DEVELOPMENT OF AN ALGORITHM FOR GOAL-DIRECTED FLUID THERAPY IN COLORECTAL SURGERY

by

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As members of the DNP Project Committee, we certify that we have read the DNP project prepared by Jon D. Bingham, titled Development of an Algorithm for Goal-Directed Fluid Therapy in Colorectal Surgery and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

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Final approval and acceptance of this DNP project is contingent upon the candidate's submission of the final copies of the DNP project to the Graduate College.

I hereby certify that I have read this DNP project prepared under my direction and recommend that it be accepted as fulfilling the DNP project requirement.

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DEDICATION

I dedicate this project to my wife, Marissa, and our daughter Grace. Their support and acceptance will provide our future with hope and career stability. I pray that my success and grit transfer over to Grace's persona.

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ABSTRACT

Many anesthesia providers rely on traditional theories and methods for the management of perioperative fluid resuscitation in colorectal surgery (Bamboat & Bordeianou, 2009). Historically, prior training favored liberal intraoperative fluid replacement, particularly after bowel or emergent colorectal surgeries. In the 2000s, data supported the use of restrictive approaches to perioperative fluid administration, especially with goal-directed fluid therapy (GDFT). Within the past two years, current evidence shows that GDFT is appropriate in some populations and colorectal procedures but not beneficial for others. This Doctor of Nursing Practice (DNP) project provides evidence-based recommendations on suggested intraoperative fluid replacement therapy in colorectal surgery in the form of an algorithm that is based on a modified clinical practice guideline. The algorithm was developed for anesthesia providers at a Level 3 hospital in Mesa, Arizona. The Iowa Model was the conceptual framework, which guided this project by making recommendations to change current practice. An algorithm guided by the "2018 ERAS CPG for Colorectal Surgery Recommendation 13" was developed by the principal investigator (PI). Prior to developing the algorithm, participants (n=3) included DNP-Certified Registered Nurse Anesthetists (CRNAs) who used the "Appraisal of Guidelines for Research and Evaluation II" (AGREE II) tool to determine the quality of the guideline. Results determined that these guidelines were of good quality. The GDFT algorithm was presented to anesthesia providers during a monthly staff meeting. Ultimately, the anesthesia providers (N=4) filled out the Stakeholder Feedback Form and confirmed it was a quality algorithm, and that they would adopt it into their own practice. Anesthesia providers must change practice as evidence-based research provides current evidence to guide practice in improving patient outcomes.

INTRODUCTION

Colorectal surgery encompasses surgical intervention of any disorder of the colon, rectum, and anus. The reasons for surgery include inflammatory bowel disease, anorectal disease, diverticulitis, benign, and malignant colorectal cancers. In 2015, the United States reported 140,788 new diagnoses of colon and rectal cancer (Centers for Disease Control and Prevention [CDC], 2018), which usually requires some type of colorectal surgery to remove the tumors (American Cancer Society, 2019). The state of Arizona reported 2,583 colorectal cancer cases requiring colorectal surgery in 2015, not including surgeries involving inflammatory, anorectal, and diverticular disease (CDC, 2018).

Colorectal surgical perioperative fluid management is an essential factor of anesthetic practice that involves maintaining intravascular hydration, improving cardiac output, preserving tissue perfusion, enhancing oxygen delivery, rectifying and retaining electrolyte balance, augmenting microcirculation, and promoting the distribution of nutrients and clearance of metabolic debris (Trinsoon & Patel, 2018). These patients are thought to be dehydrated going into surgery secondary to the colon preparations that started the day before surgery and fasting guidelines that began at midnight (Collins & Johnson, 2018).

Colon preparations usually involve intake of osmotic laxatives of four (4) liters (L) of polyethylene glycol solution or 90 milliliters (mL) of sodium phosphate solution. Intake of these agents may cause diarrhea with nausea, vomiting, and potential dehydration (A-Rahim & Falchuk, 2019). Anesthesia fasting guidelines include ‘nil per os’ (NPO) for eight (8) hours for heavy meals containing fat and meat, six (6) hours for infant formula, four (4) hours for breast milk, and two (2) hours for clear liquids. Many outpatient facilities simplify NPO guidelines by

arbitrarily instructing the patient to avoid the consumption of food or liquids after midnight before surgery.

The classic approach to intraoperative intravenous (IV) fluid administration is based on several calculations related to preoperative fluid loss, which occurs during surgery, including the 4-2-1 rule, maintenance rates, and supplementation for surgical fluid loss. Currently, a seismic shift from traditional fluid therapy using subjective fluid resuscitation based on a fixed volume approach, evaporative losses, third space loss and ambiguous estimated blood losses to safer maintenance of a euvolemic state is recommended (Trinsoon & Patel, 2018). These traditional methods were based on theories that fasting patients who were NPO were dehydrated and required volume using this classic approach (Trinsoon & Patel, 2018).

Clinical practice guidelines (CPGs) are systematically produced statements based on current evidence-based practice to assist providers and patient decisions about appropriate health care for particular clinical situations (National Center for Complementary and Integrative Health, 2017). The 2018 Enhanced Recovery After Surgery Clinical Practice Guideline (ERASCPG) for elective colorectal surgery contains the most current, high-quality recommendations, that uses Grading of Recommendations, Assessment, Development and Evaluations (GRADE), to assess the quality of research studies in the colorectal surgical population (Appendix A). The 2018 ERASCPG includes recommendations for fluid therapy but lack defining those who are high and low-risk patients and high and low-risk surgeries. Implementation of a goal-directed fluid therapy (GDFT) algorithm with the inclusion of types of patients (*high-risk, low-risk*) and types of surgery (*high-risk, low-risk*) for colorectal surgery will result in improved perioperative outcomes in the perioperative period by avoiding fluid overload and decreasing ileuses and

anastomotic leaks.

Concepts Related to Goal-Directed Fluid Therapy (GDFT)

The following concepts clarify the components of the traditional fluid therapy, the physiology of fluid balance, and how GDFT improves outcomes.

4-2-1 Rule and Maintenance

The 4-2-1 rule (Appendix B) is a fixed volume approach that the anesthesia provider calculates as a guide for fluid therapy during surgery. This rule for fluid resuscitation originated in 1957 in a study published in the *Journal of Pediatrics* (Malcolm, Holliday, & Segar, 1957). The 4-2-1 rule calculates maintenance fluid relative to body weight by supplementing

- 4 mL/kg/hr for the first 10 kg
- 2 mL/kg/hr for the second 10 kg
- 1 mL/kg/hr for every kg above 20

The second step calculates ongoing maintenance requirements based on the patient's weight using the same 4-2-1 rule as used to calculate preoperative maintenance requirements. The following is an example of the fluid deficit calculation using the 4-2-1 rule. A 70-kilogram (kg) patient has fluid requirements 110 mL/hour (hr.). If they did not take any intake for eight (8) hours, their fluid deficit would be 880 mL. The patients are rehydrated with 50% (440 mL) of fluid deficit within the first hour and 25% (220 mL) within the subsequent two hours (Department of Anesthesiology Division of Pediatric Anesthesia, 2019).

Surgical Fluid Loss

Anticipated surgical fluid loss is based on the patient's weight and anticipated tissue trauma.

- Minimal tissue trauma: 2-4 mL/kg/hr., herniorrhaphy
- Moderate tissue trauma: 4-6 mL/kg/hr., major non-abdominal or laparoscopic abdominal surgery
- Severe tissue trauma: 6-8 mL/kg/hr., bowel resection

Unanticipated surgical fluid loss is any fluid loss beyond the aforementioned anticipated values. Unanticipated surgical fluid loss includes administering 3 mL of crystalloid for every 1 mL of blood loss or 1 mL of colloid or blood for every 1 mL of estimated blood loss (Trinsoom & Patel, 2018).

The Physiology of Fluid Balance

Total body water (TBW) includes the extracellular and intracellular fluid compartments, which for the average 70 kg person is approximately 42 liters (Table 1). For the average 70 kg. person, TBW is divided into extracellular (20% of body weight=14L) and intracellular spaces (40% of TBW=28L). The extracellular space is further divided into plasma (5% of TBW or 4L in a 70 kg. person) and interstitial space (15% of TBW or 10L in a 70 kg. person) (National Clinical Guideline Centre, 2013). Fluid resuscitation can alter the balance of the equilibrium mentioned above and can either cause hypervolemia and edema or dehydration (National Clinical Guideline Centre, 2013). Fluid overload can present as hypertension, bradycardia, arrhythmias, angina, pulmonary edema with hypoxemia, and congestive heart failure with hypotension (Nagelhout & Elisha, 2018).

TABLE 1. *Body fluids in 70 kg male.* (No copyright permission needed.)

Compartment	***Volume***	***Subdivisions***
Total Body Water (TBW); 60% of Body Weight	42L	-
Intracellular Fluid, ICF (40% of TBW)	28L	-
Extracellular Fluid, ECF (20% of TBW)	14L	10L- Interstitial Fluid / 4L- Plasma

Near-Zero Fluid Balance

This alternative concept of surgical fluid therapy only replaces fluid that is lost during surgery and includes the following strategies (1) administering a balanced crystalloid solution at 1-4 mL/kg/hr to replace sensible and insensible losses, (2) replacing crystalloid-to-blood volume at a ratio of 1.5:1, (3) avoiding preloading of crystalloid before induction of general anesthesia, and (4) avoidance of nonanatomic "third space" losses as this may increase morbidity (Joshi, O'Connor, & Nussmeier, 2019). The traditional fluid therapy concept results in increased weight gain and an average of five pounds of weight gain resulting in overall complications (Joshi, O'Connor, & Nussmeier, 2019).

Goal-Directed Fluid Therapy (GDFT)

Goal-directed fluid therapy (GDFT) involves administering intermittent intravenous boluses of saline or colloid to maintain euvolemia. It assesses changes in stroke volume by measurement with a cardiac output monitor to optimize the patient's volume status on the Frank-Starling curve (Gustafsson et al., 2018). The Frank-Starling curve (Figure 1) demonstrates a relationship between left ventricular end diastolic volume (LVEDV) and myocardial contractility, as measured by stroke volume (SV). An increase in the left ventricular preload will increase myocardial contractility by stretching cardiac sarcomeres and optimizing the overlap of actin and myosin filaments to generate greater myocardial force. The ascending portion of the curve represents preload dependence and will respond to fluid volume by increasing SV. The plateau portion of the curve represents preload independence, and patients along this curve are unable to generate any additional myocardial force in response to fluid volume (Trinsoon & Patel, 2018).

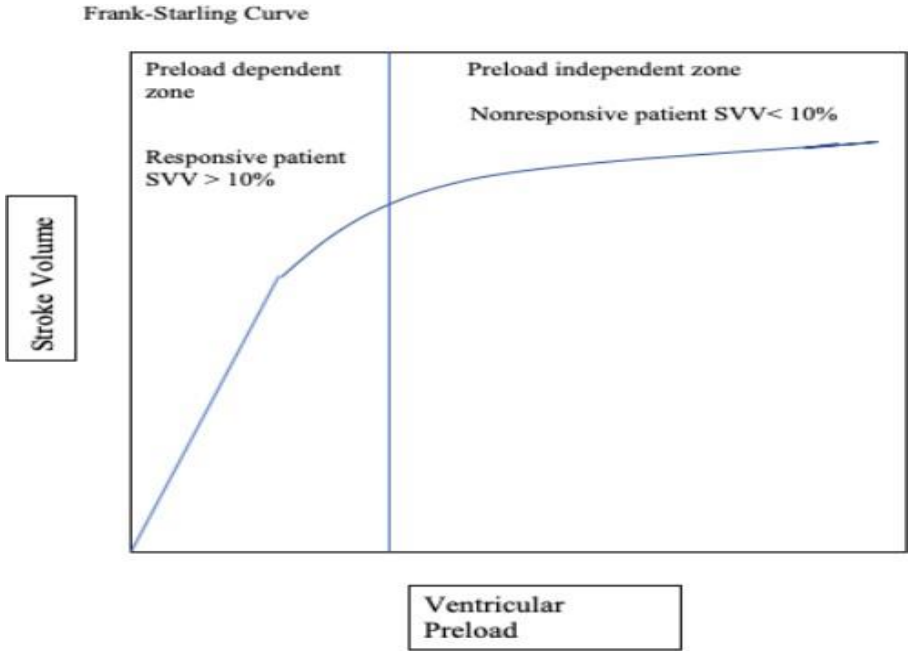


FIGURE 1. The Frank-Starling curve. (No copyright permission needed.)

Cost Analysis for Implementation of GDFT

Implementing GDFT for complex surgical patients has been shown to lower the risk for postoperative morbidity by up to 29% and reduce health care costs by up to $970 per patient (Bufano, 2015). According to a study by Manecke, Asemota, and Michard (2014), they evaluated postoperative complications from a hospital database in 2011 with a sample size of 75,140 patients. Out of this sample, 8,421 patients developed postoperative complications (morbidity rate of 11.2%). Inpatient morbidity rates with or without complications resulted in (12.4% vs. 1.4% for complications vs. no complications, respectively; $P < 0.001$), and hospital stays were longer (mean 20.5 vs. 8.1 days, respectively; $P < 0.001$). Additionally, the average direct cost of care was $47,284 for those with complications compared with $17,408 for patients with no complications ($P < 0.001$). In conclusion, the use of GDFT decreases morbidity rates by 11%, a decrease in hospital stay by 12.4 days, and $29,876 in cost savings.

Length of Hospital Stay

Current literature discusses the decrease in length of hospital stay (LOS) by potential cost savings by using GDFT in the perioperative phase of surgery. Hospital costs were obtained from the business office of the project site to analyze costs from prolonged hospital stays. The cost of one hospital day exclusive of supplies and pharmacological medications were: (1) medical-surgical bed—$1,689, (2) telemetry bed—$2,017, and (3) intensive care unit—$2,612. A hospital stay of eight days without complications in a medical-surgical bed ($1,689 per night) at the facility in Mesa totals $13,512. Comparatively, a hospital stay for those who developed complications required an additional 10 days ($16,890 + $13,512). The total cost for a hospital bed for those patients with postoperative complications would equal $30,402 versus $13,512. This does not include other costs for supplies, medications, and nights in higher levels of care. Using GDFT could result in significant cost savings as seen by this analysis of length of hospital stay.

ERAS Society Guidelines for Colorectal Surgery

The Enhanced Recovery After Surgery (ERAS) pathways include evidence-based recommendations designed to decrease perioperative stress, maintain postoperative physical function, and hasten recovery after surgery. The use of ERAS pathways have repeatedly reduced rates of morbidity including ileuses by 10% (Iversen, Ahlberg, Lindqvist, & Buchli, 2017), and has shortened the length of hospital stay anywhere from 1.55, 2.55, to 9.2 days (Feldheiser et al., 2012; Rollins & Lobo, 2016; Zhuang, Ye, Zhang, Chen, & Yu, 2013) after major colorectal surgery. The first ERAS guidelines were published in 2005. Currently, the fourth updated ERAS guideline presents evidence for optimal perioperative care in colorectal surgery with graded

recommendations for each ERAS item within the ERAS protocol (Gustafsson et al., 2018).

The ERASCPG includes 25 recommendations (Appendix A) in which evidence was appraised using the GRADE system using strong and weak recommendations. Strong recommendations suggest that the panel is confident that the desirable effects of adherence to recommendations outweigh the undesirable effects. Weak recommendations suggest the desirable effects of adherence to recommendations probably outweigh the undesirable effects, but the panel is less confident (Gustafsson et al., 2018). The ERAS recommendations for elective colorectal surgery (Table 2) include a series of treatments covering the entire perioperative period resulting in better outcomes for these patients. All these recommendations are important, however, the focus of this current project involves the anesthesia provider and intraoperative management of fluid therapy. The fluid deficit can be reduced if Recommendation 10—preoperative fluid and electrolyte therapy—is adapted, and patients are allowed oral carbohydrate drinks up to two hours before surgery. This is another major topic of discussion, but for this DNP project, the focus is on Recommendation 13—intraoperative fluid and electrolyte therapy—from the ERAS recommendations for elective colorectal surgery guidelines.

