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Evidence-Based Practice Recommendations for the use of a Cardiac Optimization Algorithm in Patients Undergoing a Whipple Procedure

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Final Scholarly Project: Evidence-Based Practice Recommendations for the use of a Cardiac Optimization Algorithm in Patients Undergoing a Whipple Procedure

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We have no conflicts of interest to disclose.

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Abstract

A fundamental responsibility of a certified registered nurse anesthetist includes intraoperative fluid and hemodynamic management. While Enhanced Recovery After Surgery protocols advocate goal-directed fluid therapy, the methodology remains controversial. An algorithmic approach systematically optimizes cardiac function and fluid volume status based on stroke volume variation, cardiac index, and mean arterial pressure. This project aims to evaluate the effects of placing intraoperative guidelines for patients undergoing a Whipple procedure when using a cardiac optimization algorithm to guide fluid and vasopressor management. The outcomes evaluated included the amount of fluids delivered intraoperatively, vasoactive medication administration, urine output, amount of blood transfusions, cardiac and respiratory outcomes, and pancreatic fistulas. The findings of this project present an effective way to manage a patient's fluid status to help improve patient surgical outcomes and postoperative complications.

Keywords: goal-directed fluid therapy, stroke volume variation, cardiac optimization algorithm, whipple procedure

Introduction

The fourth most frequent cancer-related cause of death in the United States is pancreatic adenocarcinoma. The most common surgical treatment for pancreatic head adenocarcinoma is a Whipple procedure (Whipple Procedure, 2023). The procedure is complex and involves opening the abdominal cavity surgically which causes vast fluid shifts throughout the intracellular and extracellular compartments in the body. Issues that can arise from poor fluid management include hypoperfusion to major organs, intestinal ischemia, or edema leading to inflammatory processes (Melloul et al., 2020). Adequate fluid management remains crucial to ensure that the body's physiologic state is protected. Even with advancements in surgical techniques and developments of early recovery after surgery (ERAS) protocols, complications remain relevant. The procedure complexity gives rise to long recovery times and puts the patient at risk for perioperative complications.

A Whipple procedure remains the primary treatment strategy for pancreatic cancer. There are projected increases in the rate of pancreatic cancer, which increases the need to reduce problems associated with a Whipple procedure (Weinberg et al., 2017). Current literature on managing fluids and vasopressors during the perioperative period remains controversial. Current literature advocates for goal directed fluid therapy (GDFT) within ERAS protocols during Whipple procedures (Melloul et al., 2020). The way to achieve GDFT to provide the best outcomes for Whipple procedures remains unclear. Providers can follow an algorithmic approach utilizing the FloTrac™ Catheter and Hemosphere™ monitor to guide individual treatment. The FloTrac™ device provides advanced hemodynamic parameters such as stroke volume (SV), stroke volume variation (SVV), mean arterial pressure (MAP), systemic vascular resistance (SVR), cardiac output (CO), and cardiac index (CI) every 20 seconds (FloTrac System, 2023).

By following an algorithm to guide fluid and vasopressor management an Anesthetist has clear cut goals to provide an intervention. Thus, better outcomes can be achieved for patients and complications that arise from poor management of fluids. The goal of this project is to develop an algorithmic approach based on evidence-based practice (EBP). The outcomes being studied include SVV, fluids administered during surgery, urine output, blood transfusions, vasoactive medications administered, cardiac and respiratory outcomes, and pancreatic fistulas.

Background

For the past 60 years, fluid management in the operating room has utilized a fixed volume approach regardless of fluid volume status, vascular tone, myocardial function, and renal function at the onset of surgery. (Frost, 2018). As a result of poor fluid management, patients can have issues with tissue perfusion, oxygenation, or edema. Fluid management can have a significant impact on perioperative morbidity and mortality which can include pancreatic and biliary fistulas, arrhythmias, and respiratory outcomes.

Traditional Fluid Management Strategies

Preemptive fluid administration, frequently used to address perceived fasting deficiencies, significantly contributes to fluid overload perioperative problems (Kang & Yoo, 2019). Fluid overload can lead to interstitial edema and local inflammation which negatively impacts wound healing while increasing chances of wound dehiscences, wound infections, and anastomotic leakage (Liu et al., 2019). Additionally, current research shows that prophylactic volume administration in euvolemic patients increases the chance of disrupting the endothelium glycocalyx and causing pathological fluid overload by a significant amount (Hippensteel et al., 2019).

The historical fluid administration approach utilizes uniform calculations for administering intravenous fluids intraoperatively. The 4-2-1 technique for fluid administration persists as the method that gets used by a majority of providers (Frost, 2018). There are other standard calculations within traditional fluid management that include the estimated fluid deficit, replacement of surgical losses, and replacement of blood loss (Frost, 2018). Calculating the fluid deficit is done by multiplying the maintenance fluid rate by the hours with nothing by mouth (NPO). The rationale for these calculations of the historical fluid management approach was a theory that patients incurred fluid debt in the preoperative fasting period and needed fluid volume to maintain homeostasis (Kayilioglu et al., 2015).

Recommendations for treating acute intraoperative blood loss continue to use historical techniques which utilize liberal fluid administration. A 3:1 ratio of crystalloid solutions to estimated blood loss (EBL) remains the usual practice to maintain intravascular volume and account for crystalloid filtration via the interstitial space; however, research suggests that the actual ratio of crystalloids to EBL is less than 2:1 (Doherty & Buggy, 2012). Replacement of blood calculation requires taking the estimated blood loss multiplied by three for crystalloid replacement. Replacement of blood is multiplied by one if a colloid or packed red blood cells are administered to replace the blood loss. Replacement of surgical losses involves taking the acuity of the surgery, which is categorized as mild, moderate, and severe and multiplying that by kilogram per hour (kg/hr) (Frost, 2018). When utilizing all of the approaches together it tends to lead to an overestimation of the number of fluids needed and therefore given.

Before understanding the role of neuroendocrine mechanisms within the stress response, traditional studies thought that extracellular fluids (ECFs) contributed to sodium and water retention (Shires et al., 1961). Utilizing isotope tracers while excluding fluid administration, investigators found that there ultimately was a deficit with the functional ECF that was not attributed to blood loss, giving rise to a third space. This concept rationalized liberal fluid administration to compensate for ECF in this nonfunctional space (Jacob et al., 2009). Despite evidence showing that utilizing fluid management techniques involving replacing third space losses results in poor outcomes, it has become a doctrine of the historical fluid management approach for anesthetic practice (Jacob et al., 2009). Fluid management strategies accounting for third space can lead to perioperative fluid weight gain of up-to 10kg in addition to poor clinical outcomes (Boer et al., 2018).

Central venous pressure (CVP) mainly depends on venous return, and baseline values may deviate in patients with poor right-sided heart function, severe pulmonary disease, and portal hypertension (Jalil & Cavallazzi, 2018). Targeting typical CVP values with fluids can lead to fluid overload in patients who cannot compensate for the increased vascular volume (Jalil & Cavallazzi, 2018). Historical approaches for monitoring fluid status include CVP readings through an additional invasive line or urine output (UOP). With UOP being affected by various factors, such as increased neuroendocrine reactions caused from surgical stress, utilizing it as a fluid administration goal is unreliable (Egal et al., 2016).

Antidiuretic Hormone (ADH)

Volume administration may selectively increase interstitial space in anesthetized oliguric individuals with high levels of circulating anti diuretic hormone (ADH) (Leonard &

Lee, 2017). Additionally, the high levels of circulating ADH can extend into the postoperative period resulting in poor elimination of sodium and water content. Giving increased amounts of intraoperative fluids can cause fluid overload in the postoperative period because ADH can remain in circulation postoperatively. It's important to recognize that fluid administration has its own indications, benefits, and side effects in a similar way medications do that can either promote or disrupt homeostasis during the intraopertaive period.

Lactate

In normal cell metabolism lactate plays a role in the production of ATP which is the fuel for life. Glucose is metabolized to pyruvate through the process of glycolysis. With the presence of oxygen, pyruvate is converted to pyruvate dehydrogenase in the mitochondria to acetyl coenzyme A (Honore et al., 2016). This represents aerobic metabolism and is an efficient way to produce ATP for energy. Without the presence of oxygen, pyruvate will be converted to lactate which can be used to produce ATP in the short term (Klimek et al., 2022). However, prolonged anaerobic metabolism will lead to cell death over time.

Increased lactate values have been recommended as a parameter for guiding hemodynamic resuscitation. Increased lactate levels are common with patients who require critical care, and levels above 2 mmol/L are an independent predictor of mortality (Kushimoto et al., 2016). Even though hyperlactatemia is widely recognized as a marker for hypoperfusion; the source, biochemistry and metabolic functions remain ambiguous. A disadvantage to drawing lactate levels is that they are drawn intermittently and do not reflect rapid changes (Joshi, 2024). While lactate levels are useful to reveal that there is some stress response or decreased perfusion happening in the body, they do not provide direct information about the patient's intravascular volume status.

Perioperative Arrhythmias

Arrhythmias can be common during the perioperative period, depending on the patient's history and type of surgery. According to Pecha et al. (2023), arrhythmia occurrence can exceed 90% depending on the kind of surgery and type. In non-cardiac surgery with significant fluid shifts, they are prevalent. Another common cause of arrhythmias includes the placement of a Swan-Ganz catheter. While a high percentage of patients develop arrhythmias during surgery, usually, they are self-limiting and resolve on their own (Pecha et al., 2023). The most common type of perioperative rhythm disturbance are supraventricular tachycardias, which account for up to 40%. Of these supraventricular arrhythmias, atrial fibrillation (AF) accounts for 90%. Medications to control AF should generally be continued leading up to surgery if the patient’s rhythm disturbance is pre-existing prior to surgery. If the patient takes anticoagulants, the decision to continue the anticoagulant should be made considering the benefits against the risk of bleeding during surgery (Pecha et al., 2023). New onset AF perioperatively should be treated via rate control with a beta blocker or calcium antagonist.

