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Short Communication

Teaching Diagnostic Reasoning to Advanced Practice Nurses: Positives and Negatives

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Abstract: Many nurses transitioning to advanced practice roles struggle in gaining competence in diagnostic reasoning, a core skill requiring integration and application of complex patient data. Diagnostic error, a common cause of medical error, is often a result of faulty interpretation, synthesis, or judgment of available information. Nurse educators, confronted with decreased clinical site availability, shifts to online education, and emerging learning pedagogies are increasingly challenged in facilitating student acquisition of diagnostic reasoning skills. This article presents an overview of strategies and lessons learned by primary and acute care nurse practitioner faculty in attempts to improve student competence in diagnostic reasoning.

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The diagnostic process is ‘‘a complex, patient-centered, collaborative activity that involves information gathering and clinical reasoning with the goal of determining a patient's health problem (National Academies of Sciences, Engineering, and Medicine [National Academies], 2015, pg. 32).'' Diagnostic reasoning, a core competency for advanced practice nursing (APN) roles, challenges many novice nurse practitioners, that is, NPs (Durham, Fowler, & Kennedy, 2014). Research suggests that most diagnostic errors result from faulty interpretation, synthesis, or judgment of available patient data; lack of proficiency in diagnostic reasoning is a significant contributor to preventable medical error (Cook, 2012; National Academies, 2015).

Following a review of recent graduate performance on national certification examinations along with feedback from instructors, preceptors, and new-graduate employers, faculty decided to test learning activities aimed at improving

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the domains of health assessment and differential diagnosis, foundational components in the diagnostic reasoning process. Because content knowledge related to APN practice does not automatically direct safe diagnostic reasoning, the purpose of this study was to describe several supports employed by an NP faculty to assist students in gaining skills in diagnostic reasoning. An overview of the diagnostic reasoning process in health care and summary of faculty experiences embedding multiple approaches including simulated primary and acute care patient encounters, virtual patients, simulated on-call experiences, and decision trees into foundational NP courses will be provided. Descriptions of pertinent positive and negative responses encountered while introducing each learning experience into the NP curricula, many of which are evidence supported, are provided in Table 1.

Key Points

- Because diagnostic error is a causative factor in medical errors, teaching and evaluating advanced practice nursing students' diagnostic reasoning skills is imperative.
- Multiple strategies, including various forms of simulation, may be used to teach and/or evaluate advanced practice nursing students' decision-making skills.
- Each strategy offers pertinent positives and negatives associated with its use; one program's experience will be described.

Diagnostic Reasoning in Health Care

Clinical judgment is a broad term encompassing diagnostic reasoning as well as context and resource evaluation to support the development of a treatment plan, ideally incorporating the patient in decision-making (National Academies, 2015). The process of diagnostic reasoning has been addressed from two major frameworks. The first, the hypothetico-deductive or analytic approach, is a systematic review of data presented to prioritize a list of possible explanations (hypotheses) consistent with presenting symptoms or assessments of health risk, often through the identification of patterns (Durham et al., 2014). Critically appraising the steps in diagnostic reasoning and potential sources of error can make educational experiences more focused on a range of diagnostic tasks.

The second pattern of decision-making is the gestalt, intuitive, or hermeneutic approach where the problem is identified though pattern recognition memory (Durham et al., 2014). The approach a provider uses in clinical judgment depends on the complexity of the clinical case and care environment, as well as the knowledge and skill the clinician brings to the problem. Table 2 reflects the steps in diagnostic reasoning processes and corresponding potential errors (Adapted from Chase, 2004).

Episodic/Problem-Based Examinations

Essential skills for the NP student are completion of a focused history and physical examination related to a patient's chief complaint. These competencies are critical for a practicing NP to accurately diagnose within an appropriate time frame (Muhrer, 2014). Episodic and problem-based examinations using human patient simulators, standardized patients, and objective structured clinical examinations afford the opportunity for real-time evaluation of student competencies in these areas (Anderson, Holmes, LeFlore, Nelson, & Jenkins, 2010). Core competencies for NP practice include differentiating normal from abnormal findings, generating diagnostic hypotheses, utilizing diagnostic tests to formulate diagnoses, safe prescribing, and effective verbal and written communication (American Association of Colleges of Nursing, 2016; National Organization of Nurse Practitioner Faculties [NONPF], 2015; National Task Force for Quality Nurse Practitioner Education, 2016; Thomas et al., 2017).