TABLE 2. *ERAS 25 recommendations for elective colorectal surgery.*

1. Preadmission information, education, and counseling	***13. Intraoperative fluid and electrolyte therapy***
2. Preoperative optimization	14. Preventing intraoperative hypothermia
3. Prehabilitation	15. Surgical access
4. Preoperative nutritional care	16. Drainage of the peritoneal cavity and pelvis
5. Management of Anemia	17. Nasogastric Intubation
6. Prevention of nausea and vomiting (PONV)	18. Postoperative analgesia
7. Pre-anesthetic medication	19. Thromboprophylaxis
8. Antimicrobial prophylaxis and skin preparation	20. Postoperative fluid and electrolyte therapy
9. Bowel preparation	21. Urinary drainage
10. Preoperative fluid and electrolyte therapy	22. Prevention of postoperative ileus
11. Preoperative fasting and carbohydrate loading	23. Postoperative glycemic control
12. Standard Anesthetic Protocol	24. Postoperative nutritional care
	25. Early Mobilization

Recommendation 13

The goal of perioperative fluid therapy is to maintain fluid homeostasis by avoiding fluid excess and organ hypoperfusion. Fluid excess resulting in weight gain greater than 2.5 kg. should be avoided, and perioperative near-zero fluid balance is optimal. GDFT should be adopted in high-risk patients and patients undergoing surgery with large intravascular fluid loss. Inotropes should be considered in patients with poor myocardial contractility with a cardiac index (CI) of less than 2.5 L/min (Gustafsson et al., 2018). The evidence is of high quality and strongly supports intraoperative fluid and electrolyte therapy implementing perioperative near-zero fluid balance and GDFT in high-risk patients undergoing surgery with large intravascular fluid loss (Gustafsson et al., 2018). GDFT has weak evidence in low-risk patients undergoing low-risk surgery but recommends the maintenance of zero fluid balance with high-quality supporting evidence (Gustafsson et al., 2018).

Grading of the ERAS Recommendations

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system is a transparent framework for CPG development and provides a systematic approach for making clinical practice recommendations. It is the most widely adopted tool for grading the quality of evidence and for making recommendations with over 100 organizations worldwide officially endorsing GRADE (Siemieniuk & Guyatt, 2019). First, authors decide upon the clinical question, the population that the question applies to, two or more alternatives, and outcomes that take precedence in the decision-making process. Second, the authors rate the quality of evidence specific to each outcome. The GRADE has four levels of evidence including very low, low, moderate, and high. Randomized control studies are of high quality, and

observational data starts as low quality. Very low-quality states that the true effect is probably extremely different from the estimated effect. Low quality states that the true effect is potentially different from the estimated effect. Moderate quality occurs when the authors believe that the true effect is close to the estimated effect. High quality occurs when authors have high confidence that the true effect is similar to the estimated effect (Siemieniuk & Guyatt, 2019).

Defining Patient Types

The development of this GDFT algorithm includes the direction of fluid therapy according to the type of patients undergoing colorectal surgery. Patients were categorized as high or low risk, and the type of surgery as high or low risk.

High-Risk Patients

High-risk patients included patients 18 years or older presenting for major surgery expected to last more than 1.5 hours and having a minimum of two of the following criteria: (1) cardiovascular or respiratory compromise resulting in functional limitation, (2) extensive surgery planned for carcinoma involving bowel anastomosis, (3) predictable acute massive blood loss (>500 milliliters), (4) aged over 70 years with functional limitation of one or more organ systems, (5) septicemia (positive blood cultures or septic focus), (6) respiratory failure (PaO2 <60 mmHg on FiO2> 0.4, or a PaO2: FiO2 ratio <150 mmHg or ventilation >48 hours), (7) acute abdominal complications including but not limited to pancreatitis, perforated viscous, and gastrointestinal bleed), (8) acute renal failure, and (9) disseminated malignancy (Cannesson, Pestel, Ricks, Hoeft, & Perel, 2011).

High-Risk/Major Abdominal Surgery

High-risk/major abdominal surgeries with large intravascular fluid loss included all open

abdominal laparotomy procedures, resection of gastrointestinal cancers with tumor debulking with a risk of significant blood loss, and anorectal and colectomy procedures (Ramsingh, Sanghvi, Gamboa, Cannesson, & Applegate, 2013). Other major abdominal surgeries include laparoscopic or open repair or resection of the stomach, small bowel, colon, liver, pancreas, spleen, adrenals or liver (Winnipeg Regional Health Authority, 2019). Major abdominal surgeries are associated with expected blood loss of greater than 500 mLs with significant fluid shifts and an anticipated minimum of a one-night stay in a hospital.

Low-Risk Patients and Surgery

Low-risk patients included patients with (1) no known medical problems, (2) well-controlled hypertension with systolic blood pressure less than 140 mmHg, hyperlipidemia, asthma, and other chronic stable medical conditions without significant functional impairments. Low-risk abdominal surgeries include laparoscopic and/or open inguinal and umbilical hernia repairs and laparoscopic cystectomies (University of California, Los Angeles Health, n.d.).

Background Knowledge

Over the years, the debates regarding fluid therapy during the perioperative period has pushed for more research and discussion. Many anesthesia providers use the classic approach for fluid replacement therapy during the perioperative period (Trinsoon & Patel, 2018). That calculated number is then applied to fasting hours with a determination of net deficit. The following is an example of perioperative fluid calculation for a 70 kg. patient undergoing a three-hour major abdominal surgery with an estimated blood loss of 300 mL.

- NPO for 8 hours (880 mL preoperative deficit)
- Three-hour major abdominal surgery (6-8 mL/kg/hr)

    - Insensible loss: 420-560 mL/hr
        - (840-1120 mL) for the first two hours as the first hour is omitted
- 3:1 ratio of crystalloid per milliliter of blood. If the estimated blood loss (EBL) of the patient is 100 mL, 300 mL of crystalloid is required to replace that loss.
- Classic approach to replace fluids: total fluid amount of ((880 mL + (840-1120) + 300 mL)) equaling 2,020–2,300 mLs for the entire surgery.

A variety of methodologies for low blood pressures also use fluid boluses to titrate for appropriate blood pressure. The traditional approach for fluid administration has been challenged by scientific evidence as it does not account for cardiovascular and renal dysfunctions. A meta-analysis found that preemptive fluid administration often contributed to overload-associated complications including heart failure and pulmonary congestion with disruption of the endothelial glycocalyx (which is the protective lining of the vascular endothelium and is permeable for molecules and water). The meta-analysis also found that preemptive fluid administration provided dilutional coagulopathies and caused edema in the small bowel contributing to ileuses in the colorectal surgical population (Jacob, Chappell, Conzen, Finsterer, & Rehm, 2008). Two randomized control studies with a total sample size of 105 patients found that even a slight net gain of salt and water balance causing a weight gain of three (3) kgs after elective colonic resection has proven to increase morbidities and extended hospital stays (Trinsoon & Patel, 2018).

Maintaining fluid homeostasis by avoiding fluid excess and organ hypoperfusion is the ultimate goal during the perioperative period. Current evidence states that GDFT provides a euvolemic perioperative state and can decrease hospital length of stay and decrease patient

morbidity in the colorectal surgical population (Lobo et al., 2012). The 1-4 mL/kg/hr maintenance benefits patients undergoing low-risk colorectal surgery, and GDFT seems to benefit high-risk patients undergoing surgery with large intravascular fluid loss (Gustafsson et al., 2018).

The Enhanced Recovery After Surgery (ERAS) protocols, focusing on goal-directed fluid therapy (GDFT), uses stroke volume optimization methodologies to reduce complications after major colorectal surgery by 25-50% (Miller, Roche, & Mythen, 2015). The investigation of the etiology of hemodynamic variation using stroke volume variance (SVV) aids in the appropriate identification and intervention to maintain a euvolemic state and avoid the detrimental effects of fluid overload.

The University of California-Irvine GDFT Protocol

The University of California-Irvine (UCI) has developed a protocol (Figure 2) to help guide hemodynamic instability variables (blood pressure, cardiac index, SVV, & PPV) with appropriate intervention using fluid, inotropic agents, or vasoconstricting agents to guide GDFT (University of California-Irvine School of Medicine, 2018). Inotropic agents increase myocardial contractility and include medications such as dobutamine and milrinone.

Vasoconstricting agents cause constriction of arterioles and include phenylephrine and norepinephrine. The protocol implements intravenous supplementation of crystalloid fluids and boluses based on SVV, cardiac index (CI), and blood pressure values. They suggest maintaining a fluid rate of 3 mL/kg/hr and positive pressure ventilation of 8 mL/kg of ideal body weight with additional supplementation of 350 mL of crystalloids as directed by the protocol.

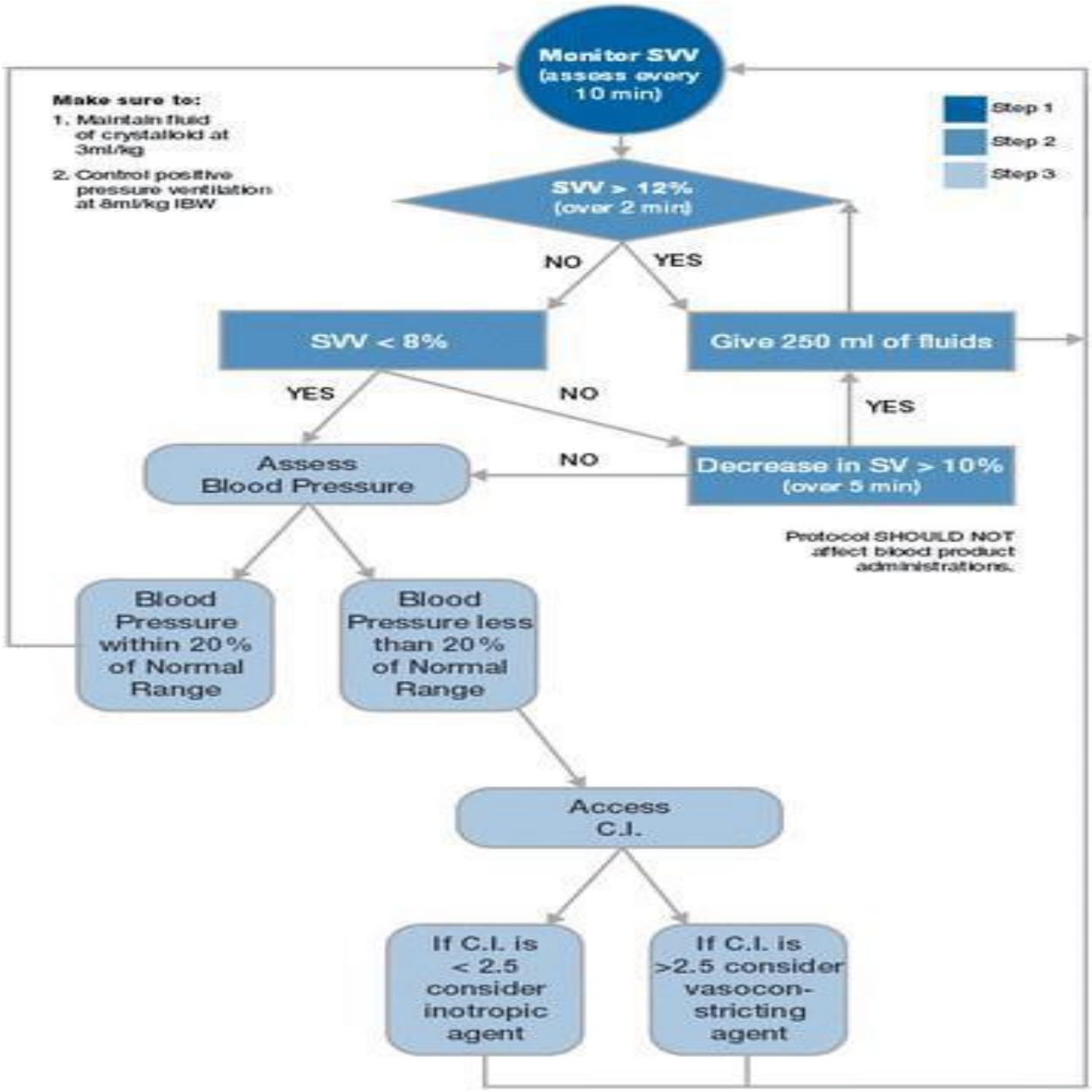


FIGURE 2. The University of California-Irvine GDFT protocol. (No copyright permission needed.)

Stroke Volume Variation (SVV)

Stroke volume variation (SVV) is the percentage of change between the maximal and minimal stroke volumes (SV) over a period divided by their average value. It reflects fluctuations of left ventricular output due to intrathoracic pressure changes induced by

mechanical ventilation. The SVV is an accurate predictor of fluid responsiveness when the SVV >10% (Correa-Gallego et al., 2015).

Composition Crystalloid Solutions Chart

Isotonic fluids with differing electrolyte composition, pHs, and osmolality are infused during the perioperative period and include Plasmalyte A/Normosol R/Isolyte-S, Lactated Ringer, and 0.9% Sodium Chloride (Table 3). Isotonic solutions have a similar osmolality to plasma which maintains intracellular neutrality to prevent cellular swelling and dehydration (Trinsoon & Patel, 2018). Plasmalyte-A/Normosol-R/Isolyte-S have a higher potassium content than human plasma with a similar pH and are also used for blood product administration. Lactated ringer is one of the most common isotonic fluids used in anesthesia but is avoided in liver failure patients due to the increase in lactate accumulation. Sodium chloride has become less popular due to hyperchloremic metabolic acidosis from the elevated chloride concentration (Trinsoon & Patel, 2018).

TABLE 3. *Composition of isotonic fluids.*

Concentration	Plasma	Plasmalyte-A / Normosol-R / Isolyte-S	Lactated Ringer	0.9% Sodium Chloride
Sodium (mEq/L)	142	140-141	130	154
Potassium (mEq/L)	4	5	4	
Chloride (mEq/L)	103	98	110	154
Phosphate (mEq/L)	1.4	1		
Magnesium (mEq/L)	2	3		
Calcium (mEq/L)	5		3	
Lactate (mEq/L)			28	
Acetate (mEq/L)		27		
Gluconate (mEq/L)		23		
pH	7.4	7.4	6.2	5.6
Osmolality (mOsm/L)	291	294-295	275	310

Significance to Advanced Practice Nursing

Certified Registered Nurse Anesthetists (CRNAs) are advanced practice registered nurses with specialized graduate-level education in anesthesiology. They have a minimum of one year of intensive care unit (ICU) experience and have 24-36 months of additional anesthesia education requiring over 2,000 hours of clinical time (American Association of Nurse Anesthetists, 2019). The CRNAs manage patients intraoperatively and managing fluid administration is important as it maintains blood pressure and tissue oxygenation. Perioperative fluid management has significant implications for postoperative morbidity and mortality in colorectal surgery (Correa-Gallego et al., 2015). Current literature supports maintaining a euvolemic state as the ultimate goal; however, the optimal method of achieving a euvolemic state with either GDFT or maintenance fluids are inconclusive. Thus, this development of an algorithm is to guide providers for intraoperative fluid resuscitation and decrease morbidity and hospital length of stays (LOS) in patients having colorectal surgery (Feldheiser et al., 2012).

Local Problem

It was observed that anesthesia providers at a facility in Mesa, Arizona were using the 4-2-1 rule. The anesthesia providers did not have an established current evidence-based algorithm for intraoperative fluid management in the colorectal surgical population.

Purpose

The purpose of this Doctor of Nursing Practice (DNP) project was to develop an algorithm to guide intraoperative fluid therapy for elective colorectal surgical patients based on the 2018 ERAS guidelines. The developed algorithm includes patient types (high & low-risk) and type of surgery (high & low-risk) which was not included in the 2018 ERAS guidelines.

Stakeholders

Key stakeholders for this project include anesthesia providers, surgeons, and patients. Optimal intraoperative management of fluid therapy occurs when these stakeholders recognize the application of GDFT, its indications, and how utilizing an algorithm will improve patient outcomes by decreasing hospital LOS and decreasing morbidity following colorectal surgery.

Project Question

This DNP project was guided by the following question: After presenting the GDFT algorithm, will anesthesia providers that directly care for patients in the intraoperative phase of colorectal surgery accept the algorithm to be implemented for their practice?

