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Ultrasonography-First Imaging Algorithm for Acute Appendicitis Diagnosis

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ULTRASONOGRAPHY-FIRST IMAGING ALGORITHM FOR ACUTE APPENDICITIS DIAGNOSIS

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Abstract

Acute appendicitis (AA) is the most common cause of acute abdominal pain requiring surgery in pediatric, adult, and pregnant patients. Several etiologies are believed to trigger luminal obstruction, which causes mucus and bacteria proliferation, resulting in inflammation and wall tension with subsequent necrosis and rupture of the appendix. Most AA patients present with the primary complaint of abdominal pain, which Murphy first described the characteristic diagnostic sequence seen in approximately 50% of patients as colicky centralized abdominal pain with subsequent vomiting with the migration of pain to the right lower quadrant (RLQ), specifically, the right iliac fossa. The typical AA patient will complain of colicky, periumbilical pain, which has progressively worsened over the past 24 hours that has become persistently sharp in the RLQ. Diagnostic imaging is essential in diagnosing AA, and it is critical for medical providers to quickly and accurately diagnose AA to reduce perforated appendix and negative appendectomy rates. Yet, there is not a universally accepted, widely utilized diagnostic imaging protocol for suspected AA patients. Ultrasonography (USG) and computerized axial tomography (CAT) scans are used most in diagnosing AA in all ages. Current evidence-based practice (EBP) literature shows that USG should be the first-line imaging modality followed by CAT scan as the second line in diagnosing AA in children and adults, to reduce ionizing radiation and cost burdens. The purpose of this Doctor of Nursing Practice (DNP) project was to develop, implement, and evaluate an educational intervention and an evidence-based USG-first algorithm for medical providers who treat patients with suspected AA. Pre- and post-test assessment questions were used to evaluate the implementation of knowledge and the AA clinical practice change over a six-to-eight-week period. Descriptive statistics were used to analyze demographic data, tabulating frequencies, and percentages. Pre- and post-assessment scores were analyzed via

a paired *t*-test for matched samples. This project's results displayed a statistically significant change in provider knowledge and may have improved clinical practice and patient outcomes. This project's USG-first imaging algorithm for diagnosing acute appendicitis can likely be sustained in clinical nursing practice.

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Chapter I

Acute appendicitis (AA) is the most common cause of acute abdominal pain requiring surgical intervention in pediatric, adults, and pregnant women (Shogilev et al., 2014). It is believed to be the result of several etiologies causing luminal obstruction, which causes proliferation of mucus and bacteria, resulting in inflammation and wall tension and, subsequently, necrosis and rupture (Rosenkrantz et al., 2016). The primary presenting complaint of patients with AA is abdominal pain. Murphy first described the characteristic diagnostic sequence seen in approximately 50% of patients as colicky centralized abdominal pain with subsequent vomiting with the migration of pain to the right lower quadrant (RLQ), specifically, the right iliac fossa (Murphy, 1904). According to Eng et al. (2018), the AA patient will typically complain of colicky, periumbilical pain, which has progressively worsened over the past 24 hours that has become persistently sharp in the RLQ.

Moreover, it is essential for medical providers to quickly and accurately diagnose AA to decrease perforation and negative appendectomy rates (Eng et al., 2018; Fu et al., 2021) Ramashankar et al., 2019). Ultrasonography (USG) and computerized axial tomography (CAT) scan are the most used diagnostic imaging modalities for diagnosing AA in all ages (Ashkenazi et al., 2020; Parker et al., 2014). Diagnostic imaging is imperative in diagnosing AA (Eng et al., 2018). Current evidence-based practice (EBP) literature shows that USG should be the first-line imaging modality followed by CAT scan as the second line in diagnosing AA in children and adults (Ashkenazi et al., 2020; Shogilev et al., 2014).

Problem and Significance

AA is the most common cause for emergency abdominal surgical intervention, with a lifetime prevalence of approximately 8.5% in males and 6.5% in females nationally (Bliss et al.,

2015). According to Zigone et al. (2015), the most common non-obstetric emergency surgical intervention is AA. It has an incidence of 6.2 per 10,000 pregnancies in the antepartum timeframe (compared to 9.5 per 10,000 in nonpregnant patients) and approximately 10% postpartum (Zigone et al., 2015). In the United States, at least 300,000 appendectomies are performed annually, with about 10% resulted in negative appendectomy (Benito et al., 2015; Ramashankar et al., 2019).

Medical providers are currently challenged by clinical contradictions and controversies in diagnosing AA, such as using the CAT-scan first policies still being utilized in many medical facilities (Mathew-Fields et al., 2017; Teoule et al., 2020). When AA diagnosis is based on just clinical scoring and with non-specificity of laboratory results, providers are often faced with the problem of striking a balance between a possible negative appendectomy or perforation. Imaging plays a vital role in diagnosing AA and its complications and identifying alternative diagnoses (Eng et al., 2018). However, it is problematic that a diagnostic imaging algorithm for diagnosing AA has yet to be universally accepted, narrowing imaging needs while considering the pros and cons of diagnostic imaging modalities (Eng et al., 2018; Ramashankar et al., 2019). The most used imaging modalities for diagnosing AA are USG and CAT scan (Eng et al., 2018; Ramashankar et al., 2019).

The American College of Radiology (ACR) recommends USG as the first-line imaging modality in children and adults, it is inexpensive, and without any patient radiation exposure (Smith et al., 2015). However, it is sonographer-dependent, there may be difficulties viewing the appendix in obese patients (Lopes-Vendrami et al., 2020), and it may not be available 24 hours per day in some medical facilities (Eng et al., 2018). Studies have found that CAT scan should be used as the second-line imaging modality when initial USG results are equivocal (Jha et al.,

2019; Mathew-Fields et al., 2017). However, there are concerns with patient ionizing radiation exposure when CAT scans are performed, especially on pediatric and pregnant patients (Eng et al., 2018).

According to Eng et al. (2018) and Malkomes et al. (2021), medical provider utilization of CAT scan after equivocal USG results is the most cost-effective algorithm in diagnosing AA. It is efficacious in reducing perforated appendix and negative appendectomy rates (Eng et al., 2018; Malkomes et al., 2021). This DNP project will develop an EBP USG-first imaging algorithm for medical providers in diagnosing AA.

Purpose

The purpose of this Doctor of Nursing Practice (DNP) project is to develop, implement, and evaluate an educational intervention and an evidence-based USG-first algorithm for medical providers who treat patients with suspected AA.

Chapter II

Review of the Literature

This chapter discusses a substantial EBP literature review. Literature searches via multiple databases were conducted to find studies less than ten years old and some for historical data. Studies less than 10 years old were chosen because they are more up-to-date and reflect the latest diagnostic imaging best practices in diagnosing AA.

