pathogens all have variable response rates to the more conventional antibiotics. Destructive parenchymal disease, including renal abscess and emphysematous pyelonephritis should be considered.



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A final consideration is that this patient may have a retained kidney stone that may or may not be infected.

2. What is the next step in this patient's management strategy and disposition plan?
  - a. Review of any available culture data would be helpful. Consider alternative causes, including renal stone disease, and broaden the workup as indicated. For cases of otherwise uncomplicated pyelonephritis, broadening the antibiotic regimen with a late-generation cephalosporin, aminoglycoside, or extended-spectrum penicillin should be considered. If the patient is non-toxic and able to tolerate oral intake, a 14-day outpatient course of antibiotics is reasonable, though admission should be considered.
3. Does gender matter and why?
  - a. While UTIs are relatively common in young females, they are relatively rare in male patients, and usually indicative of a STI, and antibiotics should be tailored towards these organisms. In general, UTIs in young males are considered "complicated," a term used to refer to UTIs that are more likely to be caused by resistant pathogens and/or have adverse outcomes. Other "complicated" UTIs include those that are: recurrent, occur after recent urogenital instrumentation, occur in structurally/functionally abnormal anatomy, occur in the setting of multiple comorbidities, occur in pregnancy, or occur in immunocompromised patients.

**Case 3:** A 29-year-old female who is a G1PO at 37 weeks presents with dysuria. On initial workup, a urine is checked and demonstrates bacteria but no leukocyte esterase, nitrites, or WBC. Physical examination was normal. She has no past medical history, does not smoke or drink alcohol, and her only medications are prenatal vitamins. She is allergic to penicillin.

## Question Prompts:

1. List potential issues with treatment or lack of treatment for this patient?
  - a. This patient has asymptomatic bacteriuria, which is the presence of bacteria in the urine in the absence of additional findings suggestive of active infection. This phenomenon is relatively common, seen in 2%-10% of pregnant patients, and in up to 40% of female patients that reside in nursing homes. While treatment of asymptomatic bacteriuria in nursing home patients has been discouraged, it is always indicated in pregnant patients, as this has been shown to lower the rates of cystitis and pyelonephritis, both of which have been linked to preterm labor.
2. What are some of the crucial bacteria to consider in this patient?
  - a. In addition to the typical pathogens, group B strep, a common cause of chorioamnionitis, should also be considered.
3. What is the appropriate management and disposition plan for this patient? What are the medication options for this patient?
  - a. Pregnant patients with asymptomatic bacteriuria and otherwise benign UTIs without systemic symptoms can be managed with outpatient antibiotics, with nitrofurantoin being first line, followed by cephalosporins. Fluoroquinolones, tetracyclines, and TMP/SMX should



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be avoided. Ill patients and those with suspected pyelonephritis should be admitted for IV antibiotics, typically 2nd-3rd generation cephalosporins plus gentamicin.

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Whelan LJ. Comorbid disorders in pregnancy. In: Tintinalli JE, Stapczynski J, Ma O, Yealy DM, Meckler GD, Cline DM, eds. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*. 8<sup>th</sup> ed. New York, NY: McGraw-Hill; 2016:636-643.

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Wolfson AB. Renal failure. In: Marx JA, Hockberger RS, Walls RM, et al. eds. *Rosen's Emergency Medicine: Concepts and Clinical Practice*. 8<sup>th</sup> ed. Philadelphia, PA: Elsevier Saunders; 2014:1291-1311.

## Key Learning Points:

### Case 1:

- UTI are generally divided into lower (cystitis) and upper (pyelonephritis). Cystitis is local (dysuria, frequency, urgency, hematuria, suprapubic pain). Pyelonephritis is systemic (fever, chills, N/V, flank pain).
- Discussion of LE, nitrites, bacteria, WBC. Attached paper in EBM helps with this.
- In children, pyelonephritis can present as only cystitis. Consider inpatient treatment for systemically ill children. Consider urology evaluation for these patients also.
- The type of urine sample is key: catheter specimen vs midstream clean catch. Diaper and bag collections are horrible. Suprapubic for anatomical abnormalities only where catheter is contraindicated.



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## Case 2:

- Issues are noncompliance, resistant organisms, concomitant kidney stone, renal abscess, emphysematous pyelonephritis
- Next step is imaging! Adding more antibiotics doesn't make sense without culture/sensitivity direction. Thorough understanding of patient's past medical history and risk factors are important.
- Gender is key. With men, this is a complicated presentation which deserves further evaluation most probably by a urologist either inpatient or outpatient. Consideration must be made for structural abnormalities as a source of their symptoms.
- Practitioners should be able to recognize uncomplicated vs complicated UTIs, as well as the appropriate changes to the diagnostic and therapeutic strategies these impose.

## Case 3:

- Pregnant patient with bacteriuria/UTI need aggressive treatment to prevent complications (preterm, miscarriage etc). Bacteriuria has a high prevalence in pregnant women, but should be treated any time it is encountered in this population.
- Group B strep is a key pathogen in this population, which if found should be treated with ampicillin before delivery (ideally 2 doses).
- Meds: nitrofurantoin, PCN, cephalosporins are all acceptable. Sulfonamides are contraindicated because they can cause neonatal hemolysis. Likewise, flouroquinolones are contraindicated because of a link to congenital defects.