Conceptual Framework

The Iowa Model

This DNP project used the Iowa Model as the conceptual framework to guide the project. Maria Titler and her associates developed the Iowa Model of Research Utilization (Iowa Model) at the University of Iowa with the intention to detail knowledge transformation and model implementation of research into clinical practice (Dontje, 2007). The Iowa Model focuses on knowledge and problem-focused triggers, which leads staff to question current practices with potential improvement opportunities through the use of current research (Doody & Doody, 2011). The Iowa Model provides a guide for (1) topic selection, (2) team formation, (3) evidence retrieval, (4) grading the evidence, (5) development of evidence-based practice (EBP) standards, (6) implementation of EBP, and (7) evaluation as depicted in Figure 3.

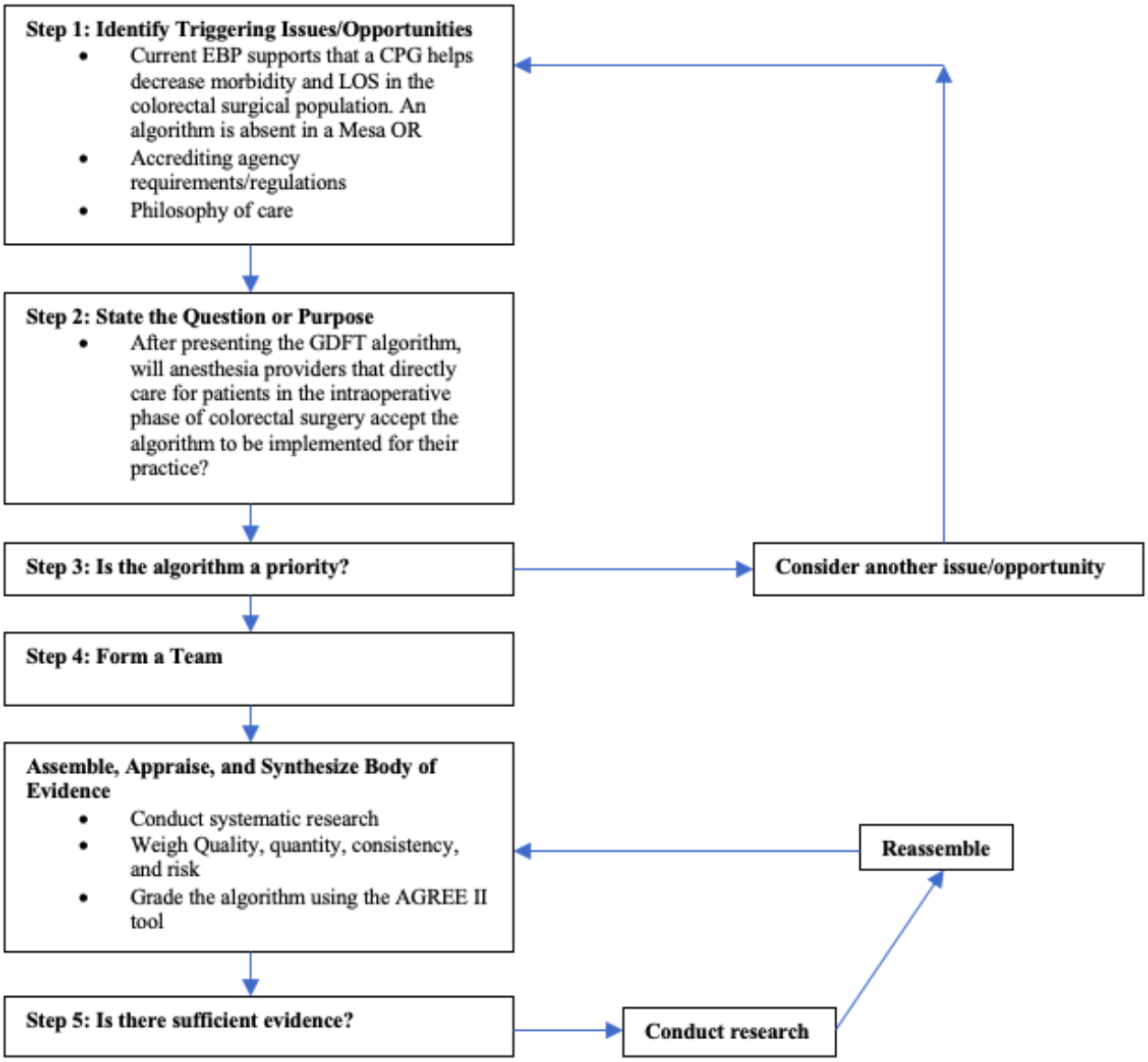


FIGURE 3. The Iowa model.

Concepts of the Iowa Model

Step 1: Topic Selection

When selecting a topic, many variables must be considered to enhance the DNP project viability. The variables include problem significance, applicability to areas of practice, contributions to improving patient care, the presence of information and evidence in the problem,

and staff engagement (Doody & Doody, 2011). In a Mesa operating room, the lack of an official algorithm, despite current EBP supporting this research, was deemed the trigger. The goal was to develop an algorithm for anesthesia providers to have an accessible, easy-to-follow guide to map the care of the colorectal surgical population intraoperatively to help decrease hospital length of stay and decrease morbidity.

Step 2: Team Formation

The team is liable for the change, implementation, and final assessment of the DNP project. A capable team includes buy-in from stakeholders through multiple organizational tiers, including staff, administration, and research experts. If the team does not have stakeholders from various levels of power, the team's morale may decline, and the growth of the DNP project may falter (Feasey & Fox, 2001). This DNP project's team included the chief CRNA and two staff CRNAs in a Mesa operating room.

Step 3: Evidence Retrieval

After topic selection and team formation, a collaborative discussion should guide the identification of reliable sources and critical terms to map the search for evidence. Evidence retrieval should come from electronic resources that may include but not limited to PubMed, Embase, ClinicalKey, CINAHL, UpToDate, Cochrane, and Medline (Doody & Doody, 2011).

Step 4: Grading the Evidence

Grading the evidence based on the quality of the research and strength of the overall evidence helps identify if the clinical practice guidelines are valid and reliable enough to implement into the organization potentially (Doody & Doody, 2011). The graded evidence is either qualitative or quantitative. Qualitative data strives to understand phenomena from a

subjective view. The target is on characterization, insight, and acknowledgment of the involved participants. Quantitative information focuses on the deduction, hypothesis testing, and objective methods used to control phenomena with its focus on theory testing and prediction (Doody & Doody, 2011). The AGREE II tool grades the evidence present in the guideline to assess the quality.

Step 5: Development of EBP Standard

After grading the evidence of the clinical practice guideline, team members collaborate to identify high-quality evidence and potential areas for improvement. The guideline should be specific to the organization supported by clear and high-strength evidence (Lo Biondo-Wood & Haber, 2006). The current guideline should be evaluated for strengths and weaknesses. The weaknesses may include poor-quality evidence and current, high-quality EBP replaces weak evidence within the guideline to benefit the organization and patient care (Doody & Doody, 2011).

Step 6: Implementation of EBP

A variety of key occurrences must take place to implement a clinical practice guideline. Written policy, procedures, and guidelines must be evidence-based with direct interaction between the organization, direct care providers, and leadership roles to embrace changes. The evidence should be diffused focusing on the guideline's strengths with potential benefits, with emphasis on how it is communicated. The guideline can be presented through in-service education, audit, and feedback given by team members (Doody & Doody, 2011). Implementation was not within the scope of this DNP project.

Step 7: Evaluation

Continual assessment and integration of EBP are imperative to the continued adoption of the clinical practice guideline. Habitual assessment and opinions from organizational members impact the future evolution of the guideline as new evidence surfaces. The guideline is subject to metamorphosis and continuous appraisal of evidence permits a high-quality guideline specific to the organization (Doody & Doody, 2011). An evaluation was not within the scope of this DNP project.

Application of the Iowa Model to the Formation of an Algorithm

The theoretical framework assists the project leader to gestate the project and assists it throughout the journey of the project (White & Zaccagnini, 2014). The Iowa Model is optimal in the promulgation of research and promoting change toward evidence-based practice (EBP) (Tymkow, 2014). The purpose of the Iowa Model was to provide a map to potentially adopt the algorithm into practice after stakeholder appraisal of the ERASCPG using the AGREE II tool (Appendix I). The Iowa Model helped the aim by educating providers on evidence-based research (EBR) regarding perioperative fluid management in the colorectal surgical population. The Iowa Model applied "triggers" to promote problem recognition (Titler, 2010). The trigger was the acknowledgment of a possible issue in the transmission of healthcare (Titler, 2010).

Subsequently, the next process of the Iowa Model was to determine if the issue took precedence within the organization. After priority confirmation of a need for an algorithm, a team was formed to assemble, appraise, and synthesize the body of evidence using the AGREE II tool regarding the 2018 ERASCPG. If sufficient evidence exists, the team designs and pilots the practice innovation; if not, they conduct more extensive research and reassemble. Next, the

determination of change appropriate for adoption into practice leads to integration and sustenance of practice change. If adoption of the algorithm is not appropriate for practice change, then explore retrograde alternatives and reassemble. Finally, dissemination of results occurs and cycles back to identifying triggering issues and opportunities to the algorithm with subsequent future research on perioperative fluid management in the colorectal surgical population (University of Iowa Healthcare, 2018).

Synthesis of Evidence

The algorithm for perioperative fluid management in the colorectal surgical population required a synthesis of evidence to evaluate studies, validity, and to determine if the evidence was sufficient to support a colorectal fluid management algorithm. The synthesis of evidence described which populations were appropriate for goal-directed fluid therapy. A literature review identified current evidence-based research (EBR) on perioperative fluid management of the colorectal surgical population. Key search terms included: “goal-directed fluid therapy,” “enhanced recovery after surgery,” “ERAS,” “colorectal surgery,” “high-risk surgery,” “low-risk surgery,” “high-risk,” “low-risk,” “conventional fluid therapy,” “traditional fluid therapy,” and “surgical outcomes” using the electronic literature databases including the Joanna Briggs Institute, ERAS Society, PubMed, Embase, Google Scholar, and Cumulative Index to Nursing and Allied Health Literature (CINAHL). Additional criteria for the literature search included: published articles within the last 10 years, English language, and human species, which yielded a total of 153 results. Exclusion criteria included articles not related to colorectal surgery or fluid management outside of the operating room, which left ten articles for the synthesis of evidence (Appendix D).

High-Risk Patients

Research supports that goal-directed fluid therapy reduces surgical mortality, morbidity, and hospital length of stays (Hamilton, Cecconi, & Rhodes, 2011; Zhuang et al., 2013) in high-risk patients and patients undergoing surgeries with a large intravascular fluid loss (Gustafsson et al., 2018). High-risk patients include patients 18 years or older presenting for major surgery expected to last more than 1.5 hours and having a minimum of two of the following criteria: (1) cardiovascular or respiratory compromise resulting in functional limitation, (2) extensive surgery planned for carcinoma involving bowel anastomosis, (3) predictable acute massive blood loss (>2.4 liters), (4) aged over 70 years with functional limitation of one or more organ systems, (5) septicemia (positive blood cultures or septic focus), (6) respiratory failure (PaO2 <60 mmHg on FiO2> 0.4, or a PaO2: FiO2 ratio <150 mmHg or ventilation >48 hours), (7) acute abdominal complications including but not limited to pancreatitis, perforated viscous, and gastrointestinal bleed), (8) acute renal failure, and 9) disseminated malignancy (Cannesson et al., 2011).

Major Abdominal Surgery with Large Intravascular Fluid Loss

Major abdominal surgeries with large intravascular fluid loss included procedures including all open abdominal laparotomy procedures, resection of gastrointestinal cancers with tumor debulking with a risk of significant blood loss, and anorectal and colectomy procedures (Ramsingh et al., 2013). Other major abdominal surgeries include laparoscopic or open repair or resection of the stomach, small bowel, colon, liver, pancreas, spleen, adrenals or liver (Winnipeg Regional Health Authority, 2019). Major abdominal surgeries are associated with expected blood loss of greater than 500 mL with significant fluid shifts, with an anticipated minimum of a one-night stay in a hospital.

GDFT is Beneficial in High-Risk Patients Undergoing Major Abdominal Surgery

The five systematic reviews and meta-analyses involving over 19,000 patients found that there was a statistically significant decrease in morbidity and hospital length of stay with the use of GDFT in high-risk patients undergoing major abdominal surgery (Hamilton et al., 2011; Sun, Chai, Pan, Romeiser, & Gan, 2017; Xu et al., 2018; Yuan, Sun, Pan, & Li, 2017; Zhuang et al., 2013) and decreased the incidence of anastomotic leakage post colon resections (Iversen et al., 2017).

GDFT Did Not Show Improvement in Low-Risk Patients Undergoing Low-Risk Surgery

The goal-directed fluid therapy is weak in low-risk patients and patients undergoing low-risk surgery; however, maintaining zero-fluid balance is strong (Gustafsson et al., 2018). Low-risk patients include patients with: (1) no known medical problems, and (2) well-controlled hypertension with systolic blood pressure less than 140 mmHg, hyperlipidemia, asthma, and other chronic stable medical conditions without significant functional impairments (University of California Los Angeles Health, n.d.). Low-risk abdominal surgeries include: (1) laparoscopic or open inguinal and umbilical hernia repairs, and (2) laparoscopic cystectomies (Winnipeg Regional Health Authority, 2019).

The Implementation of a GDFT Protocol and Fluid Variances before ERAS

Statistically significant reductions in postoperative morbidity and hospital stay after colorectal surgery was evident with the development of a GDFT (Feldheiser et al., 2012). Before the initiation of an ERAS GDFT protocol, large fluid variances in fluid resuscitation were evident without uniformity. Before the adoption of GDFT, some research studies have shown infusions of >2.5 L of fluid with 50% standard deviations and 67% variability in fluid

administration (Quinn, Brovman, & Urman, 2017).

Strengths

The articles that supported GDFT in high-risk patients receiving major abdominal surgery included five systematic reviews and meta-analyses totaled 127 RCTs and 19,657 patients undergoing colorectal surgeries (Hamilton et al., 2011; Sun et al., 2017; Xu et al., 2018; Yuan et al., 2017; Zhuang et al., 2013). RCTs and meta-analysis provide level one evidence that ranks the highest level of evidence (Polit & Beck, 2017). The article supporting GDFT in improving anastomotic leakage had sufficient study viability without mortality lasting seven years with over 800 colorectal surgical patients (Iversen et al., 2017). In articles that supported zero-balance techniques versus GDFT, the relative risk (RR) was never greater in the GDFT groups which found that GDFT did not hurt any colorectal surgical patients.

Weaknesses

Most of the articles used a variety of different methods and algorithms to use GDFT and conventional fluid administration approaches. One study found that there were no benefits to the utilization of GDFT versus traditional fluid therapy; however, the sample size was small (n=128) and had insufficient statistical power in determining whether goal-directed fluid therapy reduced primary postoperative ileuses (Gomez-Izquierdo et al., 2017). Some studies were not performed under optimal ERAS conditions (Gustafsson et al., 2018). One trial found potential selection bias as selection by both the anesthetist and surgeon were mandatory for the inclusion of the patients (Brandstrup et al., 2012). Many of the studies did not provide exact definitions of “conventional, traditional, GDFT, ERAS GDFT, zero-fluid balance, and postoperative outcomes.”

Gaps and Limitations of Articles

Due to the variety of hemodynamic measuring devices and various ways hemodynamics are measured, including direct Doppler esophageal probes, pulse pressure variation (PPV), stroke volume variation (SVV), and arterial line PPV, instrumentation seems to be variable and may cause variance in results. Many algorithms also exist, and appropriate utilization is subject to variation and inconsistencies. Two RCTs had small sample sizes, each under 200 patients. Both found that GDFT was not effective in reducing postoperative morbidities after colorectal surgeries (Brandstrup et al., 2012; Gomez-Izquierdo et al., 2017). These two studies could improve limitations by significantly increasing their sample size. Lastly, the clinical practice guideline and literature fail to differentiate high-risk patients, high-risk/major abdominal surgery, low-risk patients, and low-risk surgeries.