The databases Cochrane Database, Cumulative Index of Nursing and Allied Health Literature (CINAHL), MedLine, and PubMed were searched to scrutinize the use of USG as the first-line imaging modality in pediatric and adult patients, including pregnant women, with suspected AA. The searches were conducted using the following keywords: *acute appendicitis, ultrasonography, computed axial tomography, diagnostic algorithm.* Initially, the titles and abstracts of relevant studies were examined. Relevant studies were further reviewed via full-text articles. Searches were limited by the following required criteria: less than 10 years old, some older for historical data, peer-reviewed, systematic reviews, and English language. Numerous current EBP studies were found that provided supportive evidence for this clinical practice change proposal.

Acute Appendicitis

One of the most common causes of abdominal pain requiring emergency surgery in pediatric and adult patients is AA (Bliss et al., 2015). There are approximately 280,000 cases of AA reported annually in the United States, with a current incidence rate of 1 per 10,000 people, and those between 10 and 20 years of age having the highest incidence (Eng et al., 2018; Malkomes et al., 2021)**.** Approximately 89,000 pediatric patients are hospitalized annually versus about 189,000 adult patients requiring hospitalization for AA (Buckius et al., 2012; Malkomes et

al., 2021)**.** Annual AA-related management costs for pediatric and adult patients are roughly $900 million (Yu & Shah, 2017; Malkomes et al., 2021).

Ultrasonography

In 1986, Julien B. Puylaert initially introduced transabdominal compression ultrasonography usage in diagnosing AA (Puylaert, 1986). USG as the first-line imaging modality for suspected AA has several advantages. It is performed rapidly, inexpensive, and non-invasive (Eng et al., 2018; Malkomes et al., 2021)). There is no patient radiation exposure, sedation, or contrast media usage (Malkomes et al., 2021). However, USG is limited by ultrasonographer experience, unavailability during specific shifts at some medical facilities, patients in severe pain, and obese patients (Eng et al., 2018). Thus, medical providers commonly use USG in pediatric patients, non-obese adult patients, and child-bearing age women with suspected AA (Baruch et al., 2020; Benedetto et al., 2019; Conwell et al., 2020; Leite et al., 2005). According to Al-Khayal and Al-Omran (2007), a 25-study, 9100-patient systematic review found 96% specificity, 84% sensitivity, 92% accuracy, 90% positive predictive value (PPV), and a 94% negative predictive value (NPV) for USG in diagnosing AA. USG for suspected AA patients is currently performed worldwide by medical providers of all specialties and radiologists, and the USG-first policy should be widely recognized and implemented (Eng et al., 2018; Malkomes et al., 2021)**.**

Pediatric Patients. The ultrasound-first policy should always be utilized in pediatric patients with suspected AA (Eng et al., 2018; Conwell et al., 2020). It is recommended by the American College of Emergency Physicians (ACEP) that USG is used to confirm AA in pediatric patients (Howell et al., 2010). The ACR recommends that CAT scans should not be performed in pediatric patients with suspected AA until USG has been done (Rosenkrantz et al.,

2016). However, even in pediatric patients, the accuracy of USG varies from 48% to 96% specificity and 45% to 95% sensitivity, which may be related to ultrasonographer experience (Lee & Yun, 2019; Wong et al., 2008).

Adult Patients. There are currently no universally recognized, widely accepted clinical guidelines for USG-first that are specifically for adult patients with suspected AA (Rosenkrantz et al., 2016). Although medical providers currently commonly use CAT scans in adult patients with suspected AA, the ACR and other medical associations recommend USG as the first-line imaging modality in adults and pediatric patients (Smith et al., 2015; Jha et al., 2019).

Pregnant Patients. Diagnosing AA in pregnant patients is challenging for medical providers due to the anatomically displaced appendix (Baruch et al., 2020; Hiersch et al., 2014; Lopes-Vendrami et al., 2020). There may be severe maternal and fetal complications with delayed AA diagnosis during pregnancy (Baruch et al., 2020; Hiersch et al., 2014; Lopes-Vendrami et al., 2020). Williams & Shaw (2007) study concluded that USG performed during pregnancy for suspected AA had a specificity range of 84% to 97% and a sensitivity range of 68% to 100%. In a recent study comparing USG utilization in nonpregnant versus pregnant women, Segev et al. (2016) found a 92% PPV and a 95% PPV, respectively, and a 44% NPV and a 41% NPV, respectively. The results of this study suggested that USG use in pregnant and nonpregnant women with suspected AA is diagnostically accurate. USG is the initial imaging choice, followed by magnetic resonance imaging (MRI), which is not feasible in most emergent cases, as second-line imaging, followed by CAT scan (Baruch et al., 2020; Segev et al., 2016).

USG Reliability. Increased USG use within clinical practice and consistent, standardized reporting of findings are two components that may increase reliability. Fortea-Sanchis et al., (2020) and Mittal et al. (2013) studies concluded that sensitivity was higher in medical facilities

that increased USG utilization in suspected AA patients. It reported that medical facilities with 90% USG utilization yielded a 79% sensitivity compared to a 36% sensitivity in those facilities with less than 10% USG utilization. Additionally, Nielsen et al. (2015) and Unsdorfer et al., (2021) found that USG reporting template utilization increased USG sensitivity from 68% to 93%. According to Godwin et al. (2015) and Unsdorfer et al., (2021), standardized USG reporting may increase accuracy and allows for better communication between medical providers and radiologists.

Computed Axial Tomography

CAT scan is the most used imaging modality in patients with suspected AA (Ramashankar et al., 2019; Smith et al., 2015). Eng et al. (2018) and Malkomes et al. (2021) reported that concerns for patient radiation exposure have led to increased studies to minimize CAT scan radiation dose while accurately diagnosing AA and using an USG-first algorithm with CAT scan utilization in equivocal cases. Doria et al. (2006) meta-analysis concluded that CAT scan has higher sensitivity and lower specificity compared to USG in diagnosing AA. Additionally, a 9300-patient, 28-study meta-analysis reported a CAT scan negative appendectomy rate (NAR) of 8.7% (Krajevski et al., 2011). The commonly used clinical practice of indiscriminate CAT scan use for diagnosing AA has been decreasing due to concerns for long-term effects of patient radiation exposure, although CAT scan usage in the United States and many other countries is still unacceptably high (Eng et al., 2018; Malkomes et al., 2021). With USG being as accurate as CAT scan in pediatric patients and adult patients, as stated earlier, USG is the preferred initial imaging modality without the patient radiation exposure (Eng et al., 2018; Pedram et al., 2019).

Further, for a single abdominal CAT scan in a 5-year-old pediatric patient, Wan et al. (2009) found that the lifetime risks of ionized-radiation-induced malignancies in male patients and female patients would be 22 per 100 000 and 28 per 100 000, respectively. Using the algorithm of USG-first followed by CAT scan if USG is negative for AA would reduce the number of CAT scans by 54% in patients with suspected AA (Jha et al., 2019; Wan et al., 2009).

