Anesthetic Management of a Patient with Severe Diastolic Dysfunction for Umbilical Hernia Repair: A Case Report

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Research has shown that 1 out of 3 people aged 55 or older will develop heart failure, which is often a fatal prognosis. Investigations have demonstrated that 35% of heart failure patients will succumb to their condition within 5 years of onset. Worldwide, it is estimated that 23 million people are living with and suffering from symptoms associated with heart failure. Heart failure can result from various sequences of events, and ultimately effect either the systolic or diastolic function of the cardiovascular system. Depending upon which condition is present, anesthesia providers must take into consideration the risk factors associated with heart failure and undergoing anesthesia for various surgical procedures. This case report will examine the anesthetic management of a patient with a known diagnosis of severe left ventricular diastolic dysfunction, with acute exacerbation of congestive heart failure, who presented to the emergency room with an incarcerated umbilical hernia.

Keywords: Diastolic dysfunction, heart failure, regional anesthesia, transversus abdominis plane, truncal blocks.

Statistics collected by the National Discharge Hospital Survey (NDHS) reported that 5.8 million people within the United States are suffering from congestive heart failure (CHF).[1] During a retrospective study of hospital admissions occurring between the years 2000 and 2010, over 1 million hospital admissions were a direct consequence of CHF.[1] Current statistics estimate that approximately 23 million people worldwide are affected by heart failure (HF) and related conditions.[2] According to the American Heart Association (AHA), *heart failure* can be defined as "a complex, clinical syndrome that can result from any structural or functional cardiac disorder that impairs the ability of the ventricle to fill or eject blood."[3] HF is a heart condition that can be defined by typical symptoms such as difficulty breathing, ankle swelling, peripheral edema, fluid accumulation in the lung fields, and fatigue as a result of functional and/or structural cardiac abnormalities resulting in decreased cardiac output at rest or during times of stress from increased myocardial demand.[4] The degree of HF can be classified into different stages and classifications according to the symptoms present. In Figure 1, each stage of HF is described with recommended courses of treatment. Classifications of HF can be better described by the severity of the patient's symptoms. The most commonly used list of symptomology associated with HF, is the New York Heart Association (NYHA) functional classification. A copy of this classification system can be found within the Table. It is important to note that both, systolic and diastolic function can be altered as a result of developing or worsening heart failure conditions. According to the Kaplan-Meier analysis, patients with a known history of diabetes mellitus and diastolic dysfunction, have a 13.1% probability of developing heart failure after 1 year of diagnosis and a 36.9% probability of developing heart failure after 5 years.[1] When diastolic dysfunction (DD) is present, it is typically graded using a score of mild, moderate, or severe, with severe diastolic dysfunction being associated with increased risk of myocardial infarc-

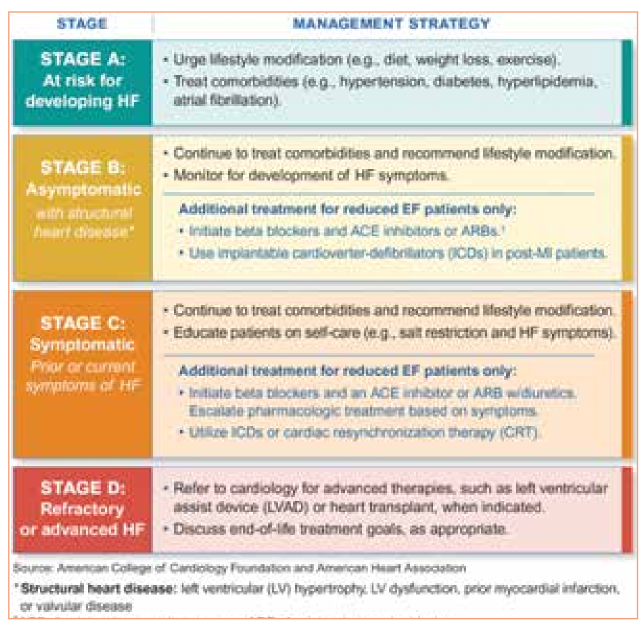

Figure 1. Stages and Management Strategy
Note: Structural heart disease: left ventricular (LV) hypertrophy, LV dysfunction, prior myocaridial infarction, or valvular disease. Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker.

Class	Patient symptoms
I	No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea (shortness of breath).
II	Slight limitation of physical activity. Comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea.
III	Marked limitation of physical activity. Comfortable at rest. Less than ordinary activity causes fatique, palpitation, or dyspnea.
IV	Unable to carry on any physical activity without discomfort. Symptoms of heart failure at rest. If any physical activity is undertaken, discomfort increases.

Table. New York Heart Association (NYHA) Functional Classification

tion, amyloidosis, hypertension, chronic renal failure, and systolic impairment. Mild and moderate graded DD is known to be an independent predictor for the risk of mortality, outside of the already established mortality risk factors of coronary artery disease (CAD), hypertension, diabetes mellitus, increasing age, and obesity.[5] Diastolic dysfunction over time can cause reciprocal changes within systolic function of the heart. The most sensitive marker for changes or indications of systolic dysfunction is regional longitudinal left ventricular function via sonography.[6] Likewise, there are numerous risk factors and known increased mortality predictions associated with DD. In recent studies, 90% of patients presenting with asymptomatic diastolic dysfunction, 87% of patients with diastolic dysfunction, and all patients with systolic failure were shown to exhibit impaired longitudinal systolic function.[6] Therefore, patients presenting to the perioperative area with a known history of diastolic dysfunction should be evaluated thoroughly and multimodal anesthetic plans should be considered to reduce the risk of worsening the diastolic dysfunction and potential systolic dysfunction. Regional anesthesia has advanced in recent years through the employment of ultrasound (US) guided techniques with plexus and fascial plane blocks. This case report describes the successful anesthetic management of a patient with severe diastolic dysfunction and congestive heart failure who required an emergent open surgical repair for an incarcerated umbilical hernia. The anesthetic approach for this emergent surgical procedure consisted of a transverse abdominis plane (TAP) block and minimal sedation.