Ethical Considerations

Respect for persons, beneficence, and justice are essential ethical considerations in the modification of a clinical practice guideline, as these three principles protect human subjects and ensure safe practice. Practice is defined as interventions designed to primarily enhance the well-being of a patient and proven to yield a reasonable expectation of success (The University of Iowa, n.d.). Data was secured in a private folder that was password-protected on a Macintosh MacBook Air ® laptop. Data were entered in a secure file in Stata and deleted after graphs were formed and transferred to this document.

Respect for Persons

Th**e** scope of this DNP project is to modify an existing clinical practice guideline to enhance the clarity of “high-risk” and “low-risk” patients and procedures undergoing colorectal

surgery to improve outcomes. Respect for persons includes two moral requirements: (1) treating individuals as autonomous agents, and (2) entitling protection to persons with diminished autonomy (The University of Iowa, n.d.). This DNP project falls under the categories of quality improvement (QI) and program evaluation (PE) and omits human research.

Participants and stakeholders involved in this project were optional and voluntary. The Participant Disclosure Forms (Appendix J & K) informed participants that they could opt-out of the project at any time. Ethnicity, religion and sexual orientation were exempt from all discussions about this project.

Beneficence

Due to the lack of human subjects and study trials, there are no identifiable economic, emotional, or security risks affiliated with this project. Advantages from this project include enhanced knowledge and admiration of current literature and resource assistance for the development of an algorithm for the appropriate use of fluid therapy in the colorectal surgical population. Anesthesia stakeholders will have an updated, evidence-based algorithm on fluid resuscitation for the colorectal surgical population available for voluntary implementation to improve morbidity and decrease hospital stays.

Justice

Justice requires equal selection of participants and avoiding participant populations that may be manipulated into participating, such as prisoners and institutionalized children. The idea of justice requires that those who undertake the burdens of research must benefit from the research (Adams, 2014). The anesthesia providers were treated with equality and respect while omitting any dialogue that may cause bias by the author, participants and stakeholders and

maintaining anonymity. Financial, economic, educational or professional conflicts were absent and did not create a conflict of interest that compromises justice.

METHODS

This quality improvement (QI) project was guided by the Iowa Model in appraising a clinical practice guideline toward the development of an algorithm for intraoperative fluid therapy for elective colorectal surgery. Descriptive statistics were used to describe the findings from the AGREE II tool and the Stakeholder Feedback Form (Appendix E).

Design

The design for this project was separated into two phases (Phase I & Phase II) with two groups of participants. Phase I participants assessed the ERAS clinical practice guideline for colorectal surgery and studies supporting GDFT by using the AGREE II tool to determine if the guideline was of high quality. Once this was done, the algorithm was developed from the modified 2018 ERAS CPG (Appendix C). Phase II participants assessed the algorithm using the Stakeholder Feedback Form to determine if it was sufficient to adopt into their practice.

AGREE II Tool

The AGREE II tool evaluates the process of practice guideline formation and the quality of reporting. It is both valid and reliable and compromises 23 items organized into the original six quality domains. It is recommended that at least two appraisers review each clinical guideline to increase the reliability of the assessment. The purpose of scoring is to identify the limitations of the clinical guideline being considered and to select high-quality clinical guidelines to implement. The two scoring methods include (1) using individual appraisers' scores, and (2) reaching consensus (Brouwers et al., 2017).

Domain 1. Scope and purpose—focuses on the comprehensive aim of the guideline, the specific health questions, and the target population.

Domain 2. Stakeholder involvement—centers around the degree to which the guideline was created by the fitting stakeholders and represents the views of its intended users.

Domain 3. Rigor of development—identifies the process used to collect and synthesize the evidence, the techniques to plan the suggestions, and a plan to update them.

Domain 4. Clarity of presentation—manages the language, structure, and configuration of the guideline.

Domain 5. Applicability—alludes to the potential barriers and facilitators to implementation, procedures to improve uptake, and resource ramifications of applying the guideline.

Domain 6. Editorial independence (Brouwers et al., 2017).

Stakeholder Feedback Form

During Phase II, the Stakeholder Feedback Form (Appendix E) gave input on the developed algorithm and included demographic questions (*n*=2), closed-ended questions with options to choose "*agree, neither agree nor disagree and disagree,"* (*n*=12) and open-ended questions (*n*=2). This form was modified from the AGREE II Next Steps Consortium, but instead of evaluating a CPG guideline, stakeholders gave feedback on the algorithm. At a monthly scheduled anesthesia meeting, the PI educated the staff about GDFT and the developed algorithm, which included a 30-minute PowerPoint presentation. The stakeholder feedback form was handed out to anesthesia providers at the end of the presentation allowing three days for completion. The completed forms were returned to a folder in the chief CRNAs office labeled

"GDFT Stakeholder Feedback Forms."

Setting and Participants

The setting was at a 178-bed, community-based hospital's anesthesia department in Mesa, Arizona that serves Mesa and surrounding communities. This facility has 10 operating rooms, two non-operating room anesthesia (NORA) sites and one obstetrics (OB) operating room. The site averages four colorectal surgical cases per week with an admixture of patient age groups.

During Phase I, participants were recruited via email for a period of two weeks. Participants included the Class of 2017 University of Arizona DNP-CRNA graduates whose emails were obtained during the PI's first week of school orientation as a resource contact while in the program. The PI sent an email to CRNAs from the graduating class of 2017 (n=8) to participate in grading the 2018 ERAS CPG. A minimum of two providers was required for evaluating evidence when using the AGREE II tool. Three participants responded and were willing to participate in appraising the 2018 ERAS CPG.

Phase II participants were recruited via email that was sent by the chief of anesthesia to all practicing CRNAs (N=10) working at the facility with a participation rate of (N=4). This email included a disclosure letter detailing the project and PI contact information for further communication (Appendix J & K). The site approval letter was signed on May 6, 2019, by the medical director of the anesthesia group at the hospital (Appendix G).

Intervention and Dissemination

The intervention and dissemination processes of this DNP project included (1) the presentation of the algorithm for the appropriate use of GDFT for potential local adoption by

anesthesia providers, (2) AGREE II validity data, and (3) summary of the 2018 ERAS CPG scores. Dissemination will include a written executive summary to the stakeholders in 2020.

Tools

The AGREE Reporting Checklist (Appendix H), the Stakeholder Feedback Form (Appendix E), and the AGREE II Score Sheet (Appendix I) were the primary tools used for this DNP project.

Data Collection

Approval from the University of Arizona's (UA) Institutional Review Board (IRB) was obtained on August 5, 2019 (Appendix L), and data collection occurred for four weeks. There were two phases of data collection. *Phase I* data collection included DNP CRNA graduates from the UA to avoid organizational bias. These participants were provided a link to the AGREE II tool with a tutorial on how to grade the domains and a confirmation form (Appendix F) validating they reviewed the tool. Once participants sent the confirmation form back to the PI, a copy of the 2018 ERAS CPG, articles, algorithm and Agree II tool were emailed to Phase I participants. The time frame to collect results from the AGREE II tool was limited to two weeks. *Phase II* data collection focused on the CRNA's stakeholder feedback form after an educational PowerPoint presentation about the algorithm, the 2018 ERAS CPG guideline, and results from the Phase I participant AGREE II scores. Once the data analysis was completed from Phase I, the stakeholder feedback form was sent to participant CRNAs explaining the algorithm and how to fill out the stakeholder form. Instructions to Phase II participants included emailing the form back to the PI within three days. The total data collection process for both phases was four weeks.

Data Analysis

Data were analyzed after completion of Phase I and again after Phase II. Phase I data analysis included AGREE II domain scores, which were calculated by summing up all the scores of the individual domain items and scaling the total as a percentage of the maximum possible score for those domains. An example of scoring is provided below in Table 4. All high-quality guidelines were those with item scores that are all greater than 70% (Brouwers et al., 2017). Phase II data analysis from the stakeholder feedback form was quantitatively analyzed with Stata® software and use relative frequencies and bar charts to show the results. The Greater Anesthesia Solution's (GAS) GDFT Algorithm was presented on 9/12/2019 during a weekly anesthesia meeting at the hospital in Mesa, Arizona. After the presentation, the PI requested that the Stakeholder Feedback Form (Appendix E) be filled out by the anesthesia stakeholders and submitted to a secured folder in the chief CRNA's office by 9/19/2019.

TABLE 4. *Example of domain 1 AGREE II scoring with three appraisers.*

	Item 1	**Item 2**	**Item 3**	**TOTAL**
Appraiser 1	5	6	6	**17**
Appraiser 2	6	6	7	**19**
Appraiser 3	2	4	3	**9**
Total	**13**	**16**	**16**	**45**

Maximum possible score = 7 (strongly agree) X 3 (items) X 3 (appraisers) = 63
Minimum possible score = 1 (strongly agree) X 3 (items) X 3 (appraisers) = 9

The scaled domain score is:

$$\frac{\text{Obtained score} = \text{Minimum possible score}}{\text{Maximum possible score} - \text{Minimum possible score}}$$

45-9)/63-9) X 100 = 67%

RESULTS

Phase I

Phase I participants (*n*=3) completed the AGREE II scores within two weeks (Appendix N). Results from Phase I included scoring for six domains and two open-ended questions (Table 5).

TABLE 5. *AGREE II score sheet statistics.*

Seven-Point AGREE II Score Calculator				
You must fill in ALL of the Question ratings from an appraiser for the Domain score to be accurate. **Note: Please use the AGREE II User's Manual for full instructions*				
Total # of Appraisers	Appraiser			Total
3	1	2	3	
Domain 1—Scope and Purpose				
Q1: The overall objective(s) of the guideline is (are) specifically described	7	7	6	**20**
Q2: The health question(s) covered by the guideline is (are) specifically described	7	7	7	**21**
Q3: The population (patient, public, etc.) to whom the guideline is meant to apply is specifically described.	7	7	7	**21**
	21	21	20	**62**
Domain 1 Score for 3 Appraisers: 98%				
Domain 2—Stakeholder Involvement				
Q4: The guideline development group includes individuals from all the relevant professional groups.	7	7	6	**20**
Q5: The views and preferences of the target population (patients, public, etc.) have been sought.	6	6	6	**18**
Q6: The target users of the guideline are clearly defined.	7	7	6	**20**
	20	20	18	**58**

TABLE 5 – *Continued*

Total # of Appraisers	Appraiser			Total
3	1	2	3	
Domain 2 Score for 3 Appraisers: 89%				
Domain 3—Rigour of Development				
Q7: Systematic methods were used to search for evidence.	7	7	6	**20**
Q8: The criteria for selecting the evidence are clearly described.	7	7	6	**20**
Q9: The strengths and limitations of the body of evidence are clearly described.	7	7	6	**20**
Q10: The methods for formulating the recommendations are clearly described.	7	7	6	**20**
Q11: The health benefits, side effects, and risks have been considered in formulating the recommendations.	6	7	7	**20**
Q12: There is an explicit link between the recommendations and the supporting evidence	7	7	7	**21**
Q13: The guideline has been externally reviewed by experts prior to its publication.	7	7	7	**21**
Q14: A procedure for updating the guideline is provided.	7	7	6	**20**
	55	56	51	**162**
Domain 3 Score for 3 Appraisers: 96%				
Domain 4—Clarity of Presentation				
Q15: The recommendations are specific and unambiguous.	3	4	5	**12**
Q16: The different options for management of the condition or health issue are clearly presented.	3	4	6	**13**
Q17: Key recommendations are easily identifiable.	7	7	6	**20**
	13	15	17	**45**

TABLE 5 – *Continued*

Total # of Appraisers	Appraiser			Total
3	1	2	3	
Domain 4 Score for 3 Appraisers: 67%				
Domain 5—Applicability				
Q18: The guideline describes facilitators and barriers to its application.	6	7	5	**18**
Q19: The guideline provides advice and/or tools on how the recommendations can be put into practice.	7	7	7	**21**
Q20: The potential resource implications of applying the recommendations have been considered.	7	7	7	**21**
Q21: The guideline presents monitoring and/or auditing criteria.	7	7	7	**21**
	27	28	26	**81**
Domain 5 Score for 3 Appraisers: 96%				
Domain 6—Editorial Independence				
Q22: The views of the funding body have not influenced the content of the guideline.	7	7	7	**21**
Q23: Competing interests of guideline development group members have been recorded and addressed.	7	7	7	**21**
	14	14	14	**42**
Domain 6 Score for 3 Appraisers: 100%				
Overall Guideline Assessment				
1. Rate the overall quality of this guideline. *Scoring: 1 (Least Quality) – 7 (Highest Quality)*	6	6	6	**18**
2. I would recommend this guideline for use. *Scoring: "Yes," "Yes, with modifications," "No"*	Yes, with Modifications	Yes	Yes	
3. Comments	Add algorithm and define high-risk/low-risk patients and procedures.			

Each domain scored well over 70%, with the exception of "*Clarity and Presentation,*" which scored 67% (Table 5).

Overall Quality

All participants (*n*=3) rated the overall quality of the guideline as a '6' out of a highest possible score of '7.'

Open-ended Questions

One participant stated they would recommend the use of the guideline with modifications, including the addition of an algorithm with the definition of high-risk/low-risk patients and procedures. Two participants stated they would recommend the guideline for use the way it is. After analyzing the Phase I results, an algorithm was developed with specific criteria defining high-risk/low-risk patients and abdominal procedures. This was included to improve the "Clarity and Presentation" domain.

Phase II

Phase II analysis included the Stakeholder Feedback Form, which evaluated the developed algorithm after an educational presentation by the PI. Results from the Stakeholder Feedback Form (Table 6) included CRNA participants only (*n*=4) with most of them with less than five years of experience (*n*=3).

Demographics

Four anesthesia providers (CRNAs) provided feedback on the presented algorithm by answering 13 questions via the Stakeholder Feedback Form (Table 5). Three respondent anesthesia providers had <5 years of experience (75%) and one had 16-20 years of experience (25%).

TABLE 6. *Stakeholder feedback form—graph and statistics.*

Stakeholder Feedback Form Questions	Agree	Neither Agree or Disagree	Disagree	N/A
1. The rationale for developing the algorithm is clear.	4 (100%)			
2. The literature search is relevant and complete (e.g., no missing key evidence nor any included that should not have been) in this algorithm.	4 (100%)			
3. The recommended algorithm is clear.	4 (100%)			
4. The algorithm recommendations are too rigid to apply to individual patients.		3 (75%)	1 (25%)	
5. When applied, the algorithm recommendations will produce more benefits for patients than harm.	3 (75%)	1 (25%)		
6. The application of the algorithm recommendations will require reorganization of service/care in my practice setting.	2 (50%)	1 (25%)	1 (25%)	
7. The algorithm recommendations are too expensive to apply.		3 (75%)	1 (25%)	
8. The algorithm recommendations are likely to be supported by the majority of my colleagues.	4 (100%)			
9. The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice (If they are the same as current practice, please pick NA). NA	2 (50%)	1 (25%)		1 (25%)
10. This algorithm should be approved into current practice.	4 (100%)			
11. If this algorithm were to be approved into current practice, I would use it in my own practice.	4 (100%)			
12. Please comment on any responses for which you strongly disagreed.	"The algorithm is clear." N/A			
13. Please share any additional thoughts or concerns you have with respect to the proposed algorithm.	N/A			

All participants (100%) agreed that the supporting literature search, rationale for developing the algorithm, and recommended algorithm was clear. They also agreed that the algorithm should be approved into current practice, and if approved into current practice, each respondent would integrate it into their own practice. Some of the respondents (25%) disagreed that the algorithm was too rigid to apply to individual patients and would be too expensive to apply, while the majority (75%) were indifferent. The majority of respondents (75%) also felt that the algorithm would produce more benefits than harm, which could strengthen the algorithm use in practice.

DISCUSSION

Goal-directed fluid therapy (GDFT) in colorectal surgery for high-risk patients undergoing high-risk procedures and euvolemia for low-risk patients undergoing low-risk procedures is supported by the developed algorithm and decreases morbidity and hospital length

of stay. It is the anesthesia providers' responsibility to acknowledge current evidence-based practice and integrate it into their current clinical practice. This DNP project aimed to develop an algorithm for the appropriate use of GDFT in colorectal surgery, present it, and assess if anesthesia providers would implement it into their practice. All of the anesthesia providers stated that the developed algorithm should be implemented into clinical practice, which answered the question of this project. The majority of providers found the algorithm requirements affordable and favorable to patient outcomes versus their current clinical practice. After the presentation, some of the anesthesia providers voiced concern about the availability of adequate hemodynamic monitoring devices. The cost-benefit of savings while using the algorithm was subsequently discussed, and the anesthesia providers thought they could possibly convince their administration to work the units into the annual budget. The stakeholders did not provide written feedback on the Stakeholder Feedback Form (Appendix E) regarding the cost concerns of hemodynamic monitoring devices.