Diagnostic Algorithms

Diagnostic imaging algorithms for AA are becoming more popular and should be widely implemented to keep patient ionizing radiation exposure and costs low and decrease perforation rates and NAR (Eng et al., 2018; Jha et al., 2019; Malkomes et al., 2021). In emergency departments (EDs) and other medical facilities, CAT scans performed on suspected AA patients exposes them to significant amounts of ionizing radiation (Malkomes et al., 2021; Ramajaran et al., 2009). A six-year retrospective outcome analysis for suspected AA conducted by Ramajaran et al. (2009) reported that their pathway established USG as the first-line imaging modality, and CAT scan was recommended for equivocal USG results. The patients who were manage using the definite USG alone pathway yielded a NAR of 7% and a missed AA rate of less than 0.4%, and a negative USG (visualized normal appendix) was clinically sufficient to remove the need for a follow-up CAT scan (Malkomes et al., 2021; Ramajaran et al., 2009).

Implementation of diagnostic imaging algorithms and clinical pathways has been recommended by the Infectious Disease Society of America (IDSA) and the Surgical Infection Society of America (SISA) guidelines to standardize AA treatment (Yu & Shah, 2017). The USG-first followed by CAT scan algorithm should be developed, implemented, and evaluated by a multidisciplinary medical provider team involved in treating suspected AA patients (Malkomes et al., 2021; Solomkin et al., 2010).

Pediatric Patients. A recent study by Saucier et al. (2014) reported that by using the USG-first algorithm on all pediatric patients with suspected AA, safety and efficacy are not decreased, but patient ionizing radiation exposure is significantly decreased (Conwell et al., 2020). After utilization of the algorithm, CAT scan use dropped from 76% to 25%, with high diagnostic accuracy maintained, and it yielded 94% specificity and 99% sensitivity rates (Shah et al., 2016).

Adult Patients. The current EBP literature yielded a variety of algorithms for adult patients with suspected AA. Poletti et al. (2016) and Malkomes et al. (2021) examined the efficacy of a diagnostic algorithm that utilizes USG-first and low-dose CAT scan protocol. They reported 98% specificity and 99% sensitivity rates, 98% PPV, and 99% NPV, thereby reducing the need for ionizing radiation-associated burdens and exposure to the intravenous contrast media of CAT scans (Malkomes et al., 2021; Poletti et al., 2016).

Summary

In summarizing the literature review, AA is a commonly seen medical problem. However, perforated appendix and negative appendectomy may be common, despite clinical and imaging advances and current EBP literature availability. Medical providers' clinical evaluation of AA with history, physical examination, and laboratory results may currently play a role in typical patient presentations. However, there remains an increased risk of perforated appendix due to missed appendicitis or negative appendectomy. With the current, ever-increasing utilization of CAT scan as the first-line imaging modality for patients with suspected AA, the EBP literature found that USG is very efficacious in ruling out or diagnosing AA. The literature supports using USG as the first-line imaging modality for diagnosing AA in all ages, and a CAT

scan would be utilized best as a second-line imaging modality considering the associated radiation and cost burdens.

Needs Assessment

A needs assessment was performed to evaluate the overuse of CAT scans for patients with suspected AA and the lack of a universally accepted USG-first imaging algorithm for diagnosing AA. It was noted that currently, medical providers are increasingly utilizing CAT scans as their initial imaging modality for diagnosing AA, even with the associated patient ionizing radiation exposure and patient cost burdens. However, the current EBP literature showed that USG should be utilized as the first-line imaging modality for all patients, especially for pediatric patients and pregnant women, followed by a CAT scan for equivocal USG findings. The optimal clinical practice is where medical providers treating suspected AA patients use USG as the initial imaging modality, followed by a CAT scan for equivocal findings. The difference between this best clinical practice and the current CAT scan-first practice is what was addressed. Medical providers must be willing to utilize a safe, accurate, and cost-effective USG-first algorithm in suspected AA patients to avoid unnecessary patient ionizing-radiation exposure and increased costs.

Further, the current question was whether some medical providers were willing to implement a change to their current imaging modality choices in suspected AA patients. An USG-first algorithm will safely and accurately diagnose AA, reduce radiation, and cost burdens. It was proposed that, ultimately, most patients can be diagnosed with AA without a CAT scan. The routine use of CAT scans in suspected AA patients was discouraged.

Chapter III

This chapter discusses the theoretical underpinnings for this DNP project.

Theoretical Underpinnings

The conceptual framework utilized for this DNP project was The Stetler Model of Evidence-Based Practice. Preparation, validation, decision making, application, and evaluation make up the five progressive steps of deliberation and action of this model (Melnyk & Fineout-Overholt, 2019). Initially published in 1976 as the Stetler-Marram Model for Research Utilization (RU) to fill the void of research results being realistically implemented into clinical practice (Stetletler & Marram, 1976). Based on the 1994 refinement of a practitioner-oriented approach, the model was called the Stetler Model (Stetler, 2001).

The Stetler Model was further refined in 2001 by incorporating additional internal and external sources of evidence that may ultimately influence implementation decisions (Stetler, 2001). According to Stetler (2001), internal evidential sources are quality improvement verified data, evaluation or operational projects, expert consensus, and clinical experience affirmation, while external evidential sources are research findings but also include expert consensus. Utilization of research findings and critical thinking remain at the center of this model (Melnyk & Fineout-Overholt, 2019), thus it is referred to as a practitioner-oriented model.

The Stetler Model is divided into five progressive steps. In the first step, referred to as "preparation," a priority need is defined and affirmed, the context in which utilization would occur is reviewed, work is organized, and a systematic search for relevant evidence, particularly research, is initiated (Melnyk & Fineout-Overholt, 2019). The defined priority need for this project is not having a universally accepted, widely utilized, USG-first imaging modality algorithm for diagnosing AA in patients of any age. This algorithm will be utilized by medical

providers who treat patients with suspected AA. Work will be organized by DNP student and DNP chair (DNP committee) for this project. A relevant, systematic EBP literature search will be conducted, particularly clinical research.

"Validation" is the second step, which involves a body of evidence assessment via a systematic critique of individual relevant studies and other documents, with a focus on utilization, then selecting and summarizing the collected evidence that is relevant to the priority need (Melnyk & Fineout-Overholt, 2019). In this DNP project, a critical appraisal conducted of the relevant and supportive EBP literature pertaining to the utilization and advantages of an USG-first strategy by medical providers in treating suspected AA patients. Keeper studies that are supportive of USG as the first-line imaging modality for diagnosing AA will be selected and summarized.

In the third step, "decision making," a decision is made about utilization after synthesizing the body of EBP evidence (Melnyk & Fineout-Overholt, 2019). The evidence supports the purpose of this project for clinical practice change to an USG-first AA algorithm. Thus, this evidence will be used to support a clinical EBP change.

The fourth step, "application," involves converting EBP literature findings into the needed change to be implemented; application plan, particularly for group utilization, implementing plan via operational details of how to utilize the accepted evidence, and then enhancing implementation with an EBP change plan; and incorporating evidential findings into one's individual clinical practice (Melnyk & Fineout-Overholt, 2019). This project will utilize the supportive EBP findings to implement a clinical practice change for an USG-first algorithm for suspected AA patients. This project will be focused on clinical practice change of medical providers by utilizing the details of how to utilize the supportive evidential findings, and then

actual implementation will be enhanced by the EBP USG-first imaging algorithm change plan, which will decrease ionizing radiation exposure and costs and decrease perforation and negative appendectomy rates. There will be no sacrifice of safety and efficacy with this policy change. The ideal goal is for medical providers to change practice to an USG-first policy in treating suspected AA patients of all ages.