Frank-Starling mechanism

The Frank-Starling mechanism describes the relationship between the left ventricular end-diastolic volume (LVEDV) and myocardial contractility measured by stroke volume (SV). Increasing the left ventricular (LV) preload will increase myocardial contractility to a certain point by expanding cardiac sarcomeres. The stretching sarcomeres optimize the overlap of actin and filament to induce greater myocardial force (Dunn et al., 2016). The

Frank-Starling mechanism is helpful until sarcomeres can no longer create additional force. At this point, further increases in preload do not generate increases in SV. The Frank-Starling relationship can be shown in a graphical representation where left ventricular end-diastolic pressure (LVEDP) appears on the X-axis, and cardiac output (CO) is on the Y-axis (Aditianingsih & George, 2014). This can be found in Appendix B.

The ascending portion of the curve represents preload dependence, while the plateau portion represents preload independence. Patients on the ascending portion will increase their SV with additional fluid, while patients on the plateau portion will not (Aditianingsih & George, 2014). Patients with no cardiac abnormalities lie on the physiologic curve and typically will increase their contractility with extra fluids. Patients who lie on the pathophysiologic curve will not always increase their contractility with more fluids due to their curve having a more significant plateau portion. These patients can advance to volume overload very quickly. The Frank-Starling curve explains the importance of GDFT, its small, fixed fluid boluses, and understanding where a patient lies on this curve (Aditianingsih & George, 2014). Nonrecognition of a hypotensive patient that lies on the plateau portion or preload independence portion of the curve typically is the reason for inappropriate fluid administration.

Strategies for GDFT

Inserting a pulmonary artery catheter presents one way to monitor a patient's fluid status. An intravascular catheter gets inserted through a central vein, such as the jugular, brachial, ante-brachial or femoral (Ziccardi & Khalid, 2023). The catheter is then advanced through the right side of the heart to the pulmonary artery. The tip of the catheter resides in the pulmonary artery, where a balloon can be inflated and deflated to obtain an indirect assessment of the left side of the heart's filling pressures. The catheter consists of four lumens with a thermodilution sensor attached to a pressure transducer outside the body (Ziccardi & Khalid, 2023). This transducer can determine central venous pressure, right atrial pressure, right ventricular pressure, and pulmonary artery pressure. Potential complications from catheter placement include air embolism, valve rupture, pulmonary infarction, pneumothorax, hemothorax, atrial arrhythmias, or ventricular arrhythmias (Ziccardi & Khalid, 2023).

Echocardiography

Intravascular volume status can be calculated fast utilizing transesophageal echocardiography (TEE) or transthoracic echocardiography (TTE). The view for assessing the intravascular fluid status is done with the transgastric mid papillary short-axis view, which gives the provider a qualitative visual assessment of the left ventricle (LV) cavity (Joshi, 2024). Acute hypovolemia can be identified by obliteration of the LV with papillary muscles kissing in the middle of the left ventricle. The disadvantage of TEE is that it is not a continuous monitoring system and requires additional training to become proficient.

Arterial line analysis

Monitoring variability in intra-arterial pressure waveform during a respiratory cycle is another way to monitor fluid status (Joshi, 2024). The parameters include pulse pressure variation (PPV), stroke volume variation (SVV), and systolic blood pressure variation. SVV emerges during controlled mechanical ventilation because the positive pressure from the ventilator increases intrathroacic pressure which reduces venous return, therefore reducing RV filling volume and ultimately reducing SV (Joshi, 2024). The degree of SVV increases as hypovolemia worsens. During expiration when there is a reduction in intrathoracic pressure the opposite effect occurs. Typical respiratory variations in these changing parameters are under 10% and values higher than this suggests the need for fluid administration. These patients lie on the ascending portion of the Frank-Starling curve and giving them a fluid bolus will increase CO (Teboul et al., 2019).

Utilizing dynamic indicators presents a way to individualize a patient's care during a Whipple procedure to make clinical decisions. The HemoSphere™ monitor paired with the FloTrac™ catheter provides quick access to patient status information, facilitating visual clinician support and better fluid administration (FloTrac system, 2023). The system is dynamic, and SV, SVV, MAP, SVR, and CO update every 20 seconds using algorithmic proprietary formulas. Utilizing these advanced hemodynamic monitoring parameters can help determine the cause of hemodynamic instability during surgery (Flotrac system, 2023).

Significance of the Problem to Nurse Anesthesia

A CRNA has many responsibilities, including monitoring and managing a patient's hemodynamics, administering intravenous fluids, and administering vasopressors intraoperatively. These are crucial responsibilities because it influences a patient's hemodynamics and tissue oxygenation. Surgery centers utilize ERAS protocols to obtain better hemodynamic outcomes for patients. Fluid management is part of ERAS protocols in Whipple procedures and advocate for GDFT (Melloul et al., 2020). While ERAS protocols advocate for GDFT, the methods on fluid management and utilization of vasopressors remain controversial in the literature.

The anesthetist should aim to optimize the patient's hemodynamics to improve cardiac function to meet the demand throughout the intraoperative period to prevent hypervolemia or hypovolemia. Having an algorithmic approach for fluid administration based on SVV provides a more straightforward method for anesthesia to provide optimal care. With the advancement of FloTrac™ catheter, monitoring through an arterial line, an additional invasive line such as a pulmonary artery catheter becomes unnecessary. Utilizing such an approach can positively affect outcomes for patients undergoing a Whipple procedure such as fluid status, number of fistulas, and cardiac and respiratory outcomes.

Problem Statement

Finding the ideal balance between establishing and sustaining central euvolemia and avoiding the administration of insufficient or excessive fluid with a high sodium content is difficult when considering intraoperative fluid management (Miller et al., 2014). Hypovolemia can cause organ failure, hypoperfusion, intestinal ischemia, and an increase in unfavorable outcomes. Contrarily, fluid excess can cause interstitial fluid shifts, consequently leading to edema within the bowel triggering inflammatory processes (Melloul et al., 2020). Due to this extensive list of complications, it is critical to regulate fluid therapy intraoperatively for each patient.

A fundamental drawback of the traditional approach to fluid management is the use and dependence on static and nonspecific markers such as MAP, CVP, and urine output (UOP). While these are valuable for overall patient assessment, these values do not predict fluid volume responsiveness (Joosten et al., 2018). Static measurements also lack the ability to determine whether an inotrope or vasoconstrictor should be administered. Despite GDFT being recommended by national societies adoption of a guideline remains infrequent (Joosten et al., 2018). Complex GDFT guidelines could explain one possible reason why adoption remains low.

PICOT

Perioperative fluid management is a fundamental aspect of anesthesia practice. It serves to maintain intravascular volume, enhance CO, maintain tissue perfusion, promote oxygen delivery, correct and maintain electrolyte balance, improve microcirculation, and facilitate the delivery of nutrients and the removal of metabolic waste (Guest, 2020). Providing the patient with proper fluid and vasopressor administration during surgery remains crucial to ensuring best outcomes. Considering these factors, a PICOT question aims to answer what approach best suits patient fluid and vasopressor management. In patients undergoing a Whipple procedure, how does the development and implementation of cardiac optimization protocol verse traditional intraoperative fluid management affect the amount of fluids delivered intraoperatively, vasoactive medication administration, urine output, amount of blood transfusions, cardiac and respiratory outcomes, and pancreatic fistula intraoperatively?

Project Objectives

This Doctor of Nursing Practice (DNP) project aims to provide CRNAs with an algorithmic approach to address hemodynamic instability throughout the perioperative period in patients undergoing Whipple surgery. Traditionally, fluids and vasoactive medications have been given at the anesthetist's discretion based on static indicators. A recent meta-analysis found positive conclusions regarding cardiorespiratory complications, cardiogenic pulmonary edema, electrolyte disturbances, and the number of required blood transfusions with goal-directed hemodynamic therapy in conjunction with ERAS protocols (Weinberg et al., 2017). Although ERAS protocols advocate for GDFT, the methodology remains unclear. Having a standardized approach in GDFT will benefit future studies as technological advancements and monitoring devices improve.

This project aims to provide anesthetists with clear CO goals intraoperatively using the FloTrac™ catheter and HemoSphere™ monitor device to know when to administer a fluid bolus based on SVV. With this approach, the ultimate goal of this DNP project is to provide Anesthetists with objective measurements to provide the best intervention for the patient during a Whipple procedure regarding fluid and vasopressor management. The project objectives are as follows:

1. Synthesize data on GDFT and vasopressor administration during Whipple procedures.
2. Develop EBP recommendations for an algorithmic approach to guide fluid and vasopressor administration during a Whipple procedure.
3. Develop a comprehensive plan to monitor patient outcomes if this project were to be implemented.
4. Review outcomes and make adjustments as needed.

Literature Search

A PICOT question guided the direction of this project. Databases utilized for the literature search included PubMed, CINAHL Plus with full text and Google Scholar. The key terms Pancreaticoduodenectomy and goal-directed fluid therapy revealed four relevant articles. Hemodynamic optimization tool protocol and Whipple procedure found two relevant articles. Additionally, Edwards Life Sciences provided evidence-based articles about the FloTrac™ sensor. Inclusion criteria included: patients undergoing Whipple procedure in the study, utilizing a FloTrac™ catheter with an EV1000™ monitoring system to guide fluid and vasopressor administration, and a protocol for how to treat various indicators such as stroke volume variation (SVV), mean arterial pressure (MAP), or cardiac index (CI). Exclusion criteria included pediatric patients and studies not in English.

After completing a literature search and analyzing articles, nine articles emerged with varying levels of evidence and study methods. The relevant articles included in the analysis for this project had one prospective multi-center randomized control trial (Weinberg et al., 2017), a systematic review (Melloul et al., 2020), three retrospective cohort studies (Boekel et al., 2020; Peltoniemi et al., 2022; Ishihara et al., 2018), a prospective comparative study (Elgendy et al., 2017), a single center prospective observational trial (Gottin et al., 2019), a case-control study (Joosten et al., 2018), and a single center retrospective study (Lian et al., 2022). The articles compare using the FloTrac™ catheter with the EV1000™ monitoring system to guide fluid, vasopressor, and inotrope administration against traditional fluid administration in patients undergoing Whipple procedures or where Whipple procedures comprised most of the population in the study.