The program uses timed, formative, and summative episodic or problem-based examinations in several courses, using standardized patients to evaluate these essential skills and to meet the core competencies (Anderson et al., 2010). This experience was adapted, with permission, from rubrics designed by Jacqueline Michael, PhD, APRN, WHNP-BC, lead faculty of graduate health assessment at the University of Texas at Arlington College of Nursing and Health Innovation and one by Dr. Sharolyn Dihigo, DNP, RN, CPNP-PC, FNP-C. Throughout the curriculum, these types of simulated experiences are scaffolded to incorporate increasingly complex diagnostic reasoning, clinical, and therapeutic management skills. Limitations and challenges have occurred, some of which have been reported in the literature (Table 1).

Virtual Simulation in a Primary Care Curriculum

Online virtual simulation (OVS), an interactive reality technology that creates and mimics real-world patient care encounters (Duff, Miller & Bruceh, 2016), has potential to augment evolving delivery of NP education in programs heavily reliant on on-line delivery. OVS learning activities afford students an opportunity to develop and refine diagnostic reasoning skills through interview, physical examination, and diagnostic workup of a virtual patient and formulation of a most-likely diagnosis and associated treatment plan using a rich library of electronic patient data including diagnostic images (Cook, Erwin, & Triola, 2010; Forsberg, Ziegert, Hult, & Fors, 2016; Posel, McGee, & Fleisher, 2015). Vendor-developed OVS activities are incorporated into multiple courses.

Early adoption of OVS technology was met with unanticipated challenges requiring adaptability on the part of faculty and students. Difficulties were encountered with

Table 1 Anectodal Pertinent Positive and Negative Responses Associated with Diagnostic Reasoning Learning Strategies, Aligned with Literature

Learning Strategy	Pertinent Positives	Pertinent Negatives
Episodic/ problem-based evaluations	• The examination can be videotaped, allowing for faculty review (Rutherford-Hemming & Jennrich, 2013) and may be used in debriefing or remediation. • Correct and accurate case-specific documentation can be evaluated with certainty. • SPs can offer feedback to the student (Kurz, Mahoney, Martin-Plank & Lidicker., 2009; Rutherford-Hemming & Jennrich, 2013). • Faculty can listen to and question the student's thought processes in the presentation portion of the activity. • Faculty member can observe how a student verbally interacts with a "patient" (Mason Barber & Schuessler, 2018). • Gaps in the curriculum can be determined (Mason Barber & Schuessler, 2018; Vessey & Huss, 2002).	• A significant amount of time is needed for preparation for the simulated encounter (Kurz, Mahoney, Martin-Plank, & Lidicker, 2009). • Simulated patient encounters are very resource intensive (Mason Barber & Schuessler, 2018). • SPs must be hired and trained (Kurz et al., 2009; Vessey & Huss, 2002). This may be done with a school's own SP program (Anderson, et al., 2010), or they may be obtained through collaboration with another school or department (Rutherford-Hemming & Jennrich, 2013). Trained faculty, volunteers (Anderson et al., 2010), or other types of trained laypersons (Kurz et al., 2009) may be utilized; however, this may create additional challenges. • When collaborating with others, scheduling can be an issue. Experiences must be scheduled early to ensure SP availability. • SP encounters can be costly (Vessey & Huss, 2002); budgeting procedures must be determined (e.g., school/program vs. course or student laboratory fee) (Anderson et al., 2010; Rutherford-Hemming & Jennrich, 2013). • If videotaping occurs, policies and procedures must be outlined; these may vary among department or school if collaboration occurs. • Multiple faculty are needed during the event to monitor students, that is, orienting, moving them along (flow) (Mason Barber & Schuessler, 2018), proctoring student presentations of "patients," and supervising the written postencounter activities.

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Table 1 (*continued*)