"Evaluation" is the final step of the Stetler Model which involves evaluating the degree of success of the implementation plan and actions and whether the goal for utilizing the EBP literature findings was achieved (Melnyk & Fineout-Overholt, 2019). This project will utilize pretests and posttests scores and questionnaires to evaluate the degree of success of medical provider practice change to utilize a USG-first policy for treating suspected AA.

The Stetler Model will guide the clinical practice change needed to implement this DNP project successfully. The model's five progressive steps are preparation, validation, decision making, application, and evaluation. The EBP literature findings will be used to substantiate the decision to implement an USG-first imaging algorithm for medical providers who treat patients with suspected AA, which is the purpose of this project. Optimally, this clinical practice change will decrease patient ionizing radiation and cost burdens without sacrificing safety and efficacy after implementation, thus reducing the perforation and negative appendectomy rates.

Chapter IV

This chapter describes the project and evaluation of this project. The purpose of this DNP project was to develop, implement, and evaluate an educational video and an evidence-based USG-first algorithm for medical providers who treat patients with suspected AA. The setting, design, population of interest, measures, instruments and activities, timeline, project tasks and personnel, resources and supports, risks and threats, and the International Review Board (IRB) approval request were discussed. Additionally, the evaluation for this project is presented.

Project Plan

Setting and Design

The settings consisted of urgent care centers, emergency departments, family medicine clinics, pediatric clinics, and other acute care facilities. Virtual clinical settings were excluded from this DNP project. A pre-post comparative design was utilized for this project.

Population of Interest

The targeted groups for this project were nurse practitioners (NPs), other advanced practice registered nurses (APRNs), medical doctors (MDs), doctors of osteopathic medicine (DOs), and other medical providers. The final sample was one of convenience and came from the accessible population which included those providers that could be reached via the email lists of the Nevada Nurses Association and the Emergency Nurses Association; individual networking among colleagues was also a recruitment strategy for this project. The inclusion criteria for the medical providers included:

- must have treated and currently treat patients of any age with suspected acute appendicitis (AA)
- must be the decision-maker in choosing the imaging modality for suspected AA

- No provider will be excluded from this DNP project based on age, race, sex, religion, or creed

Medical providers who do not treat or have never treated patients with suspected acute appendicitis were excluded from this DNP project.

Project Tasks

The project tasks consisted of:

- Institutional Review Board (IRB) approval (see Appendix)
- identified included and excluded medical providers
- developed an educational video and an AA USG-first imaging algorithm for medical providers
- implementation of the project to medical provider participants

Data analysis utilizing descriptive statistics and a paired *t*-test

Team

This project's team was made up of the DNP student, the Graduate Advisory committee Chair and Committee Members.

Procedures

Following informed consent, email invitations were sent out to the targeted, accessible population of medical providers. The medical providers who met the inclusion criteria and completed all pre- and post-assessments were included in the final sample. The goal was to have at least 30 - 50 participants. The data collected consisted of the following:

- level, age, sex, race, years of practice, board certification(s) and specialty areas(s) of providers
- ages of patients allowed to treat

- current or past treatment of abdominal pain patients
- current or past treatment of patients with suspected acute appendicitis
- imaging modality choices for diagnosing suspected acute appendicitis

An USG-first diagnostic imaging algorithm for treating patients with suspected AA was developed from the current EBP literature and an educational video was recorded for viewing online. Pretests and posttests were previously discussed in the Instruments and Outcomes section. The EBP educational literature was distributed via written materials and by recorded video to encourage the implementation of clinical practice change.

Timeline

The project's implementation took place over an eight-week period at the end of the fall 2021 and beginning of the spring 2022 semester. Data were analyzed over a two-to-three-week period, and the completion of the final project paper and PowerPoint presentation were prepared for final defense; these last timeline items took approximately six to eight weeks to complete. The final oral defense took place in March of 2022.

Instruments and Outcomes

Pre- and post-test assessment questions were used to evaluate the implementation of knowledge and the AA clinical practice change. The pre-tests were administered to medical providers, and after a period, the EBP literature educational intervention occurred, followed by the post-test assessment. The test questions measured the medical provider's AA treatment knowledge, current diagnostic imaging clinical practice for diagnosing AA, and willingness to implement a practice change based on the current EBP literature.

Resource Utilization

The questionnaires, pretests, and posttests were sent via email to local and national medical providers' accounts at urgent centers, EDs, and other medical facilities to garner maximum participation.

Data Analysis

Descriptive statistics were used to analyze demographic data, tabulating frequencies and percentages. Pre- and post-assessment scores were analyzed via a paired *t*-test for matched samples.

Key Stakeholders

The key stakeholders for this project were the DNP student, the Graduate Advisory Chair and Committee Members, participating medical providers and their employers, the health care team members, and patients.

Organizational Assessment

The organizational assessment was conducted on a multi-center urgent care corporation in Las Vegas, Nevada. Organizational assessments were also conducted on area EDs and urgent care centers. Thus, this additional medical provider participation in this project was seen from other urgent care centers, EDs, and medical facilities that treat patients with suspected AA. Healthcare facilities, medical providers, healthcare team members, insurance companies, and patients benefitted from this DNP project's success.

Risks and Threats

Risks and threats to this project included, lack of participation through completion of all project components, providers who were resistant to practice change, and health care facilities unwilling to participate in clinical practice change.

Chapter V

Results

This chapter presents the results of this DNP project. Data from the sample, project variables, and the evaluation of the project are presented. Also included are data on knowledge of acute appendicitis clinical practice, and current evidence-based practice of acute appendicitis.

Sample: Demographics and Primary Practice Area

Table 1 shows the demographic specifics of the participating medical providers who completed all requirements of this DNP project describing race, gender, provider level, and primary area of practice. A total of 35 medical providers responded to the project's email invitations, eight did not complete all project components. Twenty-seven participants completed all the project's components and comprised the final sample ($N = 27$). Most of the participants were White, males outnumbered females, and nurse practitioners outnumbered all participating providers.