Stroke Volume Variation (SVV)

A central theme of the articles was using SVV to begin a hemodynamic optimization algorithm of when to administer a fluid bolus. Different studies had different thresholds for SVV, the fluid choice between colloids or crystalloids, and how much volume to administer. The lowest threshold to begin a fluid bolus was when the SVV reached 12%, which was the threshold utilized by the majority of articles (Boekel et al., 2020; Elgendy et al., 2017; Ishihara et al., 2018; Peltoniemi et al., 2022). The next threshold was 13% (Gottin et al., 2019), followed by 15% (Joosten et al., 2018), and two studies used an SVV of 20% (Lian et al., 2022; Weinberg et al., 2017) to begin a fluid intervention.

According to Weinberg et al. (2017), an SVV of 20% was utilized to start a 250 ml fluid bolus of balanced crystalloids or colloids. Similarly, in Lian et al. (2022) study, the same parameters were used. The studies differ in that in the Weinberg et al. (2017) article the number of colloids administered are stated throughout the intraoperative period while the Lian et al. (2022) study states the amount of colloids administered throughout the entire hospital stay. The average amount of colloids used in the Weinberg et al. (2017) article during the intraoperative period is 200 ml suggesting that the primary fluid bolus of choice is crystalloid to address SVV.

Cardiac index (CI)/Mean arterial Pressure (MAP)

After addressing SVV, most articles aim to address MAP and CI goals (Boekel et al., 2020; Elgendy et al., 2017; Ishihara et al., 2018; Lian et al., 2022; Weinberg et al., 2017). If the CI falls below 2.5L/min/m^2 starting a dobutamine infusion at 2.5 ug/kg/min is warranted (Boekel et al., 2020; Elgendy et al., 2017). For the parameters, a low MAP is defined as 20% below the patient's baseline, while a low CI is below 2L/min/m^2 (Lian et al., 2022; Weinberg et al., 2017). The primary treatment strategy for the articles is that if the MAP and CI are low, then an inotropic agent such as dobutamine is warranted. If the MAP is low and CI is normal, a vasopressor should be administered, such as phenylephrine or norepinephrine. However, according to Elgendy et al. (2017), if a CI is low and the MAP is greater than 65, reassessment in 10 minutes is an appropriate action. If the MAP and CI are normal, no additional medications require administration. If the MAP is high and the CI is low, then an arterial dilator should be issued. A beta blocker or antihypertensive warrants administration if the MAP and CI are high (Lian et al., 2022; Weinberg et al., 2017). Administering the correct vasoactive medication becomes seamless by having CI and MAP goals and knowing the patient's baseline hemodynamics.

A goal directed fluid therapy (GDFT) algorithm aims to justify when to administer fluids without causing edema while giving the least amount of fluid possible to avoid hypovolemia (Weinberg et al., 2017). Additionally, perioperative hemodynamic optimization prioritizes the appropriate and timely use of inotropic and vasoactive drugs to preserve cardiac output and organ perfusion (Weinberg et al., 2017). The number of complications related to fluid overload such as pulmonary edema, cardiorespiratory complications, and acute kidney injury (AKI) were reduced utilizing a hemodynamic optimization algorithm intraoperatively (Lian et al., 2022). Administration of a bolus of colloids or crystalloid is determined by threshold value of SVV. Administration of an inotropic agent, vasoconstrictor, inodilator, or arterial dilator is based off the patient's cardiac index and baseline MAP. An example of the cardiac output algorithm can be found in appendix C.

Fluids

The total amount of fluids delivered intraoperatively presents another central idea throughout the analysis. In almost all articles, the total amount of fluids given were less in the group that utilized a hemodynamic algorithm to guide fluid administration compared to traditional approached (Boekel et al., 2020; Elgendy et al., 2017; Ishihara et al., 2018; Joosten et al., 2018; Lian et al., 2022; Weinberg et al., 2017). According to Peltoniemi et al. (2022), more total fluids were administered intraoperatively; however, the number of diabetic patients included in the GDFT group was more than double than that of the conventional group. Additionally, there were still fewer complications with the intervention group. Current guidelines for ERAS protocols analyzed more than 1700 patients and found that complication rates increased when more significant amounts of perioperative fluids were given (Melloul et al., 2020).

Urine output (UOP)

Despite giving fewer total fluids throughout the intraoperative period, the literature demonstrates that urine production was typically higher in the GDFT group (Boekel et al., 2020; Ishihara et al., 2018; Joosten et al., 2018). According to Lian et al. (2022), the control group received about two and a half times more intraoperative fluids than the fluid optimization group. The amount of UOP is not stated throughout the intraoperative period; however, the number of patients that experienced AKI throughout the hospital stay increased four and a half times. Urine output (UOP) and total fluids increased in the GDFT group relative to the conventional group (Peltoniemi et al., 2022). Despite giving about twice as much total fluids throughout surgery, UOP averaged 605 milliliters compared to 669 milliliters in the control group (Weinberg et al., 2017). Furthermore, the incidence of AKI was found to be the same.

Using UOP as a sole indicator to guide fluid administration can misguide the CRNA for fluid administration. According to Gottin et at. (2019), the amount of urine production in the liberal group had the most, followed by GDFT, and finally, the restrictive fluid group. While the liberal group had the most urine production, it was associated with more significant complications, such as pancreatic fistulas, biliary fistulas, and abdominal collections. Perhaps one of the more interesting findings was the correlation in UOP with fluid administration in the GDFT group, while the control group did not (Ishihara et al., 2018). In the control group, potentially large amounts of unnecessary fluid were administered without correlation. Furthermore, the article concluded that an algorithmic protocol demonstrated increased urine production with fewer fluids administered while maintaining better hemodynamics.

Blood Transfusions

A reoccurring concept throughout the literature search was the increased number of blood transfusions amongst the group that did not utilize a hemodynamic optimization protocol (Elgendy et al., 2017; Joosten et al., 2018; Lian et al., 2022; Weinberg et al., 2017). Over three times as many patients received blood products in one study (Lian et al., 2022). While according to Weinberg et al. (2017), no patients received red blood cells in the GDFT group, while nine patients did in the control group. Other studies that included the amount of blood transfusions only had a small difference in the number of transfusions. For instance, according to Ishihara et al. (2018), the patients receiving blood transfusions were only one higher than the control, which was not statistically significant. Given that perioperative blood transfusion has been linked to a lower survival rate in patients with pancreatic cancer having surgical resection, decreased blood transfusion administration observed with GDFT may have long-term benefits (Weinberg et al., 2017).

Vasoactive medications

The differences in vasoactive medications utilized presented itself as another common theme. Dobutamine was administered more often in the hemodynamic optimization groups compared to the control groups (Boekel et al., 2020; Elgendy et al., 2017; Ishihara et al., 2018; Lian et al., 2022; Weinberg et al., 2017). The remaining articles did not include dobutamine administration. Similarly, the number of patients receiving norepinephrine during the intraoperative period increased for intervention groups (Boekel et al., 2020; Lian et al., 2022; Peltoniemi et al., 2022; Weinberg et al., 2017). While the specific agent was not listed, the total amount of vasoconstrictors utilized during surgery was increased (Ishihara et al., 2018). When pure alpha-one agonists such as phenylephrine or metaraminol were listed in studies, the amount utilized universally decreased in the hemodynamic optimization group compared to the control group (Boekel et al., 2020; Lian et al., 2022; Weinberg et al., 2017). Higher noradrenaline usage in GDFT may have preserved plasma volume, negating the need for fluid intervention (Weinberg et al., 2017). Furthermore, by negating the need for fluid intervention, complications related to fluid overload are more likely to be avoided. Beta-blocker administration remained relatively the same (Lian et al., 2022; Weinberg et al., 2017). This could be because intraoperative hypotension is more common than hypertension throughout procedures. Proper tissue perfusion and oxygenation remains a crucial part of surgery and using conventional methods for fluid and vasoconstrictor administration resulted in higher lactate levels (Boekel et al., 2020). The normal lactate levels in the GDFT group supports that there was no infectious process or perfusion deficits during surgery.

Cardiac and respiratory outcomes

Another theme throughout the literature search included the cardiac and respiratory outcomes for the patient. According to Lian et al. (2022), cardiac and respiratory complications could occur perioperatively or postoperatively (2022). Meanwhile, cardiac and respiratory complications were limited to postoperative data in the other three articles (Joosten et al., 2018; Peltoniemi et al., 2022; Weinberg et al., 2017). Arrhythmias occurred more frequently in patients who did not receive intraoperative cardiac optimization than those who did (Lian et al., 2022; Peltoniemi et al., 2022; Weinberg et al., 2017). Cardiorespiratory complications nearly doubled in the population not receiving hemodynamic optimization in the perioperative and postoperative period (Lian et al., 2022; Weinberg et al., 2017). Patients experiencing cardiogenic pulmonary edema increased when an intraoperative protocol was not used (Joosten et al., 2018; Lian et al., 2022; Peltoniemi et al., 2022; Weinberg et al., 2017). Furthermore, atelectasis occurred more frequently without a hemodynamic algorithm being utilized. (Lian et al., 2022 and Weinberg et al., 2017).

Pancreatic Fistulas

Another common occurrence that emerged during the literature analysis is that hemodynamic optimization lowered the number of postoperative fistulas. The International Study Group of Pancreatic Fistula (ISGPF) defined the categories for pancreatic fistulas (Pulvirenti et al., 2017). The updated definitions can be found in Appendix E. Data broke down the complexity of the fistulas in the articles as well. There was a reduction in postoperative pancreatic fistulas for types A, B, and C (Lian et al., 2022; Weinberg et al., 2017). There was a significant reduction in grade B and C fistulas (Peltoniemi et al., 2022). According to Gottin et al., the group that received a liberal amount of fluid resulted in the most biliary and pancreatic fistulas compared to the goal-directed and restricted groups, which both have two total fistulas (2019). Grades B and C are clinically relevant to postoperative pancreatic fistulas because they are associated with more complications (Peltoniemi et al., 2022).