Dissemination Plan

An executive summary was emailed to all anesthesia providers at the facility (Appendix P). A poster of this DNP project was developed and presented at the Arizona Sun N' Fun Conference hosted by the Arizona Association of Nurse Anesthetists in 2020.

Strengths and Weaknesses

The success of a quality improvement project based on evidence-based practice depends on proposing the right question in a time-sensitive manner, critically appraising other studies that offer conflicting results, analyzing those results, and evaluation (Tymkow, 2014). The strength of this DNP project is an all-inclusive, well-rounded, nondiscriminatory literature review on the

evidence surrounding the appropriate use of GDFT. The literature review complimented the 2018 ERAS CPG by exploring when GDFT is appropriate in the colorectal surgical population. Another strength was stakeholder buy-in. Every CRNA stakeholder that provides intraoperative care for the colorectal surgical population stated they would integrate the developed algorithm into practice. Next, the 2018 ERAS CPG was appraised by three DNP CRNAs which increased the quality of the appraisal and decreased bias. Lastly, the GDFT presentation was well received and introduced an evidence-based colorectal intraoperative fluid therapy algorithm that has shown to decrease morbidity and decrease hospital length of stays.

A weakness of this project was that the author of this DNP project lacked the administrative influence needed to monitor the continuous use of the developed GDFT algorithm in practice. Respondents during Phase II represented a small sample size resulting in a 40% participation rate. The presentation was followed by numerous surgical cases, which could have been a reason for 60% of attendees not participating.

DNP Principles

In 2006, the American Association of Colleges of Nursing (AACN) required eight essentials for all DNP programs including (1) scientific underpinnings for practice, (2) organizational and systems leadership for quality improvement, (3) clinical Scholarship and Analytical Methods for Evidence-Based Practice, (4) Information Systems/Technology and Patient Care Technology and Patient Care Technology for the Improvement and Transformation of Health Care, (5) Health Care Policy and Advocacy in Health Care, (6) Inter-Professional Collaboration for Improving Patient and Population Health Outcomes, (7) Clinical Prevention and Population Health for Improving the Nation’s Health, and (8) Advancing Nursing Practice

(AACN, 2016). For this project, the following essentials were fulfilled:

- Essential I—*scientific underpinnings for practice*, were exemplified by identification and application of scientific practices guided by research, literature review, and grading of evidence. The physiology of intraoperative fluid resuscitation during colorectal surgery scientifically identified fluid movement on the Frank-Starling curve with an explanation of the maintenance of a euvolemic state.
- Essential II—*organizational and systems leadership for quality improvement* was exemplified by forming a team, including faculty from the University of Arizona's College of Nursing and anesthesia professionals that were key stakeholders throughout this project.
- Essential III—*clinical scholarship, and analytical methods for evidence-based practice* focused on collecting the best, current evidence-based practice research on the appropriate use of GDFT and the formation of an algorithm. Analytical methods included tools such as the AGREE II tool for appropriate appraisal of the CPG with a variety of other data collection methods that were incorporated in this project.
- Essential VIII—*advancing nursing practice*, provided advanced practice CRNAs and anesthesiologists a facility-specific algorithm based on current, evidence-based research on the appropriate use of GDFT in the colorectal surgical population based on a modified clinical practice guideline.

Conclusion

Appropriate intraoperative fluid therapy management by the anesthesia provider is essential for favorable patient outcomes. The elective colorectal surgical patient population poses different challenges secondary to the fluid shifts associated with the nature of these surgeries. Traditionally, classic approaches in intraoperative fluid resuscitation momentarily helped hemodynamics but eventually led to increased morbidities and hospital length of stays. In the early 2000s, ERAS guidelines supported GDFT in every colorectal surgical patient. Currently, the 2018 ERAS guidelines support GDFT in high-risk patients undergoing high-risk procedures and euvolemia (1-4 mL/kg/hr) in low-risk patients undergoing low-risk procedures (Gustafsson et al., 2018). The development of an GDFT algorithm decreases morbidity and hospital length of stays (Feldheiser et al., 2012). An algorithm was developed for anesthesia providers during the intraoperative phase of colorectal surgery. After a presentation, anesthesia provider stakeholders stated they would integrate the algorithm into their own practice, which answered this DNP project's question. The Iowa Model helped guide this project with the seamless adoption of new evidence-based practice.

Goal-directed fluid therapy is the way of the future for high-risk patients undergoing high-risk procedures. Thus, the development of a user-friendly algorithm will help colorectal patients recover faster and decrease hospital length of stays.

OTHER INFORMATION

Budget

This DNP project did not receive any outside funding. There were no incurred costs for supplies, software, or recruitment.

APPENDIX A:

GUIDELINES FOR THE PERIOPERATIVE CARE IN ELECTIVE COLORECTAL SURGERY: ENHANCED RECOVERY AFTER SURGERY (ERAS®) SOCIETY RECOMMENDATIONS: 2018

Website link to the Guidelines for the Perioperative Care in Elective Colorectal Surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations: 2018: https://link.springer.com/content/pdf/10.1007%2Fs00268-018-4844-y.pdf

APPENDIX B:

HISTORICAL FLUID MANAGEMENT CALCULATIONS

Historical Fluid Management Calculations

4-2-1 Calculation for Determining Maintenance Fluid Requirement

- 0-10 kg: 4 mL/kg/hr.
- 11-20 kg: 4 mL/kg/hr. for the first 10 kg; 2 mL/kg/hr. for every kg>10
- >20 kg: 4 mL/kg/hr. for the first 10 kg; 2 mL/kg/hr. for the next 10 kg; 1 mL/kg/hr. for every kg >20.

Estimated Fluid Deficit

- Estimated Fluid Deficit=Maintenance Fluid Requirement X Fasting Hours

Guidelines for Replacement of Surgical Losses

- Superficial Trauma (orofacial): 1-2 mL/kg/hr.
- Minimal Trauma (herniorrhaphy): 2-4 mL/kg/hr.
- Moderate Trauma (major nonabdominal or laparoscopic abdominal surgery): 4-6 mL/kg/hr.
- Severe Trauma (major open abdominal surgery): 6-8 mL/kg/hr.

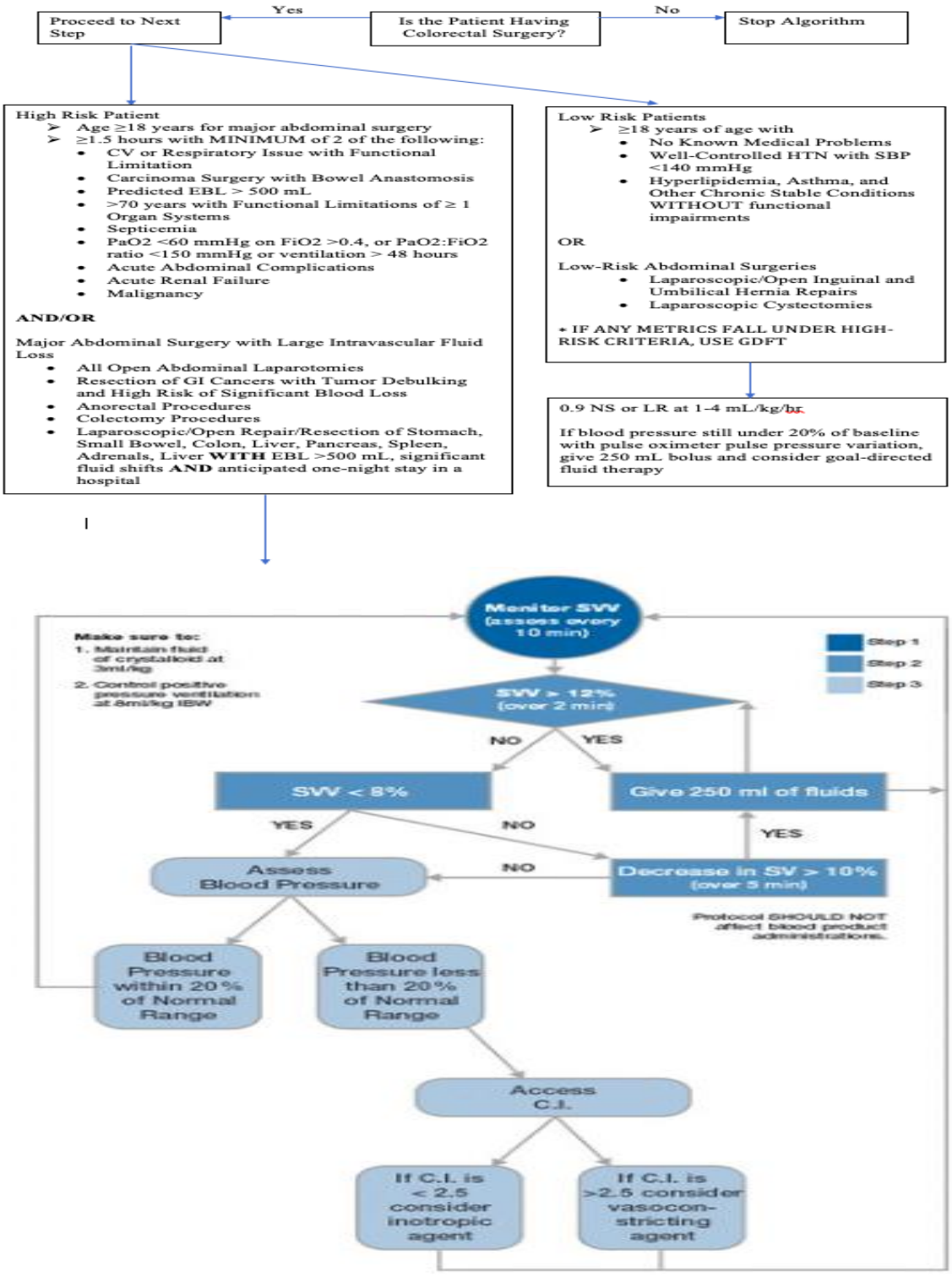
Recommendation for Replacement of Blood Loss

- Crystalloid-3:1 (3 mL for every 1 mL estimated blood loss)
- Colloid or Blood- 1:1 (1 mL for every 1 mL estimated blood loss)

Note. Reprinted from "*Nurse Anesthesia,"* by Marley, R., & Sheets, S., 2018, p. 353, St. Louis, Missouri/USA: Elsevier.

APPENDIX C:

GAS GDFT ALGORITHM


Proceed to Next Step
Yes
Is the Patient Having Colorectal Surgery?
No
Stop Algorithm
High Risk Patient
Age ≥18 years for major abdominal surgery
≥1.5 hours with MINIMUM of 2 of the following:
CV or Respiratory Issue with Functional Limitation
Carcinoma Surgery with Bowel Anastomosis
Predicted EBL > 500 mL
>70 years with Functional Limitations of ≥ 1 Organ Systems
Septicemia
PaO2 <60 mmHg on FiO2 >0.4, or PaO2:FiO2 ratio <150 mmHg or ventilation > 48 hours
Acute Abdominal Complications
Acute Renal Failure
Malignancy
AND/OR
Major Abdominal Surgery with Large Intravascular Fluid Loss
All Open Abdominal Laparotomies
Resection of GI Cancers with Tumor Debulking and High Risk of Significant Blood Loss
Anorectal Procedures
Colectomy Procedures
Laparoscopic/Open Repair/Resection of Stomach, Small Bowel, Colon, Liver, Pancreas, Spleen, Adrenals, Liver WITH EBL >500 mL, significant fluid shifts AND anticipated one-night stay in a hospital
Low Risk Patients
≥18 years of age with
No Known Medical Problems
Well-Controlled HTN with SBP <140 mmHg
Hyperlipidemia, Asthma, and Other Chronic Stable Conditions WITHOUT functional impairments
OR
Low-Risk Abdominal Surgeries
Laparoscopic/Open Inguinal and Umbilical Hernia Repairs
Laparoscopic Cystectomies
* IF ANY METRICS FALL UNDER HIGH-RISK CRITERIA, USE GDFT
0.9 NS or LR at 1-4 mL/kg/hr
If blood pressure still under 20% of baseline with pulse oximeter pulse pressure variation, give 250 mL bolus and consider goal-directed fluid therapy
Monitor SVV (assess every 10 min)
Make sure to:
1. Maintain fluid of crystalloid at 3ml/kg
2. Control positive pressure ventilation at 8ml/kg IBW
Step 1
Step 2
Step 3
SVV > 12% (over 2 min)
NO
YES
SVV < 8%
Give 250 ml of fluids
YES
NO
YES
Assess Blood Pressure
NO
Decrease in SV > 10% (over 5 min)
Protocol SHOULD NOT affect blood product administrations.
Blood Pressure within 20% of Normal Range
Blood Pressure less than 20% of Normal Range
Access C.I.
If C.I. is < 2.5 consider inotropic agent
If C.I. is >2.5 consider vasocon-stricting agent

APPENDIX D:

LITERATURE REVIEW

Author/Article	Research Question/Hypothesis	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Brandstrup, Svendsen, Rasmussen, Belhage, Rodt, Hansen, Moller, Lundbech, Andersen, Berg, Thomassen, Andersen & Simonsen (2012)	Which goal for fluid therapy during colorectal surgery is followed by the best outcome: GDFT or zero-fluid balance?	Double-Blinded Clinical Multicenter Trial	*N*= 150 patients	*N*=150 patients undergoing colorectal surgery in five Danish hospitals from March 2008 to July 2009. Patients were low risk (ASA I and II) and divided into a zero-balance group or GDFT group with block randomization and sealed opaque envelopes to provide randomization. All patients in each block were kept secret until concealment was broken at the end of the trial.	The number of patients undergoing laparoscopic or open surgery and the patient characteristics was similar between the two groups. This study showed no significant difference between GDFT and zero-fluid balance (*P*-values: 0.79; 0.62; 0.97; 0.48, respectively). No significant difference was found in the length of hospital stay [median (range) Z: 5.00 (1-61) vs D: 5.00 (2-41); *P*=0.206)
Feldheiser, Conroy, Bonomo, Cox, Garces & Spies (2012)	Does the development of an evidence-based goal-directed hemodynamic management algorithm compared to conventional hemodynamic management (1) reduce the length of hospital stay, and (2) requirement for ventilation and incidence of prolonged hospital stay resulting in reduced hospital costs?	The algorithm was developed using a systematic literature search. The algorithm was adapted to international standards and consensus was reached through a modified Delphi method at	*N*=424 patients undergoing colorectal surgeries including open right hemicolectomies, open extended right hemicolectomies, and pylorus-preserving pancreatic head resection.	Systematic search of electronic databases from January 1985 through September 2008 in the Cochrane Library, MEDLINE, PubMed, and EMBASE. Total of 22 publications evaluated using evidence criteria described by the Oxford Centre for Evidence-based Medicine. An update of the literature search was performed September 2008 through March	Implementation of the algorithm resulted in statistically significant reductions in length of hospital stay (mean ± SD ± 25.8 versus 17.7 ± 9.2 days, *P*=0.027) *Significant reductions in postoperative ventilator therapy (18.3% versus 4.8%,

Author/Article	Research Question/Hypothesis	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
		international.		2p11 with an ultimate review of 19 articles. Five recommendations were Grade A and two were Grade B.	*P*=0.004) *Significant decrease in the number of prolonged hospital stays (13.1% versus 3.2%, *P*=0.023)
Gomez-Izquierdo, Trainito, Mirzakandov, Stein, Liberman, Charlebois, Pecorelli, Feldman, Carli & Baldini (2017)	Does GDFT reduce the incidence of primary postoperative ileus after laparoscopic colorectal surgery with an ERAS program?	Single-site RCT	*N*=128 patients	Randomized patient and assessor-blind controlled trial randomly selected to receive GDFT and traditional 4-2-1 method with third space loss. Bias limited due to several perioperative confounding factors.	Incidence of primary postoperative ileus was 22% in the GDFT group and 22% in the traditional therapy control group (RR:1, CI 95%, 0.5-1.9, *P*=1)
Hamilton, Cecconi & Rhodes (2011)	Do preemptive strategies of hemodynamic monitoring and manipulation in the perioperative period for moderate- and high-risk surgical patients improve postoperative outcomes? Primary outcome: Hospital mortality Secondary outcome: Number of patients with complications after surgery.	Systematic Review and Meta-Analysis	A total of 29 articles included through snowballing of references, hand-searching, and contacting experts and industry representatives. *N*=4,805 patients	Electronic search from 1985 through January 24, 2010, using MEDLINE, EMBASE, and Cochrane Controlled Trials were searched using the following keywords: hemodynamic monitoring, cardiac output, stroke volume, oxygen delivery, goal-directed therapy, dobutamine, dopexamine, surgery, and randomized control trial (RCT). All RCTs randomized to control selection bias. Only peer-reviewed articles included. A sensitivity analysis was performed on both primary and secondary outcomes with correction of quality using Jadad score (>3	Primary Outcome: The use of preemptive hemodynamic intervention significantly reduced mortality (pooled odds ratio [95% confidence interval (CI)] of 0.48[0.33-0.78]; *P*=0.0002) Secondary Outcome: Surgical complications were also reduced (odds ratio 0.43[0.34-0.53]; *P*<0.0001).