Table 1

Sample: Demographics and Primary Practice Area

	Total (N = 27)	Percent
Race/ethnicity		
Asian or Asian American	6	22.2%
American Black or African American	6	22.2%
Hispanic or Latino(a)	4	14.8%
White or Caucasian	11	40.7%
Gender		
Female	11	40.7%
Male	16	59.3%
Provider Level		
APRN	13	48.1%
MD/DO	6	22.2%
PA	7	25.9%
RN	1	3.7%
Primary Area of Practice		
Emergency Department	2	7.4%
Family/Urgent Care	2	7.4%
Primary Care/Family Practice	4	14.8%
Primary Care/Urgent Care	2	7.4%
Specialty Care	1	3.7%
Urgent Care	9	33.3%
Urgent Care/Emergency Department	5	18.5%
Urgent Care/Family	2	7.4%

Note. APRN = advanced practice registered nurse; MD = medical doctor; DO = doctor of osteopathic medicine; N = total number of participants; PA = physician assistant; RN = registered nurse

Acute Appendicitis Clinical Practice

Table 2 displays the frequency of patients treated for abdominal pain in the provider's clinical practice, with the CAT scan being the first-line imaging choice of most providers. All participating providers in this DNP project reported no current acute appendicitis ultrasound-first policy or algorithm at their healthcare facilities, but a majority would use the policy if implemented.

Table 2

Acute Appendicitis Clinical Practice

	Total (N = 27)	Percentage
Treat Abdominal Pain		
Daily	23	85.2%
I only refer abdominal patients to the emergency department	1	3.7%
Monthly	2	7.4%
Weekly	1	3.7%
Treated Suspected Acute Appendicitis		
Yes	27	100%
Initial Diagnostic Imaging Choice for Suspected AA		
CAT Scan	25	92.6%
Ultrasonography	2	7.4%
Ultrasonography-First AA Policy at Your Healthcare Facility		
No	27	100%
If yes, would you use it?		
I do not know	5	18.5%
I may possibly use based on circumstances	1	3.7%
Yes	20	74.1%
Yes, unless it delayed AA diagnosis	1	3.7%

Note. AA = acute appendicitis; CAT Scan = computerized axial tomography; N = total number of participants

Sample: Current Evidence-Based Practice Acute Appendicitis Knowledge

Table 3 shows this DNP project's participating providers' knowledge of current evidence-based practice recommendation of ultrasonography as the first-line imaging modality to diagnose acute appendicitis. Most providers were unaware of the clinical practice recommendation.

Table 3

Sample: Current Evidence-Based Practice Acute Appendicitis Knowledge

	Total (N = 27)	Percentage
Aware of ACR AA USG Recommendations		
No	18	66.7%
Yes	6	22.2%
Yes, but I do not agree with it, nor do I follow it	3	11.1%
Aware of Current EBP Literature for USG as First-Line Imaging Modality		
No	16	59.3%
Yes	8	29.6
Yes, but I do not agree, nor do I follow it	3	11.1%

Note. AA = acute appendicitis; ACR = American College of Radiology; EBP = evidence-based practice; *N* = total number of participants; USG = ultrasonography

Evaluation of the Project

Table 4 shows the participating providers' evaluations of this project's education written and video materials. A large majority of the providers agreed or strongly agreed that the education material clarified the acute appendicitis content, and their learning objectives were met.

Table 4

Evaluation of the Project

	Total (N = 27)	Percentage
Were the Presentation Objectives Clear?		
Did not answer	1	3.7%
Agree	1	3.7%
Strongly agree	25	92.6%
My Personal Learning Objectives Were Met		
Did not answer	1	3.7%
Agree	1	3.7%
Strongly agree	25	92.6%
Appropriate Content for Intended Audience		
Did not answer	1	3.7%
Agree	1	3.7%
Strongly agree	25	92.6%
Visual Aids, Handouts, and Oral Presentations Clarified the Content		
Did not answer	1	3.7%
Agree	1	3.7%
Strongly agree	25	92.6%
Teaching Methods were Appropriate for Subject Matter		
Did not answer	1	3.7%
Agree	1	3.7%
Strongly agree	25	92.6%

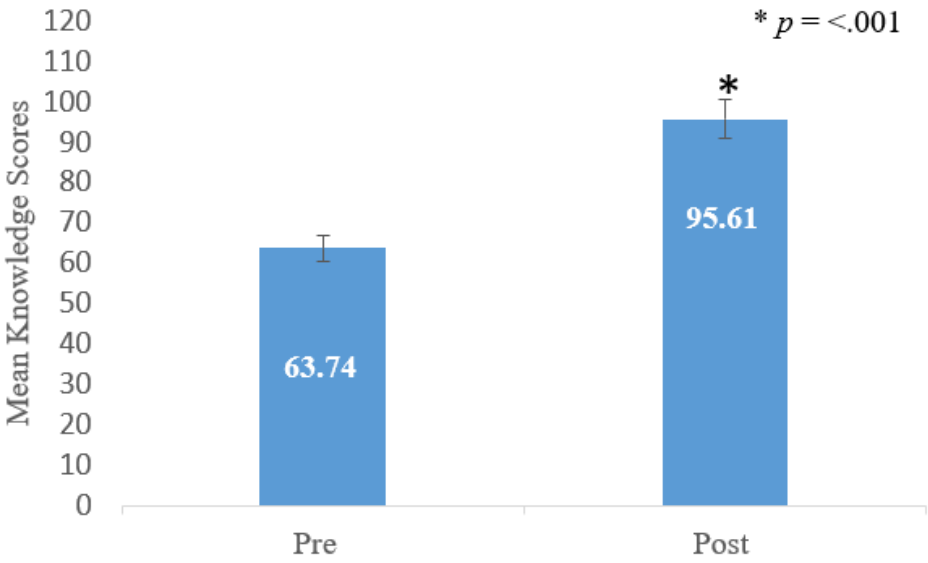
	Total (N = 27)	Percentage
The Speaker, Steven L. Moore, was Knowledgeable in the Content Area		
Did not answer	1	3.7%
Agree	1	3.7%
Strongly agree	25	92.6%

Pre- and Post-test Knowledge Scores

There was a significant change noted in the pre- and post-knowledge assessment scores (Figure 1).