Complications

A central concept throughout this literature search includes complications during the patient's postoperative period. The literature found that complications throughout the patient stay were decreased when utilizing a hemodynamic optimization protocol intraoperatively (Boekel et al., 2020; Elgendy et al., 2017; Joosten et al., 2018; Lian et al., 2022; Peltoniemi et al., 2022; Weinberg et al., 2017). Furthermore, the literature supports that major complications experienced such as requiring invasive procedures, arrhythmias, and grade B and C pancreatic fistulas were reduced (Boekel et al., 2020; Joosten et al., 2018; Peltoniemi et al., 2022).

In a study that compared the differences of liberal, GDFT, and restrictive fluid approaches during pancreatic surgeries outcomes demonstrated that the liberal approach resulted in worse outcomes. The restricted fluid and goal-directed fluid groups experienced about a third fewer complications than the liberal fluid group. A limitation of this study is that not all surgeries were Whipple procedures. Five patients developed biliary fistulas in the liberal group compared to one in the restrictive group and none in the GDFT group (Gottin et al., 2019). Five patients developed pancreatic fistulas in the liberal group compared to two in the GDFT and one in the restricted group. Three patients developed abdominal collections in the liberal group while one did in both the GDFT and restricted group (Gottin et al., 2019). The fistulas and abdominal collections being higher in the liberal group may be attributed to large amounts of unnecessary fluids.

Literature Summary

Based on the literature search and analysis, formulating an algorithmic approach for administration of fluids and vasoactive medications is an effective method in order to provide EBP care for patients. The literature search and analysis that facilitated the guidelines for this project included research based on the FloTrac™ catheter and EV1000™ monitor. However, the EV1000™ monitor is no longer sold and has been replaced by the updated HemoSphere™ monitor which has expanded capabilities of the EV1000™ such as the hypotension prediction index software (*Ev1000 Clinical Platform*, 2024). Utilizing dynamic indicators with specific interventions for a given threshold allows for the precise and timely administration of medications and fluids to improve patient outcomes. The analysis demonstrated positive effects regarding fluid balance, cardiac and respiratory outcomes, complications, hemodynamic management, and pancreatic fistulas for the patient when using this approach compared to traditional modalities.

Evidence-Based Practice Model

The conceptual model utilized to guide this DNP project is the Iowa Model. The Iowa model encourages nurses to use current research and evidence to deliver high-quality care (Doody & Doody, 2011). The Iowa model consists of seven steps that help formulate a guideline, set up implementation, and allow for reflection. A diagram of the seven steps is provided in Appendix D.

STEP 1 & 2

The first step involves selecting a topic, which is the PICOT question: In patients undergoing a Whipple procedure, how does the development and implementation of cardiac optimization protocol verse traditional intraoperative fluid management affect amount of fluids delivered intraoperatively, vasoactive medication administration, urine output, amount of blood transfusions, cardiac and respiratory outcomes, and pancreatic fistula intraoperatively? The second step of the Iowa Model involves organizing a team to develop, implement, and evaluate the project (Doody & Doody, 2011). Guidelines should be in place to aid in developing EBP.

Experienced staff supporting the project team in implementing the EBP remains crucial. Implementation of EBP by project planners is often hampered by experienced staff and institutions (Doody & Doody, 2011). To get senior team members to buy into the implementation of the EBP project, there should be evidence that supports a practice change. Presenting a slideshow and poster-board can facilitate senior members buying in. Utilizing meetings with the Anesthesia Department and operating room (OR) nursing staff, training on how to use the equipment, and an educational video on how to use the FloTrac™ and HemoSphere™ monitoring system will facilitate staff understanding of why the new fluid management protocols for cardiac optimization in Whipple Procedures can be beneficial.

STEPS 3 & 4

Retrieving evidence using key terms or phrases in electronic databases such as Cinahl, Medline, or Cochrane constitutes step three (Doody & Doody, 2011). The fourth step involves grading retrieved evidence (Doody & Doody, 2011). To grade the evidence, the researcher must address the quality of the individual research and the overall body of evidence. Specified inclusion and exclusion criteria need to be maintained for retrieving proof to ensure that studies are relevant. Inclusion criteria included patients undergoing the Whipple procedure and using SVV via the EV1000™ paired with the FloTrac™ catheter to guide fluid and vasopressor administration. Exclusion criteria includes pediatric patients and articles not written in english.

STEP 5

Developing practice guidelines according to recent literature happens in this fifth step (Doody & Doody, 2011). The proposals should have clear benefits for patients while minimizing risks. Furthermore, in ideal conditions, evidence-based practice guidelines should cater according to each patient's physiology (Doody & Doody, 2011). The literature search and analysis included articles based on the FloTrac™ catheter and EV1000™. Since the EV1000™ is no longer sold, the practice guidelines are based on the HemoSphere™which has all the capabilities of the EV1000™ with extra features. The FloTrac™ catheter with the HemoSphere™ monitor caters to each individual by being programed at the beginning of the case for the patient's specific height and weight. Furthermore, the algorithmic hemodynamic optimization tool that has demonstrated positive patient outcomes during Whipple Procedures based on the hemodynamic indicators SVV, MAP, and CI can be found in appendix C.

STEP 6

The sixth step requires EBP implementation (Doody & Doody, 2011). The focus is to distribute the evidence to staff in the anesthesia department, OR nurses, and pharmacy about the strengths and benefits of using a hemodynamic optimization tool during Whipple procedures. Considerations for this step include noting the social and organizational factors that can potentially affect implementation. Ensuring that surgeons and Anesthesiologists approve utilizing the FloTrac™ device with the HemoSphere™ would be included in this part of the implementation. Providing adequate training with the Flotrac™ catheter to become familiar with the algorithm for treating SVV, MAP, and CI and understanding the value will lead to the success of implementation and improve patient outcomes. For the anesthesia department, OR nurses, and pharmacy department staff training, there will be a one-hour in-service on following the EBP guidelines algorithm for cardiac optimization during Whipple procedures. A laminated printout of the algorithm will also be attached to the HemoSphere™ for a reference on what to do in particular scenarios. To ensure that the team feels comfortable utilizing the FloTrac™ catheter, HemoSphere™ monitoring system, and Algorithm, an opportunity for teach-back will be available following the sessions to demonstrate an understanding of the device and specific scenarios. The cardiac optimization protocol utilized as the laminated print out can be found in Appendix C.

STEP 7

In step seven, evaluation occurs to look at outcomes and determine positive or negative outcomes (Doody & Doody, 2011). Before the implementation of the evidence, a baseline of data can demonstrate usefulness in displaying how the evidence has contributed to care. This includes looking at thirty previous Whipple procedures, vital signs throughout surgery, fluids adminstered, UO, CVP, ejection fraction (EF), arrhythmias, pancreatic fistulas and if other complications occurred intra or postoperatively related to fluid and vasopressor management. Essential considerations in this phase involve noting the barriers that could hinder progress, lack of awareness of evidence by staff, or insufficient training.

After the implementation of the project and thirty Whipple cases have occurred, another evaluation will occur. The nursing informatics team will compare the data obtained before implementation against the data after the project team implements the new EBP guidelines. New data that will be added post-implementation will include SVV, SVR, SV, and CO to allow future studies to have more data to compare against to improve patient outcomes. Comparing the pre-and post-implementation outcomes will provide information on whether outcomes are positive or negative.

In conclusion, the Iowa Model represents a systematic way to address a clinical problem. Implementing the model will require practicing EBP research and application for a problem in clinical practice. Utilizing the Iowa model will provide value in following the step-by-step process to formulate a guideline and evaluate the effectiveness of a cardiac optimization protocol in Whipple procedures after implementation.

Implementation Plan

Implementation of this project will require planning and collaboration between all members in the Anesthesia department. Staff that need education for this DNP project's implementation include Nurse Anesthetists, Anesthesiology assistants, Anesthesiologists, OR nursing staff and pharmacy. Before beginning any staff training on how to use the HemoSphere™ monitor, FloTrac™ Catheter, and cardiac optimization algorithm, the project team will schedule a meeting with the management for these departments to gain support before implementation (Burson et al., 2019). During this meeting, the project team will communicate the evidence as to why a change in practice could benefit patient outcomes. With management's support, setting up one-hour-long in-service training for anesthesia providers, OR nurse staff, and pharmacy will be scheduled based on what the management team thinks would be the appropriate times for staff to receive the in-service training. Ensuring all staff get hands-on experience using the HemoSphere™ monitor, and the FloTrac™ Catheter is critical to education and training. Education and training will be offered in one-hour intervals at the time management recommends, accommodating the staff's schedule. Staff will receive standard hourly compensation and one hour for the training before the provider can use the FloTrac™ catheter and HemoSphere™ monitor during surgery. The hour-long staff meeting will prioritize explaining why the change in practice is occurring, the EBP rationale for making the change, and how to use the equipment.

To ensure that the team feels comfortable utilizing the FloTrac™ catheter, HemoSphere™ monitor, and algorithm, anesthesia providers must demonstrate a teach-back following the in-service training, demonstrating an understanding of the device and specific scenarios. Once staff has attended the in-service and demonstrated understanding, utilization of the Flotrac™ Catheter and HemoSphere™ monitor system will begin in the clinical setting for Whipple procedures. Staff checked off first will be the providers to care for the patients having a Whipple procedure with the new guidelines in place. The HemoSphere™ monitor and FloTrac™ catheter will be located near the operating room central nurses' station for providers to use.

Following implementation, evaluation must take place to ensure the practice change has been successful. During the evaluation period, the project team will collaborate with nursing informatics following thirty Whipple cases after implementation to review patients' electronic health records for positive and negative outcomes (Burson et al., 2019). Thirty cases should allow sufficient data to compare baseline data before implementation against the new practice to evaluate effectiveness. Every three months there will be a review of the data to ensure that patient outcomes are positive, relative to before implementation of the new guidelines, to ensure that no harm occurs to patients.