Learning Strategy	Pertinent Positives	Pertinent Negatives
Online virtual simulation (OVS)	• OVS activities require less capital investment in possibly expensive, rapidly changing technologies characteristic of human patient simulator products (Johnson et al., 2014). • Although some OVS products may place time demands on faculty resources, ultimately, OVS activities may be more efficient and less resource dependent than other types of simulation (Johnson et al., 2014). • OVS provides a uniform means by which faculty can evaluate diagnostic reasoning skills in a variety of program delivery modes (Bryant et al., 2015). • OVS experiences create opportunities for students to interact with avatar "clients" and afford more time to gather and process data than other timed simulation modalities (Posel et al., 2015). • OVS learning activities afford opportunities for faculty to provide individualized student feedback (Posel et al., 2015) and to identify potential group learning deficiencies in real time, allowing for timely adjustment of course delivery. • Many OVS products afford opportunities for students to compare performance against clinical exemplars and incorporate student reflection activities (Bryant et al., 2015; Posel et al., 2015).	• Available cases are limited, particularly related to lifespan, and often are unmodifiable. • Student effort on assignments may vary; increased time and student effort have been associated with improved student outcomes (Consorti, Mancuso, Nocioni, & Piccolo, 2012; Posel et al., 2015). • No evidence on the time or case dose required to optimize student performance outcomes is available (Consorti et al., 2012). • Students "gaming" the system in attempts to improve grades may discourage acquisition of focused interviewing and physical examination skills and may fail to help students gain an appreciation of the role of cost-effective diagnostic and treatment planning in real-world NP practice. • Allowances for technical failures are required during the implementation and utilization of virtual patient encounters (Foronda, Godsall, & Trybulski, 2013). • Significant preimplementation and real-time coordination with the OVS vendor is required. Products vary in delivery of student and faculty support resources. • Most current products are episodic in nature and provide limited opportunity for students to manage acute or chronic conditions longitudinally (Posel et al., 2015). • The structure of some vendor-developed OVS assignments may prompt students on required assessments and diagnostics. Students potentially do not have the ability to independently determine which systems require a focused assessment.
Decision trees	• The group decision tree exercise provides opportunity for students to gain experience with "expert schemes" characteristic of inductive problem solving (Coderre et al., 2003). • Pattern recognition and scheme-inductive problem-solving strategies produce greater diagnostic accuracy when compared to decision-making using predominantly hypothetico-deductive approaches (Coderre et al., 2003). • Being required to provide concise documents in a limited amount of space helps to focus on the most essential components to be considered during clinical decision-making. • This experience provides opportunities for students to work in teams of their own choice, which is helpful for those who do not like working in groups.	• Using graphics to create algorithms may be challenging and time consuming, which distracts from the object of the exercise; students may focus on esthetics of activity rather than diagnostic reasoning process. • Since many algorithms or decision trees are available online and in texts, this could tempt some students to provide nonoriginal work.

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Table 1 (*continued*)

Learning Strategy	Pertinent Positives	Pertinent Negatives
Simulated "on-call" experiences	• This is not a high-stakes exercise in the course. • A simulated call from an uninformed, concerned "parent" without an ability to simultaneously view the "child" requires independent, on-the-spot decision-making without time to consult many resources. This may cause student anxiety (Kelly et al., 2017). Immediate feedback appears to allay student anxiety related to the experience. • The "on-call" simulation also provides opportunities to help students distinguish among the need for reassurance, comfort measures, urgent or emergent action (Lewis, Strachan, & Smith, 2012). • The cost of this simulation was minimal except for the faculty and student time involved.	• Being accessible for a week without knowing when a simulated experience is planned by faculty can be difficult for students with hectic schedules. • It is difficult for students to be available while working.
Acute care simulation	• This simulation provides an opportunity to increase both critical thinking and communication skills in a "safe" environment (Fisher & King, 2013). • Students integrate psychomotor and diagnostic reasoning skills to intervene in a life-threatening, critical presentation. • The simulation affords the opportunity for students to prioritize interventions and practice leadership skills in directing the care team; simulation provides a method to improve interpersonal communication and team building (Lewis et al., 2012). • Psychomotor skills associated with management of the critically ill patient taught earlier in the curriculum are reinforced during capstone courses.	• Owing to the complexity of the simulation, preparation of the simulated practice environment is time intense. • Modern critical care monitors and associated equipment are necessary, are costly, and require ongoing maintenance. • Universities may not be able to collect enhanced laboratory and other technology fees from students to cover associated costs.

Note. SP = standardized patient.

the product's acute care focus, scenario complexity, time demands, and evaluation process as students "gamed" the rubric by asking numerous questions unrelated to the presenting complaint to earn points.

Despite these obstacles, faculty observed improved presentation and documentation skills and better identification of students requiring remediation following immersion in a virtual environment. An alternative OVS product more closely aligned with the program's goals was subsequently selected and remains in use in the primary care program. Faculty mapped OVS assignments between classes, allowing for progression in case complexity and associated decision-making.

Decision Trees

Decision tree assignments provide students with opportunities to practice inductive reasoning, a decision-making pattern associated with greater diagnostic success (Coderre, Mandin, Harasym, & Fick, 2003). Working in small groups, students determine important information needed when encountering a patient with a common symptom such as genitourinary complaint and subsequently identify three most-likely diagnoses related to the problem. Groups create graphics to guide decision-making including relevant history and physical examination components and risk factor considerations. They also identify appropriate problem-related diagnostics and develop management plans for each leading diagnosis. Current professional evidence-based resources provide supporting and refuting data to guide the development of all components of the decision tree. To help students focus on the most relevant information, decision trees are expected to be clear and concise and contained on a single page. Figure provides an example. The assignment also fosters teamwork and communication, critical provider skills described in the National Academies' (2015) report.