Figure 1

Providers' Pre and Post Knowledge Scores

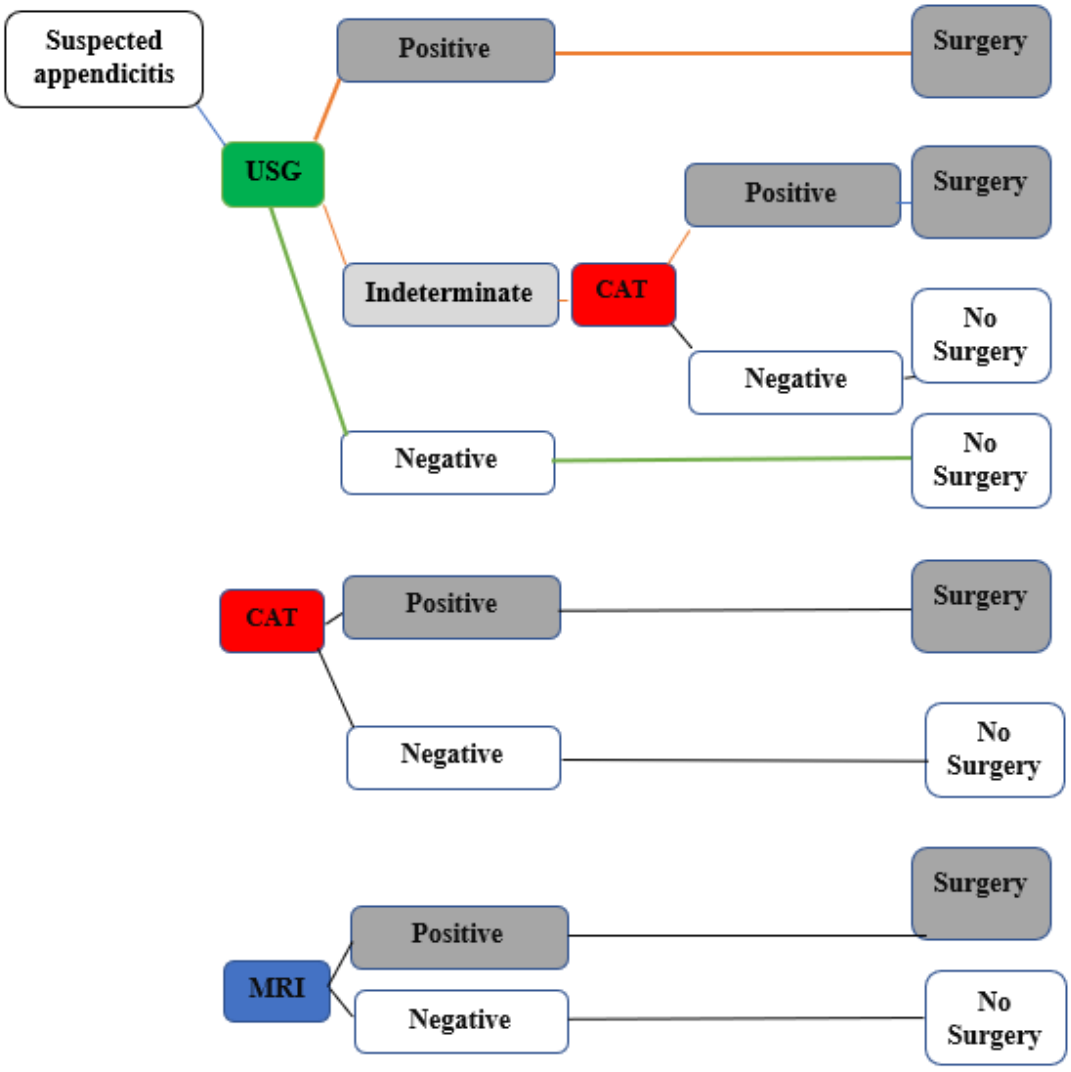


Ultrasound-First Imaging Algorithm for Diagnosing Acute Appendicitis

Figure 2 represents the current evidence-based clinical practice imaging algorithm for diagnosing acute appendicitis for medical providers who treat patients with suspected acute appendicitis. This algorithm can be used for patients of all ages.

Figure 2

Ultrasound-First Acute Appendicitis Algorithm



Notes: USG = ultrasonography/ultrasound; CAT = computerized axial tomography scan; MRI = magnetic resonance imaging scan

Chapter VI

Discussion

This chapter discusses this project's results, whether it did or did not address or remediate the identified AA diagnostic imaging clinical practice problem, the relationship of this project's results to the review of the literature, and the project's underlying theory, how the project improved medical providers' AA knowledge, and clinical practice and perhaps patient outcomes, USG-first imaging algorithm implementation sustainability potential, and the utilization and dissemination of this project's findings.

As noted in the previous chapter, this project provided a good cross-section of the participating medical providers' population across various racial, provider levels, and medical specialties, which produced a broader assessment of the medical providers' AA knowledge and diagnostic imaging treatment strategies. Furthermore, twenty-three (85.2%) of the providers treated abdominal pain patients daily in their current clinical practices, with just two (7.4%) who only treated abdominal pain patients monthly and one (3.7%) on a weekly basis. Just one (3.7%) only referred abdominal patients to the emergency department. Twenty-seven (100%) have treated patients with suspected AA in the past, which made assessing their knowledge and clinical practice significant. This project's results highlighted that 25 (92.6%) of the medical providers selected CAT scan as the initial diagnostic imaging choice for diagnosing AA, which is not supported by the current evidence-based practice literature. However, just two (7.4%) medical providers chose USG as the initial diagnostic imaging modality for diagnosing AA. Twenty-seven (100%) of the participating providers did not have an USG-first acute appendicitis algorithm at their healthcare facilities, and 22 (81.5%) may use it if implemented, with five (18.5%) being unsure. Finally, this DNP project's findings provided an assessment of the

providers' current AA knowledge and clinical practice, which can be used to improve future clinical practice and patient outcomes.

Project Did or Did Not Address Medical Providers' Acute Appendicitis Knowledge

This DNP project addressed the participating medical providers' AA knowledge via questionnaires, pretests, and posttests. Most of the providers, 18 or 66.7%, were unaware of the American College of Radiology's current recommendations that USG should be the first-line imaging modality for diagnosing AA in all ages (Howell et al., 2010), with six (22.2%) being aware. Three providers (11.1%) were aware but did not agree with nor follow the ACR's recommendations. There was a slight improvement in percentages pertaining to the awareness of the current evidence-based practice literature that states USG should be the first-line imaging modality choice for diagnosing AA in all ages.

Moreover, the pre-test knowledge results indicated a need for more provider AA diagnostic imaging education, in which this project's written and video education material provided, as evidenced by the significant increase in the posttest knowledge scores. The results showed a significant ($p < 0.001$) difference between the medical providers' mean pretest and posttest knowledge scores, 63.74% and 95.61%, respectively. Thus, this DNP project significantly remediated the medical providers' AA knowledge deficit. Twenty-six (96.3%) of the participating medical providers agreed and strongly agreed, via completing the evaluation of the written and video presentation education materials, that their personal learning objectives were met, and the visual aids, handouts, and oral presentation clarified the AA content. One (3.7%) provider abstained from completing the written and video presentation education materials evaluation. Lastly, the USG-first imaging modality algorithm for medical providers was created based solely on the current evidence-based practice literature discovered during the

database searches for this DNP project and will increase provider knowledge and improve patient outcomes.

Relationship of Project Results and the Review of Literature

This project's results showed that 11 (40.7%) providers were aware of the current evidence-based practice literature that stated that USG should be the first-line imaging modality choice for diagnosing AA in all ages, with 16 (59.3%) providers being unaware of the literature. However, twenty-five (92.6%) of the participating providers currently utilize the CAT scan-first approach in their daily clinical practice in patients with suspected AA, which leaves just two (7.4%) providers utilizing the evidence-based practice literature to guide their AA clinical practice. There was a 33.3% discrepancy between the percentage of providers aware of the evidence-based practice literature and the providers who utilized the USG-first approach. This discrepancy shows the significance of the purpose of this project to develop, implement, and evaluate an evidence-based USG-first algorithm for medical providers who treat patients with suspected AA. Reasons for the discrepancy may include but are not limited to ultrasonography availability at the facility, providers' choice, lack of current evidence-based practice knowledge, and the lack of medical facility's diagnostic imaging algorithm or protocols.