Author/Article	Research Question/Hypothesis	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
				classification of a higher quality study). A time-dependent analysis examined the influence of change in care and underlying event rates in the last 35 years by decade.	
Iversen, Ahlberg, Lindqvist & Buchli (2017)	Does the use of GDFT improve anastomotic leakage after colorectal resections? Primary outcome Incidence of anastomotic leakage after changing clinical practice using GDFT.	Retrospective Cohort Study	*N*=894 patients	All patients with a primary anastomosis after colorectal resection at a tertiary referral center between 2006 and 2013 were analyzed. In January 2010, GDFT was initiated. Occurrence of anastomotic leakage was registered during the index hospital stay or 30 days postoperatively. Bias was minimized by the inclusion of all consecutive patients undergoing colorectal resection with primary anastomosis. All patients were comparable regarding age, sex, type of diagnosis, type of resection, multi-visceral resection and protective ostomy.	Incidence of anastomotic leakage after colorectal resections decreased 10% (41 of 409) to 4.5% (22 of 485) after using GDFT [RR 0.45 (95% CI 0.27-0.75, *P*=0.002)] with adjusted odds ratio of 0.45(0.26- 0.78, *P*=0.004)
Quinn, Brovman & Urman (2017)	Before the implementation of ERAS GDFT, what was the amount of variability of fluid administration during surgery?	Retrospective Analysis	*N*=705 patients consisting of colectomies, ileocolic resections, and lower anterior resections	Retrospective analysis of patients consisting of colectomies, ileocolic resections, and lower anterior resections at an academic institution from January 1, 2010, to May 29, 2015, collected by electronic medical	Mean total crystalloid administration 2,578 mL with standard deviation (SD) 50% of the mean value. Fluid administered to patients was

Author/Article	Research Question/Hypothesis	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
				records before the implementation of ERAS pathways.	disproportional to measured intra-operative fluid losses by a factor of 10. Average rate of fluid given was 1050 mL/hr with SD of nearly the same amount (951 mL) There was a variability of >67% in total crystalloid administered on both ideal body weight and total body weight.
Sun, Chai, Pan, Romeiser & Gan (2017)	What is the effect of perioperative goal-directed fluid therapy (GDFT) in comparison with conventional fluid therapy on postoperative recovery in adults undergoing major abdominal surgery? Outcomes 1. Short-term mortality within 30 days of surgery 2. Long-term mortality 3. Overall complication rates 4. GDFT facilitation of gastrointestinal function recovery, as demonstrated by shortening the time to first flatus by 0.4 days 5. GDFT effect on time to	Systematic Review and Meta-Analysis	Total of 45 RCTs included *N*=6,344 patients	Systematic search of MEDLINE, Embase, CINAHL, Scopus, the Cochrane Controlled Trials Register, and Cochrane Database of Systematic Reviews from inception to November 2019 using terms including surgery, fluid, goal-directed, end-point, hemodynamic, target, goal, and randomized control trials. Sensitivity analyses performed including studies for colorectal surgical procedures, studies randomizing large-sample-size patients (>100), and studies judged to carry low risk of bias. Bias estimated by calculating random effects pooled estimates	1. Short-term mortality was reduced (risk ratio [RR] 0.75, 95% CI 0.61-0.91, *P*=0.004). 2. Long-term mortality was reduced (RR 0.80, 95% CI 0.64- 0.99, *P*=0.04). 3. Overall complication rates were reduced (RR 0.76, 95% CI 0.68-0.85, *P*<0.001). 4. GDFT facilitation of gastrointestinal function recovery, as demonstrated by shortening the time to first flatus by 0.4 days

Author/Article	Research Question/Hypothesis	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
	toleration of oral diet by 0.74 days			omitting each estimate one at a time. Publication bias evaluated using Begg's funnel plots with Egger's regression asymmetry test.	(95% CI -0.72 to-0.08, *P*=0.01) 5. GDFT effect on time to toleration of oral diet by 0.74 days (95% CI – 1.44 to -0.03, *P*<0.0001)
Xu, Peng, Liu, Huang, Guo, Xiao & Qi (2018)	Does GDFT versus conventional fluid therapy in colorectal using ERAS protocols improve patient outcomes? Primary outcome: 30-day mortality Secondary outcomes: Length-of-stay (LOS), ICU admissions, complication rates, time to first flatus, time to first oral diet	Meta-Analysis of RCTs	11 RCTs *N*=1,281 patients	Electronic database search from the Cochrane Library, PubMed, Embase, Wangfang Data and ClinicalTrials.com searched from January, 1990 to February, 2018. RCTs comparing two aforementioned fluid therapies in colorectal surgeries were included. Bias was not evident according to the Begg's test. Sensitivity analyses by Stata12.0. No results changed after the sensitivity analyses.	No significant differences were found between groups in 30-day mortality rate (RR 0.86, 0.28-2.63, *P*=0.79). LOS (weighted mean difference, WMD 0.22, -0.1 to 0.55, *P*=0.18). ICU admission (RR 0.42, 0.17-1.04, *P*=0.06). GDFT group had lower complication rates (RR 0.84, 0.71 to 0.99, *P*=0.04)
Yuan, Sun, Pan & Li (2017)	Does the use of GDFT decrease the risk of surgical site infections after abdominal surgery? Primary outcome: Surgical site infections with GDFT	Systematic Review and Meta-Analysis of RCTs	29 RCTs *N*=5,317 patients	MEDLINE, Embase, CINAHL, Scopus, the Cochrane Controlled Trials Register, and Cochrane Database of Systematic Reviews were searched for RCTs from inception to May 2016 that compared the incidence of	GDFT significantly reduced the incidence of SSIs after abdominal surgery. The pooled RR was 0.74(95% CI:0.63-0.86). LOS significantly

Author/Article	Research Question/Hypothesis	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
	Secondary outcome: Hospital LOS with GDFT			surgical site infections (SSIs) in abdominal surgical patients with or without GDFT treatment. Data were pooled and RR as well as WMD with 95% Cis were calculated using either fixed or random effects models, depending on heterogeneity.	reduced in the GDFT group (WMD: -1.16 days, 95% CI: -1.92-0.40, *P*=0.003).
Zhuang, Ye Zhang, Cen, & Yu (2013	Does the use of Enhanced Recovery After Surgery (ERAS®) in the colorectal surgical population using goal-directed fluid therapy versus traditional fluid therapy: (1) decrease primary and total postoperative hospital stays? (2) readmission rates? (3) total postoperative complications? (4) mortality? (5) first passage to flatus? and, (6) time to first passage of stool?	Meta-analysis of RCTs	Total of 13 RCTs included *N*=1,910 patients	Electronic databases searched randomized control trials through PubMed, Embase and Cochrane from January 1966 to July 2012. Articles were reviewed independently by two reviewers, who extracted the data and assessed the quality of the included studies. The outcome measures were analyzed and the quality of evidence for each outcome was assessed by using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system. The Cochrane Collaboration's risk of bias tool detected bias and rated as high, low or unclear.	Primary hospital stay was significantly lower for the ERAS group than the traditional group (WMD, -2.44 days; 95% CI, -3.06 to -1.83 days; *P*<0.00001). Total hospital stay was significantly reduced for the ERAS group (WMD, -2.39 days; 95% CI, -3.70 to -1.09; *P*=0.0003). No significant difference in readmission rates between the ERAS and traditional groups (RR, 0.93; 95% CI, 0.56 – 1.54; *P*=0.88). The ERAS patients had significantly fewer complications (RR, 0.71; 95% CI, 0.58 – 0.86; *P*=0.0006).

Author/Article	Research Question/Hypothesis	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
					No significant difference in mortality between the ERAS and traditional groups (RR, 1.02; 95% CI, 0.40 – 2.57; *P*=0.97). Time to first passage of flatus was significantly reduced from the ERAS group (WMD, -1.02 days; 95% CI, -1.36 to -0.67 days; *P*<0.00001). Time to first passage of stool was significantly reduced for the ERAS group (WMD, -1.12 days; 95% CI, -1.37 to -0.87 days: *P*<0.00001).

APPENDIX E:

STAKEHOLDER FEEDBACK FORM

Stakeholder Feedback on the Developed Algorithm for Goal-Directed Fluid Therapy in Colorectal Surgery			
Type of Anesthesia Provider: ☐ CRNA ☐ Physician	Years of Practice in Current Role: ☐ <5 ☐ 5-10 ☐ 11-15 ☐ 16-20 ☐ 21-25 ☐ 25+		
	Agree	Neither Agree or Disagree	Disagree
1. The rationale for developing an algorithm is clear.	☐	☐	☐
2. The literature search is relevant and complete (e.g., no key evidence was missing nor any included that should not have been) in this algorithm.	☐	☐	☐
3. The recommended algorithm is clear.			
4. The algorithm recommendations are too rigid to apply to individual patients.			
5. When applied, the algorithm recommendation will produce more benefits for patients than harm.	☐	☐	☐
6. The application of the algorithm recommendations will require reorganization of service/care in my practice setting.	☐	☐	☐
7. The algorithm recommendations are too expensive to apply.	☐	☐	☐
8. The algorithm recommendations are likely to be supported by the majority of my colleagues.	☐	☐	☐
9. The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice (If they are the same as current practice, please tick NA). NA	☐	☐	☐
10. This algorithm should be approved into current practice.			
11. If this algorithm were to be approved into current practice, I would use it in my own practice.			
12. If this algorithm were to be approved in practice, I would apply the recommendations to my practice.	☐	☐	☐
13. Please comment on any responses for which you strongly disagreed.			
14. Please share any additional thoughts or concerns you have with respect to the proposed algorithm.			

Adopted From: Brouwers, M. C., Kho, M. E., Browman, G. P., Burgers, J. S., Cluzeau, F., Feder, G., Fervers, B., Graham, I., Grimshaw, J., Hanna, S., Littlejohns, P., Makarski, J., & Zitzelberger, L. (2017). User's manual: Instructions for using the AGREEII. *Appraisal of Guidelines Research & Evaluation II.*

APPENDIX F:

AGREE II APPRAISER EDUCATIONAL TRAINING COMPLETION CONFIRMATION FORM

AGREE II Appraiser Educational Training Completion Confirmation

I have successfully completed the AGREE II Overview Tutorial and received a copy of the AGREE II Instrument that includes the user's manual with instruction for completion of the GDFT algorithm evaluation. I have also received the AGREE II Practice Exercise and understand it is recommended to enhance standardization of scoring.

_____ _____

Signed Name Date

_____

Printed Name

APPENDIX G:

SITE APPROVAL LETTER

Greater Anesthesia Solutions
1301 South Crimson Road
Mesa, AZ 85209

May 6, 2019

University of Arizona Institutional Review Board
c/o Office of Human Subjects
1618 E. Helen Street
Tucson, AZ, 85721

Please note that Mr. Jon Bingham, UA Doctor of Nursing Practice student, has permission of Greater Anesthesia Solutions to conduct an evidence-based project at our facility for his project, "Development of an Algorithm After the Modification of a Clinical Practice Guideline for Goal-Directed Fluid Therapy in Colorectal Surgery."

Mr. Bingham will modify a clinical practice guideline (CPG) and develop an algorithm with the input, in part, of anesthesia providers from one of our primary practice sites, Mountain Vista Medical Center. The anesthesia providers will provide expert opinion and valuable organizational insight regarding the algorithm. This will include communication conducted off-site as agreed upon from both parties. Mr. Bingham's activities will be completed by May 5, 2020.

Mr. Bingham has agreed to provide and present the final modified CPG, algorithm and evaluation results based upon his completion to anesthesia stakeholders of Greater Anesthesia Solutions.

If there are any questions, please contact my office.

Signed,

Dr. Ned Sciortino
Medical Director of Anesthesia

APPENDIX H:

AGREE II REPORTING CHECKLIST

AGREE Reporting Checklist
2016

This checklist is intended to guide the reporting of clinical practice guidelines.

CHECKLIST ITEM AND DESCRIPTION	REPORTING CRITERIA	Page #
DOMAIN 1: SCOPE AND PURPOSE		
1. OBJECTIVES *Report the overall objective(s) of the guideline. The expected health benefits from the guideline are to be specific to the clinical problem or health topic.*	☐ Health intent(s) (i.e., prevention, screening, diagnosis, treatment, etc.) ☐ Expected benefit(s) or outcome(s) ☐ Target(s) (e.g., patient population, society)	
2. QUESTIONS *Report the health question(s) covered by the guideline, particularly for the key recommendations.*	☐ Target population ☐ Intervention(s) or exposure(s) ☐ Comparisons (if appropriate) ☐ Outcome(s) ☐ Health care setting or context	
3. POPULATION *Describe the population (i.e., patients, public, etc.) to whom the guideline is meant to apply.*	☐ Target population, sex and age ☐ Clinical condition (if relevant) ☐ Severity/stage of disease (if relevant) ☐ Comorbidities (if relevant) ☐ Excluded populations (if relevant)	
DOMAIN 2: STAKEHOLDER INVOLVEMENT		
4. GROUP MEMBERSHIP *Report all individuals who were involved in the development process. This may include members of the steering group, the research team involved in selecting and reviewing/rating the evidence and individuals involved in formulating the final recommendations.*	☐ Name of participant ☐ Discipline/content expertise (e.g., neurosurgeon, methodologist) ☐ Institution (e.g., St. Peter's hospital) ☐ Geographical location (e.g., Seattle, WA) ☐ A description of the member's role in the guideline development group	
5. TARGET POPULATION PREFERENCES AND VIEWS *Report how the views and preferences of the target population were sought/considered and what the resulting outcomes were.*	☐ Statement of type of strategy used to capture patients'/publics' views and preferences (e.g., participation in the guideline development group, literature review of values and preferences) ☐ Methods by which preferences and views were sought (e.g., evidence from literature, surveys, focus groups) ☐ Outcomes/information gathered on patient/public information ☐ How the information gathered was used to inform the guideline development process and/or formation of the recommendations	
6. TARGET USERS *Report the target (or intended) users of the guideline.*	☐ The intended guideline audience (e.g. specialists, family physicians, patients, clinical or institutional leaders/administrators) ☐ How the guideline may be used by its target audience (e.g., to inform clinical decisions, to inform policy, to inform standards of care)	