Simulated "On-Call" Experiences

Activities in which students must assume independent clinical responsibility through "on-call" experiences can strengthen both communication and decision-making skills (Kelly, Blunt, & Nestor, 2017; Little & McCoubrie, 2016). In a simulated on-call experience, the educator assumes the role of a parent calling about a child with an "after hours" health concern such as an immunization reaction in a

Table 2 Steps in Diagnostic Reasoning and Associated Potential Errors

Steps in Diagnostic Reasoning	Potential Errors
Data acquisition	• Not listening to patient/family • Not using a systematic approach to data collection • Failure of developing situational awareness • Failure to note trends in data over time • Stopping data acquisition before process is complete
Hypothesis generation	• Failure to generate multiple hypotheses • Ignoring most obvious diagnosis • Ignoring the "not to be missed" hypothesis • Allowing gender, age, or other bias to cloud hypothesis generation
Hypothesis evaluation	• Not using a systematic approach to evaluate hypotheses: body systems, "skin in" • Not seeking further data to rule out a hypothesis • Not seeking further data to confirm a hypothesis • Not ordering tests to support data collection
Diagnostic choice	• Premature closure on one hypothesis • Failure to consider "What else could this be?" • Delay in diagnostic consultation
Communication	• Not providing team communication during hypothesis evaluation • Not providing patient/family communication regarding hypotheses
Goal setting	• Not communicating with patient/family regarding preferences for goals of care • Not considering resources and demands on the patient/family
Treatment choices	• Not considering patient/family capacity for self-care • Not considering appropriate referral to specialists
Evaluation of effectiveness	• Not checking back to assess effect of care • Not involving patient's family in evaluating treatments including medication side effects

Adapted from Chase, 2004. *Clinical judgment and communication in nurse practitioner practice*. Philadelphia: F.A. Davis (permission requested).

toddler, an acute respiratory complaint in a small infant, or school-age child with arm pain. Delivery of scenarios coincides with weekly didactic course content. Students are expected to respond in a timely manner and address the ''parent's'' concerns appropriately. Faculty feedback is provided shortly after the ''on-call'' communication.

Applying Diagnostic Reasoning Skills to an Acute Care Nurse Practitioner Program

A number of progressively complex simulated learning activities challenging students' technical and decision-making skills are embedded in the Adult-Gerontology Acute Care NP (AG/ACNP) curriculum to support development of diagnostic reasoning competencies in nurses transitioning to AG/ACNP roles. Simulated acute care experiences incorporate clinical patient data into skill training scenarios, providing an opportunity for students to integrate diagnostic reasoning into complex skill acquisition. This integration is critical in providing AG/ACNP students with opportunities to respond to varied patient presentations across the range of patient acuity.

In one simulated experience with a human patient simulator, students respond to a cardiac arrest scenario. Students use diagnostic reasoning and team communication skills to stabilize, diagnose, and manage the patient while gaining experience with psychomotor skills including ultrasonography for point-of-care, echocardiography, cardiopulmonary resuscitation, endotracheal intubation, and invasive venous/arterial insertion. Students are evaluated on timely response to call, appropriateness of diagnosis, effectiveness of team communication, problem-appropriate clinical management, and safe performance of psychomotor skills. Feedback is provided during debriefing. Integration of diagnostic reasoning with complex skill acquisition in team scenarios may facilitate a successful transition from student to practitioner, preparing them to deliver safe, quality care in multiple settings.

Conclusion

A goal of APN education is to support progression of diagnostic reasoning skills from the hypothetico/deductive/analytic approaches to a more gestalt/intuitive/hermeneutic approach. This is best accomplished through repeated exposures using varied learning activities. Nationally, rapid growth of NP programs, decreasing supply of onsite clinical preceptors, and expanded use of online delivery of NP education (Bryant, Miller, & Henderson, 2015) have placed demands on faculties to incorporate alternative, evidence-based learning methods that support development of core assessment, diagnostic reasoning, and clinical decision-making competencies in APN students (Ballman, Garritano, & Beery, 2016; LeFlore & Thomas, 2016). Having worked through a number of