USG utilization for diagnosing AA is currently performed worldwide by medical providers of all specialties and radiologists, and the USG-first policy should be widely recognized and implemented (Eng et al., 2018; Malkomes et al., 2021)**.** The dissemination of this project's results, EBP education materials, and the USG-first algorithm may assist in implementing an AA clinical practice change.

Implication for Clinical Practice and Patient Outcomes

This project may have improved clinical practice and patient outcomes in several ways. First, disseminating an EBP AA algorithm to medical providers who treat patients with suspected AA increased knowledge and enhanced clinical practice, which may lead to improved patient outcomes. Second, widespread healthcare systems clinical practice protocol changes may potentially occur from this project's educational materials and improve healthcare organizational training and education. Third, the utilization of this algorithm prevented patient ionizing radiation exposure, patient high costs burdens, and iodine contrast risks from unnecessary CAT scan usage. Finally, USG can garner widespread medical provider and healthcare facility recognition, acceptance, and utilization as the first-line imaging modality for diagnosing AA with aggressive dissemination of this project's results.

Ultrasonography-First Algorithm Implementation Sustainability Potential

This project's USG-first imaging algorithm for diagnosing acute appendicitis can likely be sustained in clinical practice. First, it is simple to perform, non-ionizing radiating procedure, non-invasive, and its easy readiness makes it an efficacious first-line diagnostic imaging modality for diagnosing patients with suspected AA. Second, ultrasonography is the most cost-effect first-line diagnostic imaging method for diagnosing AA in patients of all ages. Lastly, and most importantly, USG has shown significant accuracy in diagnosing patients with AA.

Utilization and Dissemination of DNP Project's Results

By following the current AA diagnostic imaging EBP recommendation guidelines, which reduce negative appendectomy and ruptured appendix rates, medical providers who treat patients with suspected AA significantly decreases patient ionizing radiation exposure, high-cost burdens,

and iodine contrast risks from unnecessary CAT scan usage (Fu et al., 2021). AA provider education is essential for safe, high-quality, and cost-effective AA treatment plan and improving clinical practice and patient outcomes (Jennings et al., 2020).

Future Scholarly Activity Resulting from this Project

The future scholarly activity resulting from this project may involve evaluating the accuracy of medical providers performing point of care USG (POCUS) in diagnosing AA in emergency departments and other outpatient healthcare facilities. Another future scholarly activity that may result from this project is to facilitate high-quality and timely dissemination of the essential EBP DNP project data.

Plan for Dissemination of Results

Dissemination of this DNP project's results may improve the AA knowledge of medical providers who treat abdominal pain patients via the EBP education materials to improve clinical practice and patient outcomes. It is the intention of this author to disseminate this projects data and results, to medical providers and nurses who treat abdominal patients, via algorithm cards, EBP posters, PowerPoint presentations, in-service presentations, pamphlets, and other education materials as needed. The results will also be disseminated via annual computer-based training (CBT) competencies to sustain and supplement AA knowledge to medical providers who treat abdominal pain patients in urgent care centers, family/primary care clinics, other out-patient clinics, and emergency departments. The dissemination of this DNP project's results to medical providers will be continuous and as needed. In collaboration with medical providers who treat abdominal pain patients at affiliated and non-affiliated clinics, hospitals, and emergency departments, AA-focused education strategies will be discussed in the quarterly provider

meetings to reduce the misdiagnosed, negative appendectomy, and ruptured appendix rates. Finally, further dissemination will be sought via potential publication of this project's findings and conducting presentations at professional organizations' conferences.

Limitations

The limitations of this DNP project include the small sample size of the participating medical providers ($N = 27$), the online pre-posttest assessments format, and the unknown availability of USG (24 hours or on-call ultrasonographer) at the providers' healthcare facilities. Another limitation of this project is the potential inherent bias or preference for USG over CAT scan or vice versa. Further research is needed on the effects of ultrasonographer skill-level on diagnostic accuracy and ruptured appendix and negative appendectomy rates. Also, more research needs to be conducted on the accuracy of provider-performed bedside USG for diagnosing AA.

Conclusion

Acute appendicitis (AA) is a common abdominal pain emergency requiring surgical intervention with a lifetime prevalence of approximately 8% and is recognized as a challenging diagnosis by medical providers. Conclusive AA diagnosis has continually been challenging to medical providers because of its non-specific signs, symptoms, and laboratory results, which can be confused with other abdominal pain pathologies. An accurate diagnosis is crucial to prevent complications from surgical intervention delay, such as ruptured appendix. CAT scan and USG are the most used imaging modalities for diagnosing AA.

The findings of this DNP project showed a high percentage of medical providers had an AA knowledge deficit and currently prefer using the CAT scan as the first-line imaging modality

for diagnosing AA. The current evidence-based practice literature states that USG has excellent AA specificity and positive predictive value in patients of all ages and should be the first-line imaging modality for diagnosing AA. CAT scan should have a limited role only after utilizing USG in suspected AA patients, based on available healthcare facility resources. CAT scan has specific limitations, including ionizing radiation exposure, iodine contrast administration risk, resource utilization increase, high cost, and future cancer development risk.

The current EBP literature showed that the most feasible and cost-effective approach would be USG as the first-line imaging modality, followed by a CAT scan or an MRI (for pregnant or pediatric patients) if USG is equivocal. Ultimately, most patients can be diagnosed with AA without initial CAT scan utilization, which is the primary purpose of this project. This approach can be accomplished by individual healthcare institutions implementing an USG-first AA diagnostic imaging algorithm for medical providers, as created during this project, eliminating the CAT scan limitations and decreasing the negative appendectomy and rupture appendix rates.

Appendix

Institutional Review Board Exempt Status Approval Letter

UNLV Biomedical IRB - Exempt Review
Exempt Notice

DATE:	August 4, 2021
TO:	Mary Bondmass, PhD
FROM:	Office of Research Integrity - Human Subjects
PROTOCOL TITLE:	[1752033-1] Ultrasonography-First Imaging Algorithm for Acute Appendicitis Diagnosis
ACTION:	DETERMINATION OF EXEMPT STATUS
EXEMPT DATE:	August 4, 2021
REVIEW CATEGORY:	Exemption category # 2i

Thank you for your submission of New Project materials for this protocol. This memorandum is notification that the protocol referenced above has been reviewed as indicated in Federal regulatory statutes 45CFR46.101(b) and deemed exempt.

We will retain a copy of this correspondence with our records.

PLEASE NOTE:
Upon final determination of exempt status, the research team is responsible for conducting the research as stated in the exempt application reviewed by the ORI - HS and/or the IRB which shall include using the most recently submitted Informed Consent/Assent Forms (Information Sheet) and recruitment materials.

If your project involves paying research participants, it is recommended to contact the ORI Program Coordinator at (702) 895-2794 to ensure compliance with the Policy for Incentives for Human Research Subjects.