Timeline

Multiple departments will need collaboration to facilitate the implementation of the project guidelines. The beginning of the project will focus on getting stakeholders on board for the project. Stakeholders include management in the anesthesia department, anesthesia staff, OR nurses, pharmacy, and nursing informatics department. Getting stakeholders on board will require setting up meetings to explain the change needed. If this project were to be accepted, an Institutional Review Board would review the project immediately following the proposal. The anticipated timeline for setting up appointments for the stakeholders will be one month. During this time, a retrospective analysis will collect data on Whipple procedures and patient outcomes. Once all stakeholders are aware of the plan and on board for the implementation of new guidelines, staff training will begin. The anticipated time to train staff will take one month. Following staff training, the rollout of the new guidelines will begin. With the new guidelines in place during this time, a retrospective analysis will begin to collect data on vital signs throughout surgery, fluids administered, UO, CVP, EF, SV, SVV, SVR, arrhythmias, pancreatic fistulas and if other complications occurred intra or postoperatively related to fluid and vasopressor management. Data will be compared with before and after the intervention at the end of the next twelve months. Twelve months allows enough time for an adequate sample size of thirty patients to compare the intervention to previous practice to extinguish outliers.

Furthermore, twelve months for the anticipated project duration allows for a quarterly analysis. During the retrospective quarterly analysis, outcomes will be measured against the historical practice against the guidelines to ensure no harm is being done to patients.

Budget

The budget for this project would be divided into equipment costs and then costs for staff training. Equipment costs include the FloTrac™ Catheter and the HemoSphere™ monitor. The HemoSphere™ monitor system will be a one-time cost for a retail price of $30,000 *(New Edwards Hemosphere Advanced Monitor, 2024)*. The FloTrac™ catheter is disposable and can only be used for one patient. The retail price for the disposable FloTrac™ catheter is $815.99 *(Edwards Lifesciences Flotrac Sensors, 2024).* Using 30 Whipple cases for the study for calculations for the budget, at the level 1 trauma center in Columbus, Ohio, and a margin of error of 10% for equipment failure puts a yearly cost of disposable FloTrac™ sensors at $26,927.67. Adding costs of the FloTrac™ catheters and Hemosphere™ monitor puts the total annual costs for equipment at $56,927.67.

Staff training would be the following cost for this theoretical project. Staff members will receive their hourly wages. CRNAs. According to *Crna salary in Columbus, OH* (2023), the average hourly wage for a CRNA is $113. With around 50 CRNAs on staff at the level 1 trauma center in Columbus, Ohio, training CRNA staff costs $5,650. According to *Anesthesiologist salary in Columbus, OH* (2023), the average hourly wage for an Anesthesiologist is $173. With around 25 anesthesiologists on staff, the total cost for training anesthesiologists is $4,325. Adding the prices between the anesthesiologists and CRNAs puts the cost of training anesthesia staff at $9,975. Total equipment and training staff costs comprises the budget, with the total being $66,902.67.

Outcome Analysis

The outcome analysis begins once data is collected and organized within a Microsoft Excel © spreadsheet. Data will retrospectively be collected continuously from the previous year of Whipple Procedures. Data will be accessed from the electronic health record (EHR), including vital signs throughout surgery, fluids administered, UO, CVP, EF, arrhythmias, pancreatic fistulas and if other complications occurred intra or postoperatively related to fluid and vasopressor management. Patients' EHRs will be reviewed for up to 30 days following the surgery to assess for adverse patient outcomes related to fluid and vasopressor administration during the surgery. This data will be used to get a baseline value utilizing the historical fluid approach. This baseline will be compared against the statistics obtained after implementing the algorithmic, systematic strategy.

Once the new fluid administration protocol is implemented, data reviews occur quarterly to ensure no harm occurs to patients. The same data will be obtained for the information gathered for the pre-intervention period. As long as patient outcomes remain positive relative to the historical approach, the study will last 12 months. Positive outcomes include a reduction in amount of fluids delivered intraoperatively, vasoactive medication administration, urine output, amount of blood transfusions, cardiac and respiratory outcomes, and pancreatic fistula intraoperatively. There will be three quarterly reviews, then one final analysis at the end of the 12 months. After the 12 months, data will be thoroughly analyzed between the historical fluid approach and the newly implemented guidelines. Collaboration with the information technology department will be crucial during this period.

Meeting with managers from the anesthesia department, OR nurses, and pharmacy would be the following step after the conclusion of the project to disseminate the findings. If the project succeeds, implementing the new guidelines for using a cardiac optimization algorithm during Whipple Procedures to guide fluid and vasopressor administration will be the standard. A successful project would include a reduction in the arrhythmias, pancreatic fistulas, blood transfusions, and adverse cardiac and respiratory outcomes. A negative project would be an increase in the amount arrhythmias, pancreatic fistulas, blood transfusions, adverse cardiac and respiratory outcomes relative to before the project started. The rollout from the analysis to implementation should be seamless if the project were to succeed since the equipment and protocol will remain at the facility.

Limitations

While the evidence demonstrated positive outcomes when using a cardiac optimization algorithm during Whipple procedures, there are some limitations. First, not all the studies included only Whipple procedures (Boekel et al., 2020; Elgendy et al., 2017; Gottin et al., 2019; Joosten et al., 2018). The studies included a range of intra-abdominal surgeries, however, Whipple procedures comprised most of the surgical population. One of the studies did not include vasoactive medication administration throughout the intraoperative period and primarily focused on fluid management (Gottin et al., 2019). Another limitation included not stating the number of lymph nodes and the size and texture of the pancreas (Lian et al., 2022; Weinberg et al., 2017). Given the limitations, it remains crucial for project planners to collaborate with the nursing informatics team during the retrospective analysis to ensure that no harm is done to patients and positive outcomes are demonstrated regarding arrhythmias, hemodynamics, pancreatic fistulas, blood transfusions, and adverse cardiac and respiratory outcomes.

Conclusions

Pancreatic adenocarcinoma is one of the highest causes of cancer related mortality in the United States with a Whipple procedure is the most common treatment strategy. A

Whipple procedure is a complex surgery that causes vast fluid shifts throughout the body. Goal directed fluid therapy is advocated for according to ERAS protocols during Whipple procedures. Utilizing a cardiac optimization algorithm presents a way to follow ERAS protocols based on EBP. Positive outcomes regarding fluid balance, cardiac and respiratory outcomes, blood transfusions, complications, hemodynamic management, and pancreatic fistulas were demonstrated using this the EV1000™ and FloTrac ™ catheter compared to traditional approaches for fluid and hemodynamic management. Despite positive outcomes being demonstrated using this approach there were some limitations according to recent literature. With different surgeries, not knowing the number of lymph node involvement, and size and texture of the pancreas, comprising of some of the recent research further studies during Whipple procedures is required. Implementation of the theoretical project would take approximately one year with a retrospective analysis collecting data to ensure that positive patient outcomes are occurring relative to before the new guidelines are in place. If the results demonstrate reductions in arrhythmias, pancreatic fistulas, blood transfusions, and adverse cardiac and respiratory outcomes, the new guidelines will be adopted.

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Appendix A

Literature Synthesis Table

Appendix A: Evidence Review Worksheet Assignment C								
APA Citation: Boekel, M. F., Venema, C. S., Kaufmann, T., van der Horst, I. C., Vos, J. J., & Scheeren, T. L. (2020). The effect of compliance with a perioperative goal-directed therapy protocol on outcomes after high-risk surgery: A before-after study. Journal of Clinical Monitoring and Computing, 35(5), 1193–1202. https://doi.org/10.1007/s10877-020-00585-w								
Conceptual Framework or Model	**Design or Method**	**Sample & Setting**	**Major Variables Studied & their Definitions, if any**	**Outcome Measurement(s)**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence: Critical Worth to Practice**
Aim of study is to evaluate the effects of protocol compliance on postoperative e outcomes following high risk surgery after implementing preoperative goal directed fluid therapy	Retrospective cohort study	**Number of Characteristics:** N=239 with 214 in before group and 215 in after group. 96 of which were PPPD Other surgeries included APR, AAA, open esophageal resection, and femoral popliteal artery repair. **Exclusion Criteria:** Patients under 18, pregnant patients, thoracoscopic, laparoscop	**Independent variables: IV1=** pGDT treatment algorithm utilizing FloTrac™ monitoring system. **IV2=** Utilized algorithm to treat SVV first, CI second **Control:** historical fluid approach. Anesthesiologist s' discretion	Data was obtained from EMR database. FloTrac™ data was separately collected and added to data base	Independent -test, MannWhitney U test, Chi square or fishers ,and a P-value SPSS 23.0 for windows for statistical analyses	Urine production was increased in the after group Amount of phenylephrine used was decreased in pGDT	III	**Strengths:** utilizing intervention **Limitations:** Different surgeries. No hemodynamic data provided intraoperatively Focus is more on postoperative outcomes **Risk or harm if implemented:** low

		ic and emergent surgeries **Attrition:** 22 removed because of interventional studies **Setting:** Academic teaching hospital						

Will complete this in Assignment E
Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style): In a recent retrospective study, perioperative goal-directed fluid therapy's effects were studied for multiple surgeries where Whipple procedures represented about 40% of the population. To measure dynamic indicators such as stroke volume variation (SVV), a FloTrac™ catheter was plugged into an existing arterial line and then monitored on the EV 1000. There was a specific protocol for when an intervention was needed for SVV and cardiac index (CI). The results demonstrated an increase in urine production and decreased amount of phenephrine used perioperatively
Thematic Analysis **Key Themes or FSP related significance:** **1.** A perioperative GDF protocol was utilized with SVV threshold for intervention being 12%. **2.**Majority of patients were classified as ASA II followed by ASA III for intervention and control group. **3.**The moderate, severe and total postoperative complications were decreased when there was high compliance with SVV and CI interventions. **4.**The protocol compliance for SVV and CI interventions had to be over 85% to be labeled as a high compliance rate. **5.**The amount of phenylephrine used in the GDFT group was lower while administration rates of norepinephrine was higher