Scrotal Mass		
Physical Exam Findings: • Sudden onset of severe testicular pain • Heavy sensation in testicle • Lower abdominal and/or groin pain • + Prehn's sign • Fever, chills • May report dysuria, flank pain, and testicular pain worsening with bowel movements or straining • Testicle red, hot, swollen, and painful with palpable, tender lump • Intact cremasteric reflex	**Physical Exam Findings**: • Swollen, smooth, tense mass • Most often painless, but can be uncomfortable • May fluctuate in size • Gradual, not immediate swelling • Mass transilluminates	**Physical Exam Findings:** • Painless, solid, firm mass that does NOT transilluminate • Sensation of fullness in scrotum • Abdominal pain • May have palpable abdominal mass • May have enlarged retroperitoneal lymph nodes • Anorexia and nausea • Constipation • Voiding difficult. • Gynecomastia may be present
History and Risk Factors: • History of sexually transmitted infection, HIV, UTI, or prostatitis • Recent trauma • Participation in risky sexual behaviors such as unprotected anal intercourse	**History and Risk Factors:** • *Newborns/Infants*: may be present at birth due to patent processus vaginalis. • *Adults*: recent trauma, hernia, testicular tumor, torsion, or epididymitis complication.	**History and Risk Factors:** • Personal of family history of testicular cancer • History of testicular disorders including cryptorchidism • Prior testicular surgeries • Infertility
Epididymitis	**Hydrocele**	**Testicular Cancer**
Diagnostic Plan: 1. CBC 2. Urinalysis with culture and sensitivity 3. Nucleic acid amplification test (NAAT) to r/o chlamydia and gonorrhea 4. C-reactive protein 5. Doppler ultrasound	**Diagnostic Plan:** 1. Transillumination exam 2. Scrotal ultrasound	**Diagnostic Plan:** 1. Testicular ultrasound to confirm size, type, and location of mass 2. CT of chest, abdomen, and pelvis to determine degree of involvement of mass and to rule out metastasis 3. Serum tumor markers: human chorionic gonadotropin (HCG), alpha fetoprotein (AFP), lactate dehydrogenase (LDH) 4. Biopsy to confirm diagnosis 5. PET scan to r/o metastasis
Pharmacological Interventions: 1. Anti-infective therapy: single dose cetriaxone IM 250---500mg 2. *For men < 35yo*: Doxycycline 100mg PO BID x 10 days OR *For men ≥ 35yo*: Levofloxacin (IV or PO) 500-750mg x 10 days* OR Ciprofloxacin 500mg (IV or PO) x 10-14 days* *severe cases may require IV antibiotics 3. Supportive therapy with anti-emetics, antipyretics, and anti-inflammatories **Non-pharmacological Interventions**: 1. Bed rest 2. Scrotal elevation **Education and Follow-up:** 1. Complete full course of antibiotics. 2. Return to clinic if symptoms worsen or do not improve. 3. Educate on safe sex practices if symptoms coincide with STI. 4. Allow time for patient to express and address any concerns or fears.	**Pharmacological Interventions:** 1. None **Non-pharmacological Interventions**: *Newborns/Infants* 1. Usually self-resolve. No surgical intervention needed. *Children/Adults* 1. if mass transilluminates easily with no suspicion of mass or patient discomfort, no treatment necessary. *All Patients* 1. Continued observation for asymptomatic hydrocele. 2. If symptomatic with increasing discomfort or suspicion of mass, refer to urology for surgical consultation. 3. Provide reassurance. **Education and Follow-up:** *Infants* 1. Return to clinic is testicle continues to increase in size or infant is crying without resolution, which may suggest pain. *Children/Adults* 1. Return to clinic if testicle becomes painful or continues to increase in size.	**Pharmacological Interventions:** 1. Oncology referral to determine plan for chemotherapy and/or radiation therapy. 2. Supportive therapy for anxiety, depression or related stress, if clinically indicated. **Non-pharmacological Interventions** 1. Referral to urologist for surgical consultation. 2. Ongoing monitoring of tumor markers: hCG, AFP, LDH. **Education and Follow-up:** 1.Referral to counseling and testicular cancer support groups. 2. Discussion on future fertility risks associated with treatments; discuss sperm bank options before beginning treatment. 3. Follow-up for results of imaging then follow-up with urologist/oncologist for continued coordination in care. 4. Incorporate family/partner in education. 5. Allow time for patient and family to express and address any concerns or fears related to diagnosis.

Figure Student-developed decision tree. Used with permission from Megan Martin, Cristyl McClure, Thomas Milbourne, Claudia O'Brian, and Ashley Trivett.

resource, procedural, and technical issues associated with learning activities described in this study, many incorporating simulation, this NP program is now prepared to begin systematic, formal assessment of student learning outcomes associated with the learning modalities described in this study.

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