Any changes to the application may cause this protocol to require a different level of IRB review. Should any changes need to be made, please submit a **Modification Form**. When the above-referenced protocol has been completed, please submit a **Continuing Review/Progress Completion report** to notify ORI - HS of its closure.

If you have questions, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 702-895-2794. Please include your protocol title and IRBNet ID in all correspondence.

Office of Research Integrity - Human Subjects
4505 Maryland Parkway . Box 451047 . Las Vegas, Nevada 89154-1047
(702) 895-2794 . FAX: (702) 895-0805 . IRB@unlv.edu

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Curriculum Vitae

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Licenses

- Nevada: Advanced Practice Registered Nurse (APRN) – Certified Nurse Practitioner (CNP); Expiration 6/28/2022
- Nevada: RN; Expiration 6/28/2022
- U.S. Drug Enforcement Agency (DEA); Expiration 1/31/2025
- Nevada State Board of Pharmacy (BOP) – Controlled Substance; Expiration 10/31/2022

Certifications

American Academy of Nurse Practitioners Certification Board (AANP-CB)

- **Emergency Nurse Practitioner Certification (ENP-C):**
  E01180006; Expiration 1/2/2023
- **Family Nurse Practitioner Certification (FNP-C):**

F07171590; Expiration 7/24/2022

Advanced Trauma Life Support **(ATLS)**

- ATLS ID: 3636881; Expiration 9/18/2025

Board Certified Emergency Nurse **(BCEN)**; 8/31/2023

Advanced Cardiac Life Support **(ACLS);** Expiration 1/2024

Pediatric Advanced Life Support **(PALS);** Expiration 2/2024

Basic Life Support **(BLS);** Expiration 2/2024

Skills Highlights

- Over four years ENP / FNP experience, 19 years ED RN experience (levels I, II, III trauma centers)
- Critical thinker, ability to handle pressure
- Strong interpersonal skills
- Ability to quickly identify and assess patient's clinical condition and treatment planning
- ECG interpretation
- Laceration repair- 34+ years' experience
- I&D of abscesses
- X-ray interpretation
- Pelvic exams
- Laboratory results interpretation

Professional Experience

11/2018 to Present Emergency medicine nurse practitioner

CareNow Urgent Care - Sole provider (17 clinics across the Las Vegas Valley) at very busy CareNow Urgent Care clinics throughout the Las Vegas Valley -- Las Vegas, Henderson, and North Las Vegas.

As healthcare provider:

- Provide acute and non-acute care to patients of all ages at very busy urgent care clinics with an average of 55 to 65 (on occasions 80 plus) patients seen per 13-hour shift.
- Differential diagnoses developed via taking thorough history and physical exams and the ordering of ECG, laboratory studies, and x-rays
- Carefully analyze information obtained during examinations and test results to accurately diagnose diseases and illnesses
- Quickly recognize, assess, and respond to medical emergencies.

- Often refer acutely ill and emergent patients to area emergency departments for further evaluation and higher level of care
- Always strictly protect the confidentiality of patients, families, team members, and any sensitive information

Registered Nurse Emergency Department (Levels I – III Trauma Centers); Staff RN / Relief Charge RN / Head Triage RN:

- ensure the provision of quality emergency medical care to patients requiring emergency treatment in accordance with physician orders, hospital policy, and standard nursing practice
- perform patient assessment and nursing diagnosis
- manage the planning and implementation of interventions.

***All RN experience obtained in emergency department settings (ED RN).**

8/2014 – 5/2017	Fulltime Graduate Student
	Loyola University Chicago – Family/Emergency Nurse Practitioner; Chicago, Illinois
9/2013 – 5/2014	*(ED RN)* - Sentara Careplex; Hampton, Virginia
8/2011 – 6/2013	*(ED RN)* - West Suffolk Hospital Accident & Emergency Department; Bury Saint Edmunds, England
	Addenbrooke's Hospital Accident & Emergency Department; Cambridge, England
9/2009 – 6/2011	*(ED RN)* - Memorial University Medical Center Emergency Department; Savannah, Georgia
5/2005 – 6/2009	*(ED RN)* - Sunrise Hospital and Medical Center Emergency Department; Las Vegas, Nevada
	Valley Hospital; Las Vegas, NV
	Mountain View Hospital Emergency Department; Las Vegas, NV
5/2002 - 4/2005	*(ED RN)* - University of Cincinnati Medical Center Emergency Department; Cincinnati, Ohio
	Good Samaritan Hospital Emergency Department; Dayton, OH
	Riverside Hospital Emergency Department; Columbus, OH

Mercy Hospital Emergency Department; Springfield, OH

12/1999 – 5/2002 *(ED RN)* - Addenbrooke's Hospital Accident & Emergency Department; Cambridge, England

8/1995 – 6/1999 *(ED RN)* - South Georgia Medical Center Emergency Department; Valdosta, Georgia

Colquitt Regional Medical Center Emergency Department; Moultrie, GA

Professional Organizations

- **3/2022 – present –** The Honor Society of Phi Kappa Phi
- **9/2021 – present** - Zeta Kappa-at-Large Chapter of Sigma Theta Tau International Honor Society of Nursing (Sigma) – UNLV member at-large
- **12/2021 – present** - Western Regional Advanced Practice Nurses Network - ENP Network - member
- **2021 – present** - The Society for Collegiate Leadership and Achievement - member
- **2017 – present** - American Academy of Emergency Nurse Practitioners – (AAENP) – member
- **2015 – present** - Sigma Theta Tau (STT) International Honor Society of Nursing – Alpha Beta Chapter: **Loyola University Chicago** – past member
- **1995 – present** - Emergency Nurses Association – ENA - member

Leadership Experience

- **2018 – present –** Primary/ sole medical provider – high patient volume urgent care centers – Las Vegas, NV – direct all medical care of all patients in clinic during shift
- **2017** - Suturing assistant during suturing course – Loyola University Chicago
- **2009 – 2011** - Head triage/ trauma/cardiac nurse - emergency department/trauma center – Memorial Health University Medical Center

Awards

- **2012** - Putting You First Award - Addenbrooke's Hospital NHS Accident & Emergency Department – Cambridge, England

Presentations

- **5/2017** – Loyola University Chicago Day of Scholarship Podium Presentation: Emergency Department Treatment of Patient Initial Deep Vein Thrombosis Diagnosis

- **4/2017** – Osgood-Schlatter Poster Presentation - Emergency Nurses Association (ENA) Conference in Chicago, Illinois

- **2/2016** – Asthma/Inhaler-Usage Podium Inservice / Presentation at Yacktman Pediatrics - Chicago, Illinois

Community Service

- **2003 – Present** – Numerous community-service volunteer activities as a member of Kappa Alpha Psi Fraternity, Incorporated.

    - Annual thanksgiving turkey dinner deliveries to selected low-socioeconomic families
    - Annual Christmas "take-a-child-shopping" activities for selected low-socioeconomic children
    - Monthly (1st Monday) assisting with serving food to the homeless at homeless shelter
    - Volunteer annually (or as needed when available) at community health fair(s)