Appendix A: Evidence Review Worksheet Assignment C
APA Citation:

Elgendy, M. A., Esmat, I. M., & Kassim, D. Y. (2017). Outcome of intraoperative goal-directed therapy using vigileo/flotrac in high-risk patients scheduled for major abdominal surgeries: A prospective randomized trial. Egyptian Journal of Anaesthesia, 33(3), 263–269. https://doi.org/10.1016/j.egja.2017.05.002								
Conceptual Framework or Model	**Design or Method**	**Sample & Setting**	**Major Variables Studied & their Definitions, if any**	**Outcome Measurement(s)**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence: Critical Worth to Practice**
Theoretical basis for the study: Compared to conventional fluid therapies, how does intraoperative goal directed fluid therapy evaluated by SVVusing FloTrac™ system affect post operative morbidities and mortality rates	Prospective comparative study	86 patients in single center (8 patients for Whipple, 5 control, 3 GDT) Inclusion criteria: high risk patients scheduled for abdominal surgeries with anticipated length of surgery over two hours. High risk defined as open abdominal with OR time >120 minutes and	**IV1-** GDFT utilizing FloTrac™ device connected to arterial line. **IV2-** specific parameters were addressed for when to administer crystalloid, colloids, dobutamine, and norepi. **Control:** conventional fluid therapy. **Dependent variables:** MAP, CVP, HR, UOP and lactate levels were all recorded.	Intraoperatively MAP, CVP, HR, and UO were recorded at start of procedure and every 30 minutes until 270 minutes Lactate levels were additionally taken preoperatively and upon ICU admission	P--value, standard deviation	MAP was consistently higher in GDT group. It was statistically significant at 150 minutes and 210 minutes. Lactate levels were significantly lower in GDT group 3.12 +- 0.75 and 1.18 +- 0.38 in GD	4`	**Strengths:** related to interventions and outcomes **Limitations:** single center study, different surgeries. Small patient population of Whipple

		>20% blood loss.						

Will complete this in Assignment E

Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style):

Utilizing the FloTrac™ catheter device, a recent prospective comparative study measured the effects of MAP and lactate levels.
The population included 86 open abdominal surgical patients, with Whipple procedures representing around a tenth of the people. The surgery had to be over 120 minutes long and anticipated over 20% blood loss for surgeries to be included. The study found that the average MAP was higher at 150 and 210 minutes throughout the surgery. Additionally, the immediate postoperative lactate levels were significantly lower in the intraoperative goal-directed therapy than in conventional practice.

Thematic Analysis
Key Themes or FSP related significance:

1. An intraoperative protocol was utilized with the SVV threshold being above 12% for a colloid bolus to be administered.

2. A little over half of the patient population were classified as ASA III and a little under half were ASA II status.

3. Blood Lactate levels were lower from ICU admission through 24 hour period at ICU period.

4. The GDFT group received less crystalloids, more colloids and total overall fluids.

5.A norepinephrine infusion was started on over twice as many patients in the conventional group.

Appendix A: Evidence Review Worksheet Assignment C

APA Citation:
Gottin, L., Martini, A., Menestrina, N., Schweiger, V., Malleo, G., Donadello, K., & Polati, E. (2019). Perioperative fluid administration in pancreatic surgery: A comparison of three regimens. Journal of Gastrointestinal Surgery, 24(3), 569–577. https://doi.org/10.1007/s11605-019-04166-4

Conceptual Framework or Model	Design or Method	Sample & Setting	Major Variables Studied & their Definitions, if any	Outcome Measurement(s)	Data Analysis	Findings	Level of Evidence	Quality of Evidence: Critical Worth to Practice
Studying intraoperartive fluid management and postoperat	Single-center, prospective observational	**Number of Characteristics:** N= 86. 47 of which were	**IV 1**: Liberal fluid management (12 ml/kg/hr)	SPSS 11.0 software, Mann Whitney U and chi2 tests	P-value, median and interquartile ranges	Major postoperative complications in liberal	III	**Strengths:** Comparing three different fluid manage

ive effects by splitting patients between liberal fluid managem ent, restricted fluid managem ent and goal-directed fluid	trial	Whipple procedure's. **Exclusion Criteria:** less than 18 years old, coagulopath y, preexisting arrhythmias , heart failure, and pregnancy	**IV 2:** Restricte d fluid manage ment (4 ml/kg/hr) **IV3:** Goal directed fluid replacem ent determin ed by FloTrac™ device	Data was recorded intraoperati vely for patients.		fluid administra tion group than GD and restricted groups (p<0.05) *pancreati c and Biliary fistualas were most common.		ment styles. **Limition s** study included multiple surgeries , whipped was the most common though

Will complete this in Assignment E
Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style): A recent single-center prospective observational trial was conducted to determine the best fluid management strategy in pancreatic resection surgeries. Over half of the surgeries consisted of Whipple procedures, and patients with abnormal coagulation, preexisting arrhythmias, pregnancy, or heart failure were excluded from the study. The fluid management styles included liberal with 12 ml/kg/hr, restricted with 4 ml/kg/hr, and goal-directed replacement determined by a Flotrac™ device. The results demonstrated increased postoperative complications in the liberal fluid group, with pancreatic and billiard fistulas being the most common problems. Urine output was also higher in the restricted and FloTrac™ device intervention groups. Limitations of the study included there being multiple surgical populations other than Whipple procedures.
Thematic Analysis **Key Themes or FSP related significance:** **1.** ASA status for the liberal fluid group was a median of 1.5 while restricted and GDFT were 2. **2.** A SVV above 13% was the threshold for a crystalloid and/or colloid bolus of 3ml/kg to be administered until resolved. **3.** Total fluids and UO was decreased in the GDFT and restricted approach for patients while have less complications. **4.** The intraoperative complications recorded were only observed in the liberal fluid administration group. **5.**One patient developed renal insufficiency in the goal directed group while two did in the restricted and liberal group.

Appendix A: Evidence Review Worksheet Assignment C
APA Citation:

Ishihara, S., Yokoyama, T., & Katayama, K. (2018). Goal-directed therapy reduces fluid balance while maintaining hemodynamic stability in intraoperative management of pancreaticoduodenectomy: A retrospective comparative study. JA Clinical Reports, 4(1). https://doi.org/10.1186/s40981-017-0144-z								
Conceptual Framework or Model	**Design or Method**	**Sample & Setting**	**Major Variables Studied & their Definitions, if any**	**Outcome Measurement(s)**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence: Critical Worth to Practice**
Examine the effects of GDT on perioperative outcomes vs historical controls in PD surgery.	Retrospective cohort study	**Number of Characteristics:** N=90, 46 in control and 44 in GDT group **Exclusion Criteria: -** Non PD surgeries **Attrition:** **Setting:** tertiary hospital	**IV1=** GDT group **Dependent variables:** HR, MAP, UO	Fishers test, Welch's t test, Mann-Whitney U test	Confidence interval and P value	GDT group significantly increased UO Amount of fluids was lowered MAP and HR were maintained despite decrease in intraoperative fluids and increase in UP	III	**Strengths:** perioperative outcomes for Whipple procedures only **Limitations:** single-center study Postoperative outcomes weren't measured
Will complete this in Assignment E								

Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style):

In a recent retrospective cohort study, the results demonstrated better-sustained MAP and HR, delivering fewer crystalloids and utilizing goal-directed fluid therapy than historical fluid management. The study included 90 patients, with 44 patients receiving the intervention during pancreaticoduodenectomy procedures. The goal-directed group also increased the urine output throughout the intraoperative period.

Thematic Analysis
Key Themes or FSP related significance:

1.The dynamic indicators utilized for the GDT group included SVV, CI, and MAP with a 12% SVV being the threshold for a crystalloid or colloid to be delivered.

2. The most common ASA status for the patient population was II representing 60% of the total study's population.

3. The MAP remained higher throughout the surgery consistently for the GDT group.

4. There was a trend of increased heart rate in the perioperative period.
5. The GDT group received more inotrope and vasoconstrictor infusions.

Appendix A: Evidence Review Worksheet Assignment C								
APA Citation: Joosten, A., Coeckelenbergh, S., Delaporte, A., Ickx, B., Closset, J., Roumeguere, T., Barvais, L., Van Obbergh, L., Cannesson, M., Rinehart, J., & Van der Linden, P. (2018). Implementation of closed-loop-assisted intra-operative goal-directed fluid therapy during major abdominal surgery. European Journal of Anaesthesiology, 35(9), 650–658. https://doi.org/10.1097/eja.0000000000000827								
Conceptual Framework or Model	**Design or Method**	**Sample & Setting**	**Major Variables Studied & their Definitions, if any**	**Outcome Measurement(s)**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence: Critical Worth to Practice**
To study utilizing a closed loop assisted GDFT management system in major	Case-control study	**Number of Characteristics:**N= 208 patients with half in closed loop intervention group. Over half of the population were pancreatectomy's **Exclusion Criteria:** ASA status above 3, LV function below 35%, cardiac arrythmias, aortic regurg, impaired hepatic or renal function, and coagulation disorders.	**IV1=** Closed loop GDFT protocol with EV1000™ monitoring system **Dependent variables:** Fluids delivered, urine output, pulmonary complications, arrhythmias, minor complications, and length of stay.	Mann-Whitney U test, X^2 test	P-value, standard difference	The closed loop group received less colloids, crystaloids and blood products.	III	**Strengths:** compared amounts of different fluids administered. **Limitations:** Included multiple surgery types.
Will complete this in Assignment E								
Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style): A recent case-control study used a closed-loop GDFT protocol to guide intraoperative fluid administration. The GDFT protocol used the EV1000™ monitoring system for dynamic indicators, while the control group used historical methods. Patients above ASA status three consisted in the exclusion criteria. The results demonstrated fewer colloids, crystalloids, and blood products administered intraoperatively in the closed-loop group.								