DOMAIN 3: RIGOUR OF DEVELOPMENT		
7. SEARCH METHODS *Report details of the strategy used to search for evidence.*	☐ Named electronic database(s) or evidence source(s) where the search was performed (e.g., MEDLINE, EMBASE, PsychINFO, CINAHL) ☐ Time periods searched (e.g., January 1, 2004 to March 31, 2008) ☐ Search terms used (e.g., text words, indexing terms, subheadings) ☐ Full search strategy included (e.g., possibly located in appendix)	
8. EVIDENCE SELECTION CRITERIA *Report the criteria used to select (i.e., include and exclude) the evidence. Provide rationale, where appropriate.*	☐ Target population (patient, public, etc.) characteristics ☐ Study design ☐ Comparisons (if relevant) ☐ Outcomes ☐ Language (if relevant) ☐ Context (if relevant)	
9. STRENGTHS & LIMITATIONS OF THE EVIDENCE *Describe the strengths and limitations of the evidence. Consider from the perspective of the individual studies and the body of evidence aggregated across all the studies. Tools exist that can facilitate the reporting of this concept.*	☐ Study design(s) included in body of evidence ☐ Study methodology limitations (sampling, blinding, allocation concealment, analytical methods) ☐ Appropriateness/relevance of primary and secondary outcomes considered ☐ Consistency of results across studies ☐ Direction of results across studies ☐ Magnitude of benefit versus magnitude of harm ☐ Applicability to practice context	
10. FORMULATION OF RECOMMENDATIONS *Describe the methods used to formulate the recommendations and how final decisions were reached. Specify any areas of disagreement and the methods used to resolve them.*	☐ Recommendation development process (e.g., steps used in modified Delphi technique, voting procedures that were considered) ☐ Outcomes of the recommendation development process (e.g., extent to which consensus was reached using modified Delphi technique, outcome of voting procedures) ☐ How the process influenced the recommendations (e.g., results of Delphi technique influence final recommendation, alignment with recommendations and the final vote)	
11. CONSIDERATION OF BENEFITS AND HARMS *Report the health benefits, side effects, and risks that were considered when formulating the recommendations.*	☐ Supporting data and report of benefits ☐ Supporting data and report of harms/side effects/risks ☐ Reporting of the balance/trade-off between benefits and harms/side effects/risks ☐ Recommendations reflect considerations of both benefits and harms/side effects/risks	
12. LINK BETWEEN RECOMMENDATIONS AND EVIDENCE *Describe the explicit link between the recommendations and the evidence on which they are based.*	☐ How the guideline development group linked and used the evidence to inform recommendations ☐ Link between each recommendation and key evidence (text description and/or reference list) ☐ Link between recommendations and evidence summaries and/or evidence tables in the results section of the guideline	

13. EXTERNAL REVIEW *Report the methodology used to conduct the external review.*	☐ Purpose and intent of the external review (e.g., to improve quality, gather feedback on draft recommendations, assess applicability and feasibility, disseminate evidence) ☐ Methods taken to undertake the external review (e.g., rating scale, open-ended questions) ☐ Description of the external reviewers (e.g., number, type of reviewers, affiliations) ☐ Outcomes/information gathered from the external review (e.g., summary of key findings) ☐ How the information gathered was used to inform the guideline development process and/or formation of the recommendations (e.g., guideline panel considered results of review in forming final recommendations)	
14. UPDATING PROCEDURE *Describe the procedure for updating the guideline.*	☐ A statement that the guideline will be updated ☐ Explicit time interval or explicit criteria to guide decisions about when an update will occur ☐ Methodology for the updating procedure	
DOMAIN 4: CLARITY OF PRESENTATION		
15. SPECIFIC AND UNAMBIGUOUS RECOMMENDATIONS *Describe which options are appropriate in which situations and in which population groups, as informed by the body of evidence.*	☐ A statement of the recommended action ☐ Intent or purpose of the recommended action (e.g., to improve quality of life, to decrease side effects) ☐ Relevant population (e.g., patients, public) ☐ Caveats or qualifying statements, if relevant (e.g., patients or conditions for whom the recommendations would not apply) ☐ If there is uncertainty about the best care option(s), the uncertainty should be stated in the guideline	
16. MANAGEMENT OPTIONS *Describe the different options for managing the condition or health issue.*	☐ Description of management options ☐ Population or clinical situation most appropriate to each option	
17. IDENTIFIABLE KEY RECOMMENDATIONS *Present the key recommendations so that they are easy to identify.*	☐ Recommendations in a summarized box, typed in bold, underlined, or presented as flow charts or algorithms ☐ Specific recommendations grouped together in one section	
DOMAIN 5: APPLICABILITY		
18. FACILITATORS AND BARRIERS TO APPLICATION *Describe the facilitators and barriers to the guideline's application.*	☐ Types of facilitators and barriers that were considered ☐ Methods by which information regarding the facilitators and barriers to implementing recommendations were sought (e.g., feedback from key stakeholders, pilot testing of guidelines before widespread implementation) ☐ Information/description of the types of facilitators and barriers that emerged from the inquiry (e.g., practitioners have the skills to deliver the recommended care, sufficient equipment is not available to ensure all eligible members of the	

	population receive mammography) ☐ How the information influenced the guideline development process and/or formation of the recommendations	
19. IMPLEMENTATION ADVICE/TOOLS *Provide advice and/or tools on how the recommendations can be applied in practice.*	☐ Additional materials to support the implementation of the guideline in practice. For example: ▫ Guideline summary documents ▫ Links to check lists, algorithms ▫ Links to how-to manuals ▫ Solutions linked to barrier analysis (see Item 18) ▫ Tools to capitalize on guideline facilitators (see Item 18) ▫ Outcome of pilot test and lessons learned	
20. RESOURCE IMPLICATIONS *Describe any potential resource implications of applying the recommendations.*	☐ Types of cost information that were considered (e.g., economic evaluations, drug acquisition costs) ☐ Methods by which the cost information was sought (e.g., a health economist was part of the guideline development panel, use of health technology assessments for specific drugs, etc.) ☐ Information/description of the cost information that emerged from the inquiry (e.g., specific drug acquisition costs per treatment course) ☐ How the information gathered was used to inform the guideline development process and/or formation of the recommendations	
21. MONITORING/ AUDITING CRITERIA *Provide monitoring and/or auditing criteria to measure the application of guideline recommendations.*	☐ Criteria to assess guideline implementation or adherence to recommendations ☐ Criteria for assessing impact of implementing the recommendations ☐ Advice on the frequency and interval of measurement ☐ Operational definitions of how the criteria should be measured	
DOMAIN 6: EDITORIAL INDEPENDENCE		
22. FUNDING BODY *Report the funding body's influence on the content of the guideline.*	☐ The name of the funding body or source of funding (or explicit statement of no funding) ☐ A statement that the funding body did not influence the content of the guideline	
23. COMPETING INTERESTS *Provide an explicit statement that all group members have declared whether they have any competing interests.*	☐ Types of competing interests considered ☐ Methods by which potential competing interests were sought ☐ A description of the competing interests ☐ How the competing interests influenced the guideline process and development of recommendations	

APPENDIX I:

AGREE II SCORE SHEET

AGREE II Score Sheet

Domain	Item	AGREE II Rating						
		1 *Strongly Disagree*	2	3	4	5	6	7 *Strongly Agree*
Scope and purpose	1. The overall objective(s) of the guideline is (are) specifically described.							
	2. The health question(s) covered by the guideline is (are) specifically described.							
	3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described.							
Stakeholder involvement	4. The guideline development group includes individuals from all the relevant professional groups.							
	5. The views and preferences of the target population (patients, public, etc.) have been sought.							
	6. The target users of the guideline are clearly defined.							
Rigor of development	7. Systematic methods were used to search for evidence.							
	8. The criteria for selecting the evidence are clearly described.							
	9. The strengths and limitations of the body of evidence are clearly described.							
	10. The methods for formulating the recommendations are clearly described.							
	11. The health benefits, side effects and risks have been considered in formulating the recommendations.							
	12. There is an explicit link between the recommendations and the supporting evidence.							
	13. The guideline has been externally reviewed by experts prior to its publication.							
	14. A procedure for updating the guideline is provided.							
Clarity of presentation	15. The recommendations are specific and unambiguous.							
	16. The different options for management of the condition or health issue are clearly presented.							
	17. Key recommendations are easily identifiable.							
Applicability	18. The guideline describes facilitators and barriers to its application.							
	19. The guideline provides advice and/or tools on how the recommendations can be put into practice.							
	20. The potential resource implications of applying the recommendations have been considered.							
	21. The guideline presents monitoring and/ or auditing criteria.							
Editorial independence	22. The views of the funding body have not influenced the content of the guideline.							
	23. Competing interests of guideline development group members have been recorded and addressed.							
Overall Guideline Assessment	1. Rate the overall quality of this guideline.	1 *Lowest possible quality*	2	3	4	5	6	7 *Highest possible quality*
Overall Guideline Assessment	2. I would recommend this guideline for use.	*Yes*	*Yes, with modifications*					*No*

APPENDIX J:

PHASE I PARTICIPANT DISCLOSURE LETTER

Dear Participant,

My name is Jon Bingham, and I am a nurse currently in the Nurse Anesthesia Doctor of Nursing Program (DNP) at the University of Arizona. I am inviting you to participate in my DNP project about developing a goal-directed fluid therapy (GDFT) algorithm after modification of a current clinical practice guideline (CPG). I have developed an algorithm which guides intraoperative fluid therapy for elective colorectal surgical patients based off the 2018 Enhanced Recovery After Surgery (ERAS) CPG. I have included in this algorithm patient type (high-risk or low-risk) and type of surgery (high-risk or low-risk) which was not included in the original ERAS guideline. You are being asked to participate in this project because you currently work in a relevant health profession and are considered a key stakeholder for making decisions about intraoperative fluid therapy.

Participation in the project entails completing the AGREE II Overview Tutorial at http://www.agreetrust.org/resource-centre/agree-ii-training-tools/ and then apprising the developed CPG utilizing the AGREE II assessment tool. Prior to accessing the appraisal of the algorithm, you will be asked to sign the confirmation form that you have completed the tutorial and understand directions. An email will be sent directly from the My AGREE Plus platform with directions and links to complete the online CPG appraisal as well as the algorithm.

Completing the online CPG appraisal and participating in this project is completely voluntary and implies informed consent. If you decide to participate in this project, all data collected will remain confidential and anonymous. Information gathered through this project will be used for this DNP project and may be used for the development of future scholarly projects. At this time, the author has no plans to publish the information gathered from this project. The Determination of Human Research application was reviewed by the University of Arizona Institutional Review Board and is deemed Not Human Research.

Your choice to participate in this project is entirely voluntary with no known risks. You may choose to decline or stop participation at any time during the project with no questions asked.

For questions, concerns, or complaints related to this project, please feel free to contact the principle investigator, Jon Bingham at jonbingham85@email.arizona.edu. If you have questions or concerns regarding your rights as a participant in this project, you are encouraged to contact the Human Subjects Protection Program at the University of Arizona. Their email address is VPR-IRB@email.arizona.edu and phone number is (520) 626-7575.

Thank you for your time and consideration in supporting my DNP project.

Jon Bingham, BSN, RN, SRNA-DNP Jonbingham85@email.arizona.edu (414) 813-0088

APPENDIX K:

PHASE II PARTICIPATION DISCLOSURE LETTER

Dear Participant,

My name is Jon Bingham, and I am a nurse currently in the Nurse Anesthesia Doctor of Nursing Program (DNP) at the University of Arizona. I have developed an algorithm for goal-directed fluid therapy (GDFT) which was modified from the 2018 Enhanced Recovery After Surgery (ERAS) guidelines. I have included in this algorithm patient type (high-risk or low-risk) and type of surgery (high-risk or low-risk) which was not included in the original ERAS guidelines. The algorithm has been appraised and deemed high-quality by Doctor of Nursing Practice (DNP) Certified Registered Nurse Anesthetists. I am inviting you to participate in providing feedback on the developed algorithm using the stakeholder feedback form. You are being asked to participate in this project because you currently work in a relevant health profession and are considered a key stakeholder for the developed GDFT algorithm.

Participation in this project entails viewing a PowerPoint presentation of the 2018 ERAS guidelines for GDFT and the importance of intraoperative fluid therapy. Once this is completed, I ask that you provide feedback on the developed algorithm for *Goal-Directed Fluid Therapy in Colorectal Surgery* using the Stakeholder Feedback Form.

Completing the Stakeholder Feedback Form and participating in this project is completely voluntary and implies informed consent. If you decide to participate in this project, all data collected will remain confidential and anonymous. Information gathered through this project will be used for this DNP project and may be used for the development of future scholarly projects. At this time, the author has no plans to publish the information gathered from this project. The Determination of Human Research application was reviewed by the University of Arizona Institutional Review Board and is deemed Not Human Research.

Your choice to participate in this project is entirely voluntary with no known risks. You may choose to decline or stop participation at any time during the project. Your decision to decline or stop participation will be respected and will not affect any future relationship with the University of Arizona, or affiliated organization.

For questions, concerns, or complaints related to this project, please feel free to contact the principle investigator, Jon Bingham at jonbingham85@email.arizona.edu. If you have questions or concerns regarding your rights as a participant in this project, you are encouraged to contact the Human Subjects Protection Program at the University of Arizona. Their email address is VPR-IRB@email.arizona.edu and phone number is (520) 626-7575.

Thank you for your time and consideration in supporting my DNP project.

Jon Bingham, BSN, RN, SRNA-DNP Jonbingham85@email.arizona.edu (414) 813-0088

APPENDIX L:

THE UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

THE UNIVERSITY OF ARIZONA
Research, Discovery & Innovation

Human Subjects Protection Program

1618 E. Helen St.
P.O.Box 245137
Tucson, AZ 85724-5137
Tel: (520) 626-6721
http://rgw.arizona.edu/compliance/home

Date: August 05, 2019

Principal Investigator: Jon David Bingham

Protocol Number:	1908854229
Protocol Title:	Development of an Algorithm for Goal-Directed Fluid Therapy in Colorectal Surgery
Determination:	Human Subjects Review not Required

Documents Reviewed Concurrently:

HSPP Forms/Correspondence: *Bingham IRB Determination of Human Research 3.pdf*

Regulatory Determinations/Comments:

- Not Research as defined by 45 CFR 46.102(l): As presented, the activities described above do not meet the definition of research cited in the regulations issued by U.S. Department of Health and Human Services which state that "Research means a systematic investigation, including research development, testing, and evaluation, designed to develop or contribute to generalizable knowledge. Activities that meet this definition constitute research for purposes of this policy, whether or not they are conducted or supported under a program that is considered research for other purposes. For example, some demonstration and service programs may include research activities. For purposes of this part, the following activities are deemed not to be research."

The project listed above does not require oversight by the University of Arizona.

If the nature of the project changes, submit a new determination form to the Human Subjects Protection Program (HSPP) for reassessment. Changes include addition of research with children, specimen collection, participant observation, prospective collection of data when the study was previously retrospective in nature, and broadening the scope or nature of the study activity. Please contact the HSPP to consult on whether the proposed changes need further review.

The University of Arizona maintains a Federalwide Assurance with the Office for Human Research Protections (FWA #00004218).

APPENDIX M:

AGREE II APPRAISER EDUCATIONAL TRAINING COMPLETION CONFIRMATION

AGREE II Appraiser Educational Training Completion Confirmation

I have successfully completed the AGREE II Overview Tutorial and received a copy of the AGREE II Instrument that includes the user's manual with instruction for completion of the GDFT algorithm evaluation. I have also received the AGREE II Practice Exercise and understand it is recommended to enhance standardization of scoring.

[redacted] 8/6/2019
Signed Name Date

[redacted]
Printed Name

AGREE II Appraiser Educational Training Completion Confirmation

I have successfully completed the AGREE II Overview Tutorial and received a copy of the AGREE II Instrument that includes the user's manual with instruction for completion of the GDFT algorithm evaluation. I have also received the AGREE II Practice Exercise and understand it is recommended to enhance standardization of scoring.

[redacted] 8/5/2019
Signed Name Date

[redacted]
Printed Name

AGREE II Appraiser Educational Training Completion Confirmation

I have successfully completed the AGREE II Overview Tutorial and received a copy of the AGREE II Instrument that includes the user's manual with instruction for completion of the GDFT algorithm evaluation. I have also received the AGREE II Practice Exercise and understand it is recommended to enhance standardization of scoring.