Additionally, urine output was higher. Patients experienced less pulmonary edema, arrhythmias, and acute coronary syndrome during the postoperative period.
Thematic Analysis **Key Themes or FSP related significance:** **1.** Most of the patients were ASA status 2 while the rest were ASA status 3. **2.** Total fluid input including blood products was lower in closed loop group than historical group urine output was higher. **3.** Overall fluid balance more than 3L lower in closed loop group. **4.** Amount of vasoactive interventions utilized between the two groups was practically the same. **5.** Fluid interventions consisted of 100 ml of plasmalyte or volulyte over six minutes based off a SVV above 15%.

Appendix A: Evidence Review Worksheet Assignment C								
APA Citation: Lian, L., Wang, Y., & Ning, X. (2022). A retrospective study from a single center of 252 patients who underwent elective pancreaticoduodenectomy to compare perioperative hemodynamic optimization therapy and usual protocols in terms of perioperative cardiac function. Experimental and Therapeutic Medicine, 24(5). https://doi.org/10.3892/etm.2022.11632								
Conceptual Framework or Model	**Design or Method**	**Sample & Setting**	**Major Variables Studied & their Definitions, if any**	**Outcome Measurement(s)**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence: Critical Worth to Practice**
To compare usual protocols of eras procedures without fluid optimization against with intraoperative fluid optimization in patients undergoing PD surgery	Single Center Retrospective study	**Number of Characteristics:** N=252, 142 under UC and 110 patients under FO **Exclusion Criteria:** Patients with coagulopathies, renal impairment ASA status > four, chronic liver disease. Distal, central, or	**IV1=** Intraoperative fluid protocol utilizing flow track pulse contour device. If SVV were >20% then intervention was given. **Dependent variables:**	The patients had same postsurgical management in the ICU following the surgery. Clavier-Dindo Classification	**Statistical tests, if any:** Unpaired t-test, x^2, confidence interval, p-value	UC cohort reported higher number of grade A pancreatic fistulas (P=0.011) UC cohort reported higher number of grade pancreatic	III	**Strengths:** Current article Intervention was compared to an eras protocol group **Limitations:** Data did not report size/texture of pancreas, or the

		total pancreatectomy.	peri and post operative outcomes			fistulas (p=0.037) All grades of fistualas (P=0.0001) Number of arrhythmias were statistically significant (pvalue 0.026) Electrolyte disturbances were significantly significant (0.028) Amount of blood products given was significantly less in FO group (p0.035)		amount of lymph nodes.
Will complete this in Assignment E								
Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style): In surgical patients undergoing pancreaticoduodenectomy, perioperative and postoperative effects were studied with patients with fluid optimization against standard ERAS procedures. This single-center retrospective study consisted of 252 patients, with 110 receiving intraoperative fluid optimization. Patients excluded from the study included abnormal coagulation levels, renal impairment, high ASA status, or doing a total pancreatectomy. The patients with a FloTrac™ catheter received a fluid bolus when the stroke volume variation exceeded 20%. The results demonstrated fewer arrhythmias, electrolyte disturbances, postoperative fistulas, and intraoperative blood products.								

Thematic Analysis **Key Themes or FSP related significance:** **1.**The majority of patients were categorically ASA III or IV patients for the intervention and control groups. **2.**The parameters utilized for the intervention group in the study included SVV, MAP, and CI with 20% being the threshold for SVV intervention. **3.**Total amount of crystalloids and blood transfusions were decreased while amount of colloids administered increased. **4.**The total blood loss throughout the surgery were decreased in the fluid optimization group. **5.** The amount of dobutamine and norepinephrine were increased in the fluid optimization group.

Appendix A: Evidence Review Worksheet Assignment C								
APA Citation: Peltoniemi, P., Pere, P., Mustonen, H., & Seppänen, H. (2022). Optimal perioperative fluid therapy associates with fewer complications after pancreaticoduodenectomy. Journal of Gastrointestinal Surgery, 27(1), 67–77. https://doi.org/10.1007/s11605-022-05453-3								
Conceptual Framework or Model	**Design or Method**	**Sample & Setting**	**Major Variables Studied & their Definitions, if any**	**Outcome Measurement(s)**	**Data Analysis**	**Findings**	**Level of Evidence**	**Quality of Evidence: Critical Worth to Practice**
Aim of study was to examine difference between perioperative fluid administration and postoperative complications in patients undergoing PD	Retrospective cohort study	**Number of Characteristics:** N= 168 with 93 in control and 75 in IV **Exclusion Criteria:** all other pancreatic surgeries **Setting:** Helsinki University hospital, a tertiary center	**Control-** Conventional fluid therapy **IV1=** Using GDFT with FloTrac ™ sensor	Mann-Whitney U-test and Shapiro-Wilk's test Logistic regression for associations between postoperative complication and independent variables	Standard deviation, medians, p-values	Pancreatic fistulas were greater in CFM group than GDFT group ($p<0.011$) Intraoperative urine output was higher in GDF group.	III	**Strengths:** univariable analysis demonstrated postoperative fluid management had no influence on postoperative outcomes **Limitations:** other characteristics of anesthesia were not standardized

								Risk or harm if implemented: Low

Will complete this in Assignment E

Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style):

A recent retrospective cohort study examined differences in perioperative fluid management studies. One hundred sixty-eight patients consisted in the study during pancreaticoduodenectomy surgeries, with the intervention group utilizing a FloTrac™ catheter to guide fluid management intraoperatively. The study's primary outcomes included reduced pancreatic fistulas in the intervention group and higher urine output. Limitations included the characteristics of anesthesia not being standardized in the control group.

Thematic Analysis
Key Themes or FSP related significance:
1. A goal directed fluid therapy protocol was utilized for the intervention group.
2. The majority of the patients were ASA class III for the GDFT group and conventional therapy followed by ASA II.
3. The total amount of crystalloids delivered and urine output both increased in the GDFT group despite a decrease in complications
4. Blood loss and total number of transfusions were increased in the GDFT group.
5. The number of pleural effusions, pancreatic fistulas, and length of stay were decreased in the postoperative complications.

Appendix A: Evidence Review Worksheet Assignment C

APA Citation:
Weinberg, L., Ianno, D., Churilov, L., Chao, I., Scurrah, N., Rachbuch, C., Banting, J., Muralidharan, V., Story, D., Bellomo, R., Christophi, C., & Nikfarjam, M. (2017). Restrictive intraoperative fluid optimisation algorithm improves outcomes in patients undergoing pancreaticoduodenectomy: A prospective multicentre randomized controlled trial. PLOS ONE, 12(9), e0183313. https://doi.org/10.1371/journal.pone.0183313

Conceptual Framework or Model	Design or Method	Sample & Setting	Major Variables Studied & their Definitions, if any	Outcome Measurement(s)	Data Analysis	Findings	Level of Evidence	Quality of Evidence: Critical Worth to Practice
To determine if using a cardiac optimization algorithm in PD surgery vs	Prospective multi center RCT	**Number of Characteristics:** 52 total patients **Exclusion Criteria:**	**IV1=** Intraoperative fluid optimization algorithm using Flotrac™	All outcomes were defined and classified according to the European	P-values, incidence rate ratios, CI interval	Reduced number of postoperative pancreatic fistulas	I	**Strengths:** multi-center RCT **Limitations:** didn't collect data on pancreati

without one in presence of ERAS protocols affected postoperative outcomes.		younger than 18, pregnant, coagulopathies, renal impairment, liver disease, ASA status > IV **Setting:** Multi-centers	catheter and EV1000™ monitor **Control:** EV1000™ monitor covered and alarms silenced **Dependent variables:** Perioperative outcome	Perioperative Clinical Outcome (EPCO) definition		Number of blood transfusions were significantly reduced with intervention. (p-value 0.0005) Number of electrolyte disturbances were reduced (p-value 0.012) Arrhythmias were reduced (p-value 0.558) Use of dopamine/dobutamine (p-value 0.007)		c duct size, size/texture of pancreas and number of lymph nodes **Risk or harm if implemented:** low

Will complete this in Assignment E

Annotated Bibliography statement (may be several sentences summarizing the article based upon the information above using professional APA writing style):

In a multi-center RCT the perioperative results were recorded for patients receiving cardiac output goal directed therapy against not utilizing a hemodynamic optimization protocol in the presence of ERAS protocols. Patients with an ASA status more significant than 4, pregnant, and renal impaired patients comprised the exclusion criteria. There was a reduction in arrhythmias, electrolyte disturbances, blood transfusions, and postoperative pancreatic fistulas. The methods for comparing group included using the FloTrac™ catheter with the EV1000™ device while the control group would cover the EV1000™ and silence the alarms.

Thematic Analysis
Key Themes or FSP related significance:

1. 1. The dynamic parameters being studied included stroke volume index, stroke volume variation, and cardiac index.

2. The stroke volume variation end point for a fluid intervention was at 20%.

3. A vasopressor and fluid management algorithm is utilized for the intervention group.

4. The majority of patients were classified as ASA status III or higher.

5. The amount of noradrenaline was higher in the cardiac output goal directed therapy.

Appendix B

Frank-Starling Mechanism

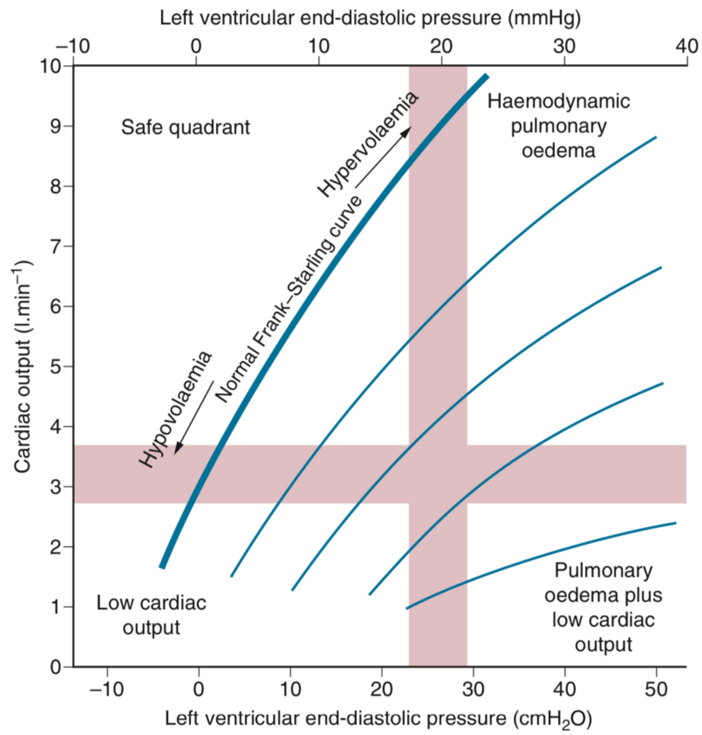
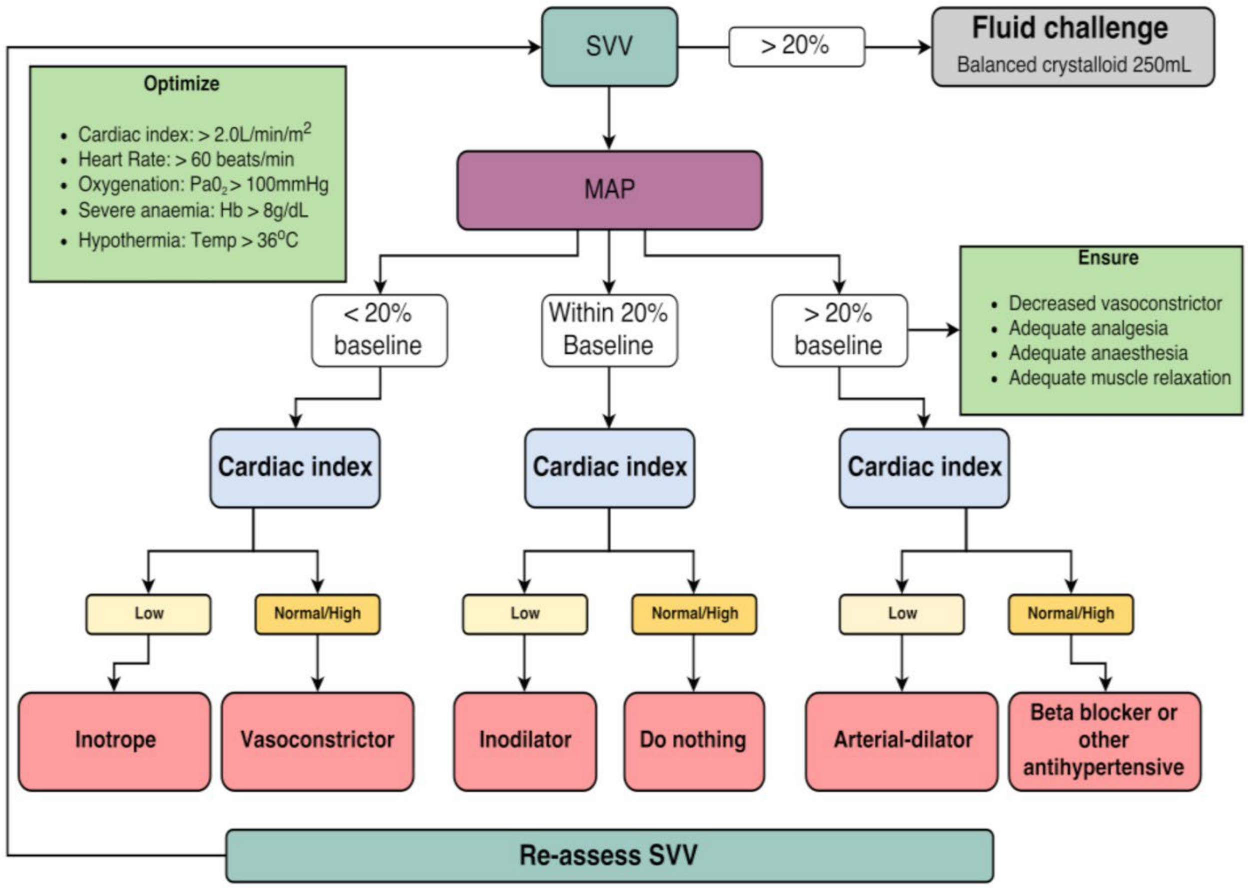


FIG. 28.3 Quadrant diagram relating cardiac output to left ventricular end-diastolic pressure. The thick blue curve is a typical normal Frank–Starling curve. To the right are shown curves representing progressive left ventricular failure. *Top left* is the safe quadrant, which contains a substantial part of the normal curve, but much less of the curves representing ventricular failure. *Top right* is the quadrant representing normal cardiac output but raised left atrial pressure, attained at the upper end of relatively normal Frank–Starling curves (e.g. hypervolaemia). There is a danger of haemodynamic pulmonary oedema. *Bottom left* is the quadrant representing normal or low left atrial pressure but low cardiac output, attained at the lower end of all curves (e.g. hypovolaemia). The patient is in shock. *Bottom right* is the quadrant representing both low cardiac output and raised left atrial pressure. There is simultaneous danger of pulmonary oedema and shock, and the worst Frank–Starling curves hardly leave this quadrant.

(Lumn, 2017)

Appendix C

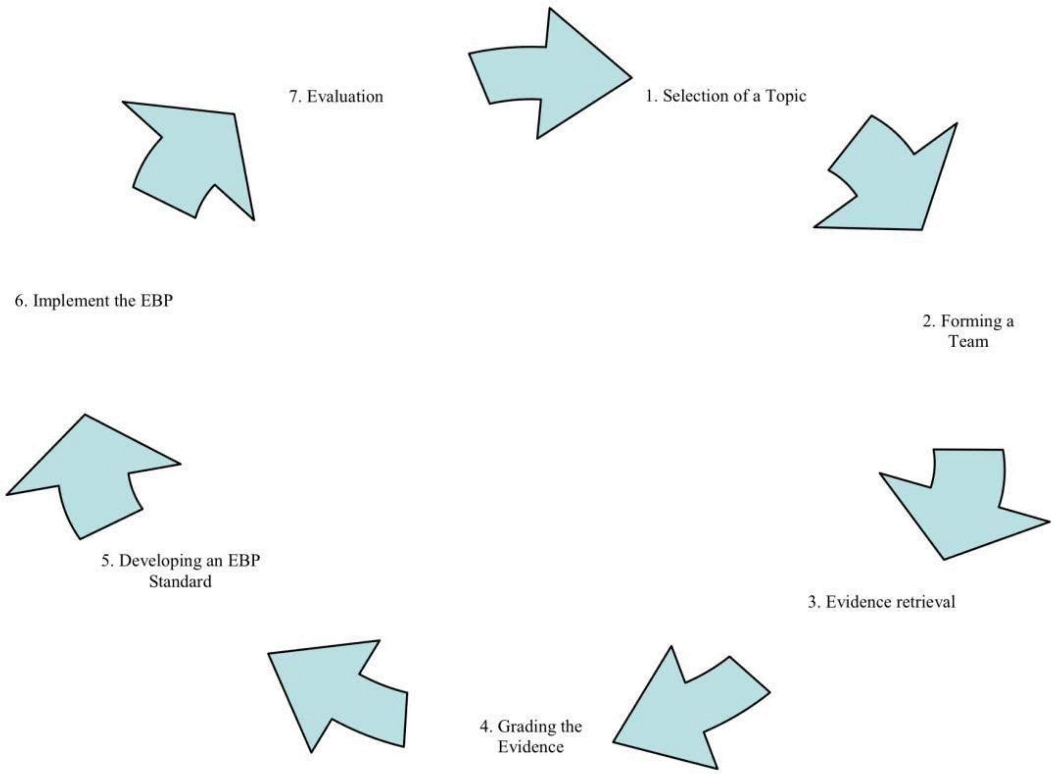
Cardiac Optimization Protocol



(Lian et al., 2022 and Weinberg et al., 2017)

Appendix D

Diagram of Iowa Model



(Doody & Doody, 2011, Figure 1)

Appendix E

International Study Group of Pancreatic Fistula Definitions

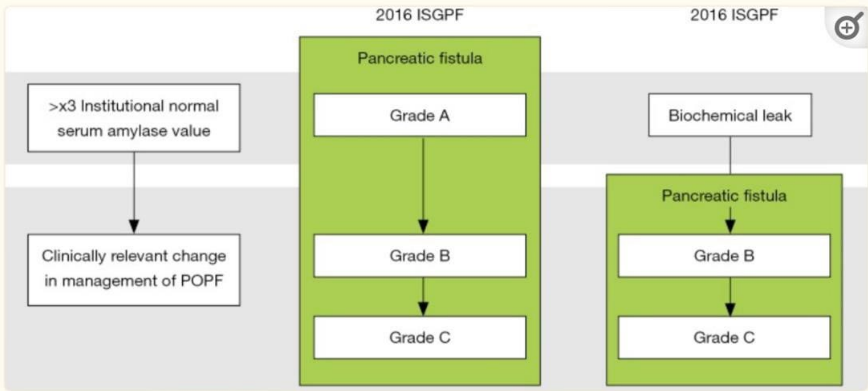


Figure 1

Change in POPF diagnosis. POPF, postoperative pancreatic fistula; ISGPF, the International Study Group of Pancreatic Fistula.

(Pulvirenti et al., 2017)

Table 1

Change in Grade B and C discriminating criteria

Event	2005 ISGPF	2016 ISGPS
Percutaneous or endoscopic drainage	Grade C/Grade B (unclear)	Grade B
Angiographic procedures for POPF related bleeding	Grade C	Grade B
Organ Failure	Not included	Grade C
Sepsis	Grade C	Not included
All events and treatment on POPF classification must be POPF-related	No	Yes

POPF, postoperative pancreatic fistula; ISGPF, the International Study Group of Pancreatic Fistula; ISGPS, the International Study Group for Pancreatic Surgery.

(Pulvirenti et al., 2017)