[redacted] 8/7/2019
Signed Name Date

[redacted]
Printed Name

APPENDIX N:

COMPLETED AGREE II SCORE SHEETS

AGREE II Score Sheet

Domain	Item	AGREE II Rating						
		1 *Strongly Disagree*	2	3	4	5	6	7 *Strongly Agree*
Scope and purpose	1. The overall objective(s) of the guideline is (are) specifically described.							✓
	2. The health question(s) covered by the guideline is (are) specifically described.							✓
	3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described.							✓
Stakeholder involvement	4. The guideline development group includes individuals from all the relevant professional groups.							✓
	5. The views and preferences of the target population (patients, public, etc.) have been sought.						✓	
	6. The target users of the guideline are clearly defined.							✓
Rigor of development	7. Systematic methods were used to search for evidence.							✓
	8. The criteria for selecting the evidence are clearly described.							✓
	9. The strengths and limitations of the body of evidence are clearly described.							✓
	10. The methods for formulating the recommendations are clearly described.							✓
	11. The health benefits, side effects and risks have been considered in formulating the recommendations.						✓	
	12. There is an explicit link between the recommendations and the supporting evidence.							✓
	13. The guideline has been externally reviewed by experts prior to its publication.							✓
	14. A procedure for updating the guideline is provided.							✓
Clarity of presentation	15. The recommendations are specific and unambiguous.			✓				
	16. The different options for management of the condition or health issue are clearly presented.			✓				
	17. Key recommendations are easily identifiable.							✓
Applicability	18. The guideline describes facilitators and barriers to its application.						✓	
	19. The guideline provides advice and/or tools on how the recommendations can be put into practice.							✓
	20. The potential resource implications of applying the recommendations have been considered.							✓
	21. The guideline presents monitoring and/ or auditing criteria.							✓
Editorial independence	22. The views of the funding body have not influenced the content of the guideline.							✓
	23. Competing interests of guideline development group members have been recorded and addressed.							✓
Overall Guideline Assessment	1. Rate the overall quality of this guideline.	1 *Lowest possible quality*	2	3	4	5	6	7 *Highest possible quality*
Overall Guideline Assessment	2. I would recommend this guideline for use.	*Yes*		*Yes, with modifications*				*No*
				Add algorithm and define high-risk/low-risk patients and procedures				

AGREE II Score Sheet

Domain	Item	AGREE II Rating						
		1 *Strongly Disagree*	2	3	4	5	6	7 *Strongly Agree*
Scope and purpose	1. The overall objective(s) of the guideline is (are) specifically described.							X
	2. The health question(s) covered by the guideline is (are) specifically described.							X
	3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described.							X
Stakeholder involvement	4. The guideline development group includes individuals from all the relevant professional groups.							X
	5. The views and preferences of the target population (patients, public, etc.) have been sought.					X		
	6. The target users of the guideline are clearly defined.							X
Rigor of development	7. Systematic methods were used to search for evidence.							X
	8. The criteria for selecting the evidence are clearly described.							X
	9. The strengths and limitations of the body of evidence are clearly described.							X
	10. The methods for formulating the recommendations are clearly described.							X
	11. The health benefits, side effects and risks have been considered in formulating the recommendations.							X
	12. There is an explicit link between the recommendations and the supporting evidence.							X
	13. The guideline has been externally reviewed by experts prior to its publication.							X
	14. A procedure for updating the guideline is provided.							X
Clarity of presentation	15. The recommendations are specific and unambiguous.				X			
	16. The different options for management of the condition or health issue are clearly presented.				X			
	17. Key recommendations are easily identifiable.							X
Applicability	18. The guideline describes facilitators and barriers to its application.							X
	19. The guideline provides advice and/or tools on how the recommendations can be put into practice.							X
	20. The potential resource implications of applying the recommendations have been considered.							X
	21. The guideline presents monitoring and/ or auditing criteria.							X
Editorial independence	22. The views of the funding body have not influenced the content of the guideline.							X
	23. Competing interests of guideline development group members have been recorded and addressed.							X
Overall Guideline Assessment	1. Rate the overall quality of this guideline.	1 *Lowest possible quality*	2	3	4	5	6	7 *Highest possible quality*
Overall Guideline Assessment	2. I would recommend this guideline for use.	*Yes*	*Yes, with modifications*					*No*
		X						

AGREE II Score Sheet

Domain	Item	AGREE II Rating						
		1 *Strongly Disagree*	2	3	4	5	6	7 *Strongly Agree*
Scope and purpose	1. The overall objective(s) of the guideline is (are) specifically described.						✓	
	2. The health question(s) covered by the guideline is (are) specifically described.							✓
	3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described.							✓
Stakeholder involvement	4. The guideline development group includes individuals from all the relevant professional groups.						✓	
	5. The views and preferences of the target population (patients, public, etc.) have been sought.						✓	
	6. The target users of the guideline are clearly defined.						✓	
Rigor of development	7. Systematic methods were used to search for evidence.						✓	
	8. The criteria for selecting the evidence are clearly described.						✓	
	9. The strengths and limitations of the body of evidence are clearly described.						✓	
	10. The methods for formulating the recommendations are clearly described.						✓	
	11. The health benefits, side effects and risks have been considered in formulating the recommendations.							✓
	12. There is an explicit link between the recommendations and the supporting evidence.							✓
	13. The guideline has been externally reviewed by experts prior to its publication.							✓
	14. A procedure for updating the guideline is provided.						✓	
Clarity of presentation	15. The recommendations are specific and unambiguous.					✓		
	16. The different options for management of the condition or health issue are clearly presented.						✓	
	17. Key recommendations are easily identifiable.						✓	
Applicability	18. The guideline describes facilitators and barriers to its application.					✓		
	19. The guideline provides advice and/or tools on how the recommendations can be put into practice.							✓
	20. The potential resource implications of applying the recommendations have been considered.							✓
	21. The guideline presents monitoring and/ or auditing criteria.							✓
Editorial independence	22. The views of the funding body have not influenced the content of the guideline.							✓
	23. Competing interests of guideline development group members have been recorded and addressed.							✓
Overall Guideline Assessment	1. Rate the overall quality of this guideline.	1 *Lowest possible quality*	2	3	4	5	(6)	7 *Highest possible quality*
Overall Guideline Assessment	2. I would recommend this guideline for use.	*Yes*		*Yes, with modifications*				*No*
		✓						

APPENDIX O:

COMPLETED STAKEHOLDER FEEDBACK FORMS

Stakeholder Feedback on the Developed Algorithm for Goal-Directed Fluid Therapy in Colorectal Surgery

Type of Anesthesia Provider: ☑ CRNA ☐ Physician

Years of Practice in Current Role: ☑ <5 ☐ 5-10 ☐ 11-15 ☐ 16-20 ☐ 21-25. ☐ 25+

	Agree	Neither Agree or Disagree	Disagree
1. The rationale for developing an algorithm is clear.	✓		
2. The literature search is relevant and complete (e.g. no missing key evidence nor any included that should not have been) in this algorithm.	✓		
3. The recommended algorithm is clear.	✓		
4. The algorithm recommendations are too rigid to apply to individual patients.		✓	
5. When applied, the algorithm recommendation will produce more benefits for patients than harms.		✓	
6. The application of the algorithm recommendations will require reorganization of service/care in my practice setting.	✓		
7. The algorithm recommendations are too expensive to apply.		✓	
8. The algorithm recommendations are likely to be supported by the majority of my colleagues.	✓		
9. The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice (If they are the same as current practice, please pick NA). NA	✓		
10. This algorithm should be approved into current practice.	✓		
11. If this algorithm were to be approved into current practice, I would use it in my own practice.	✓		
12. Please comment on any responses for which you strongly disagreed.			
13. Please share any additional thoughts or concerns you have with respect to the proposed algorithm.			

Adopted From: Brouwers, M. C., Kho, M. E., Browman, G. P., Burgers, J. S., Cluzeau, F., Feder, G., Fervers, B., Graham, I., Grimshaw, J., Hanna, S., Littlejohns, P., Makarski, J., & Zitzelberger, L. (2017). User's manual: instructions for using the AGREEII. *Appraisal of Guidelines Research & Evaluation II.*

Stakeholder Feedback on the Developed Algorithm for Goal-Directed Fluid Therapy in Colorectal Surgery

Type of Anesthesia Provider: ☒ CRNA ☐ Physician

Years of Practice in Current Role: ☐ <5 ☐ 5-10 ☐ 11-15 ☒ 16-20 ☐ 21-25. ☐ 25+

	Agree	Neither Agree or Disagree	Disagree
1. The rationale for developing an algorithm is clear.	X		
2. The literature search is relevant and complete (e.g. no missing key evidence nor any included that should not have been) in this algorithm.	X		
3. The recommended algorithm is clear.	X		
4. The algorithm recommendations are too rigid to apply to individual patients.			X
5. When applied, the algorithm recommendation will produce more benefits for patients than harms.	X		
6. The application of the algorithm recommendations will require reorganization of service/care in my practice setting.		X	
7. The algorithm recommendations are too expensive to apply.		X	
8. The algorithm recommendations are likely to be supported by the majority of my colleagues.	X		
9. The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice (If they are the same as current practice, please pick NA). NA		X	
10. This algorithm should be approved into current practice.	X		
11. If this algorithm were to be approved into current practice, I would use it in my own practice.	X		
12. Please comment on any responses for which you strongly disagreed.			
13. Please share any additional thoughts or concerns you have with respect to the proposed algorithm.			

Adopted From: Brouwers, M. C., Kho, M. E., Browman, G. P., Burgers, J. S., Cluzeau, F., Feder, G., Fervers, B., Graham, I., Grimshaw, J., Hanna, S., Littlejohns, P., Makarski, J., & Zitzelberger, L. (2017). User's manual: instructions for using the AGREEII. *Appraisal of Guidelines Research & Evaluation II.*

Stakeholder Feedback on the Developed Algorithm for Goal-Directed Fluid Therapy in Colorectal Surgery

Type of Anesthesia Provider: ☒ CRNA ☐ Physician

Years of Practice in Current Role: ☒ <5 ☐ 5-10 ☐ 11-15 ☐ 16-20 ☐ 21-25. ☐ 25+

	Agree	Neither Agree or Disagree	Disagree
1. The rationale for developing an algorithm is clear.	✓		
2. The literature search is relevant and complete (e.g. no missing key evidence nor any included that should not have been) in this algorithm.	✓		
3. The recommended algorithm is clear.	✓		
4. The algorithm recommendations are too rigid to apply to individual patients.		✓	
5. When applied, the algorithm recommendation will produce more benefits for patients than harms.	✓		
6. The application of the algorithm recommendations will require reorganization of service/care in my practice setting.			✓
7. The algorithm recommendations are too expensive to apply.			✓
8. The algorithm recommendations are likely to be supported by the majority of my colleagues.	✓		
9. The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice (If they are the same as current practice, please pick NA). NA			
10. This algorithm should be approved into current practice.	✓		
11. If this algorithm were to be approved into current practice, I would use it in my own practice.	✓		
12. Please comment on any responses for which you strongly disagreed.	N/A		
13. Please share any additional thoughts or concerns you have with respect to the proposed algorithm.	N/A		

Adopted From: Brouwers, M. C., Kho, M. E., Browman, G. P., Burgers, J. S., Cluzeau, F., Feder, G., Fervers, B., Graham, I., Grimshaw, J., Hanna, S., Littlejohns, P., Makarski, J., & Zitzelberger, L. (2017). User's manual: instructions for using the AGREEII. *Appraisal of Guidelines Research & Evaluation II.*

Stakeholder Feedback on the Developed Algorithm for Goal-Directed Fluid Therapy in Colorectal Surgery

Type of Anesthesia Provider: ☒ CRNA ☐ Physician

Years of Practice in Current Role: ☒ <5 ☐ 5-10 ☐ 11-15 ☐ 16-20 ☐ 21-25. ☐ 25+

	Agree	Neither Agree or Disagree	Disagree
1. The rationale for developing an algorithm is clear.	✓		
2. The literature search is relevant and complete (e.g. no missing key evidence nor any included that should not have been) in this algorithm.	X		
3. The recommended algorithm is clear.	✓		
4. The algorithm recommendations are too rigid to apply to individual patients.		✓	
5. When applied, the algorithm recommendation will produce more benefits for patients than harms.	X		
6. The application of the algorithm recommendations will require reorganization of service/care in my practice setting.	X		
7. The algorithm recommendations are too expensive to apply.		✓	
8. The algorithm recommendations are likely to be supported by the majority of my colleagues.	✓		
9. The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice (If they are the same as current practice, please pick NA). NA	✓		
10. This algorithm should be approved into current practice.	✓		
11. If this algorithm were to be approved into current practice, I would use it in my own practice.	✓		
12. Please comment on any responses for which you strongly disagreed.	THE ALGORITHM IS WELL		
13. Please share any additional thoughts or concerns you have with respect to the proposed algorithm.			

Adopted From: Brouwers, M. C., Kho, M. E., Browman, G. P., Burgers, J. S., Cluzeau, F., Feder, G., Fervers, B., Graham, I., Grimshaw, J., Hanna, S., Littlejohns, P., Makarski, J., & Zitzelberger, L. (2017). User's manual: instructions for using the AGREEII. *Appraisal of Guidelines Research & Evaluation II.*

APPENDIX P:

EXECUTIVE SUMMARY

Executive Summary

Overview

- The goal of this project was to use the current 2018 ERAS clinical practice guideline (CPG) recommendations regarding the appropriate use of goal-directed fluid therapy (GDFT) in the colorectal surgical population.
- In 2015, there were 2,583 new colorectal cancers requiring surgical intervention excluding surgeries involving inflammatory, anorectal, and diverticular disease.
- Evidence shows that GDFT is appropriate for high-risk patients undergoing high-risk surgery.
- The GAS GDFT Algorithm may reduce health care costs by up to $970 per patient.
- The average direct cost of care was $47,284 for patients with complications compared with $17,408 for patients without complications.

Methods

- This QI project was guided by the Iowa Model in appraising the 2018 ERAS CPG toward the development of an algorithm for intraoperative fluid therapy for elective colorectal surgery.
- The 2018 ERAS CPG was appraised by DNP-prepared CRNAs using the AGREE II tool.
- The 2018 ERAS CPG was improved by identifying high-risk patients and colorectal surgical procedures and low-risk patients and colorectal procedures.
- The GAS GDFT Algorithm was developed after modification of the 2018 ERAS CPG.
- The GAS GDFT Algorithm was presented on September 12, 2019 during a weekly meeting.
- After the presentation, four anesthesia providers filled out the Stakeholder Feedback Form to determine if the GAS GDFT Algorithm would be accepted and implemented for their practice.

Results

- 100% of respondents stated that they agreed that:
  - The rationale for developing the algorithm was clear.
  - The literature search was relevant and complete relating to the algorithm.
  - The recommended algorithm was clear.
  - The algorithm should be approved into current practice.
  - If the algorithm were approved into current practice, they would use it in their own practice.
- 75% of respondents stated they agreed that:
  - When applied, the algorithm recommendations will produce more benefits for patients than harm.
- 75% of respondents neither agreed or disagreed that:
  - The algorithm recommendations are too rigid to apply to individual patients.
  - The algorithm recommendations are too expensive to apply.
- 50% of respondents agreed that:
  - The application of the algorithm and recommendations will require reorganization of service/care in my practice setting.
  - The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice.

- 25% of respondents neither agreed or disagreed that:
  - When applied, the algorithm recommendations will produce more benefits for patients than harm.
  - The application of the algorithm recommendations will require reorganization of service/care in their practice setting.
  - The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice.
- 25% of respondents disagreed that:
  - The algorithm recommendations are too rigid to apply to individual patients.
  - The application of the algorithm recommendations will require reorganization of service/care in my practice setting.
  - The algorithm recommendations are too expensive to apply.
- 25% of respondents responded non-applicable to:
  - The algorithm reflects a more effective approach for improving patient outcomes than is current usual practice (If they are the same as current practice, please pick NA).
- Comments for which respondents disagreed included:
  - "N/A"
  - "The algorithm is clear."

Recommendations

- Consider enhancing knowledge through dissemination of evidence illustrating the value of the GAS GDFT Algorithm.
- Consider using the GAS GDFT Algorithm to decrease morbidity and hospital length of stays.
- Consider investing in more hemodynamic monitoring devices to implement the GAS GDFT Algorithm.
- Consider using available hemodynamic monitoring devices to implement the GAS GDFT Algorithm.
- Consider presenting this knowledge to new anesthesia providers to improve patient outcomes undergoing elective colorectal surgery.

Conclusion

- Current evidence proves that goal-directed fluid therapy (GDFT) is appropriate in high-risk patients undergoing high-risk colorectal procedures and euvolemia is appropriate for low-risk patients undergoing low-risk procedures.
- The GAS GDFT Algorithm is evidence-based and should be adapted into current practice.

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