Patient's Medical History

A 79-year-old woman (height 152.4 cm, weight 73 kg) presented to the emergency room with complaints of abdominal pain and a potential bowel obstruction. The patient was extremely dyspneic, displaying a respiratory rate of 24-28 breaths per minute, and maintaining an oxygen saturation of 93%. The patient had a known history of extensive umbilical hernia, however, no surgical interventions had been performed. A suspected small bowel obstruction and incarcerated hernia was confirmed via physical evaluation and computed tomography (CT) scan results. A chest x-ray was obtained due to the patient's complaints of dyspnea at rest. Results showed a bibasilar-atelectasis with pulmonary effusions from acute exacerbation of congestive heart failure (CHF). Medical history for this patient was notable for gastro-esophageal reflux disease (GERD), hypertension, type 2 diabetes mellitus, coronary atherosclerosis, atrial fibrillation, previous subdural hematoma, hypothyroidism and CHF. Surgical history included hysterectomy, breast biopsy, open-reduction internal fixation of left ankle fracture, and previous cataract removal. She reported no known drug allergies or food allergies. Routine medications were noted for atorvastatin, amiodarone, gabapentin, glimepiride, levothyroxine, losartan, metformin, metoprolol, omeprazole, warfarin, and potassium chloride. Lab values revealed white blood cell count, 6,400/μL; platelet count 429,000/μL; hemoglobin 10.1 g/dL; and hematocrit 33.2%. All electrolyte levels were within the normal parameter range. A 12-lead electrocardiogram was ordered and revealed a possible anterior infarct, with age undetermined, with underlying junctional rhythm with a heart rate in the 50s. A repeat chest x-ray was obtained, still evident for bibasilar atelectasis, with resolving pulmonary edema. Last known echocardiogram results evident for a normal left ventricular ejection fraction estimated to 60%. Left ventricular DD noted, graded severe and abnormal due to restrictive physiology, with decreased left ventricular compliance. An increase in left atrial pressure and mild left atrium dilation was noted. Moderate tricuspid regurgitation was present, as well as mild aortic valve regurgitation. Doppler parameters were consistent with restrictive physiology, demonstrating decreased atrial contractility and ventricular filling. After the second day of admission into the medical-surgical unit, the general surgeon on call made the decision that emergent surgical intervention was necessary to repair the incarcerated hernia. Results from pre-operative anesthesia evaluation demonstrated that the patient was a very high-risk surgical candidate due to the acute exacerbation of CHF, persistent dyspnea, and underlying severe diastolic dysfunction.

Due to the patient's acute exacerbation of CHF and left ventricular DD, the decision to proceed with regional anesthesia was made after consulting with the general surgeon. Due to the risk associated with poor compliance due to the restrictive physiology of left ventricular DD, the anesthetic plan was comprised of administering an ultrasound guided TAP block with minimal sedation to maintain current hemodynamic and respiratory parameters. The patient was then informed of the deci-

Figure 2. Approach of the TAP Block
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sion to proceed with the scheduled surgery utilizing a TAP block, with the possibility of needing to convert to general anesthesia if the block failed to provide adequate anesthesia. The patient and immediate family members were made aware of the independent risk factors associated with converting to general anesthesia, as the patient's current pulmonary and cardiac conditions were not optimal for general anesthesia. The surgeon then agreed that he would augment with local anesthetic at the skin to supplement the TAP block as needed.

Case Management

The patient was placed on the OR table, in a supine position with bilateral arms abducted no more than 90 degrees. Oxygen was delivered at a rate of 3 liters per minute (LPM) via nasal cannula with end tidal carbon dioxide monitoring in place. In accordance with ASA standards, all appropriate monitoring equipment was attached to the patient. The abdomen was then prepped and draped utilizing sterile technique. The patient was then given 2.5 mg midazolam and 50 µg fentanyl for sedation during block placement. The patient's left iliac crest and costal margins were identified, the ultrasound transducer was placed in a transverse orientation with optimal probe location located in the anterior axillary line between these two anatomical structures. The exact approach of the TAP block can be seen in Figure 2. Once the patient was adequately sedated, the TAP block was performed using strict sterile technique. After the Certified Registered Nurse Anesthetist (CRNA) obtained a clear image of the external oblique, internal oblique, and transversus abdominal muscles with ultrasound guidance, a skin wheal was made using 1% Lidocaine for skin desensitization. The recommended ultrasound guided technique results in a long axis view of the abdominal anatomy, maintaining an in-plane needle approach. Using the long axis view with an in-plane approach, a 21 G echogenic needle was then advanced using a 45-degree entry angle into the TAP plane with hydrodissection using preservative free saline to confirm needle tip placement. When the needle tip was confirmed to be within the fascial plane, 15 mL 0.5% Ropivacaine was injected with spread noted within the TAP fascial plane. This sequence was performed to contralateral side to ensure adequate sensory block of the abdomen. An injection of 15 mL of 0.5% Ropivacaine was performed on each side of the abdomen, totaling 30 mL of 0.5% Ropivacaine. Approximately 20 minutes after the last injection, the surgeon tested the surgical site with a slight stimulus from tweezers to assess the patient's ability to sense a "pinching" or "sharp" sensation. The patient confirmed that she did not feel anything sharp. The surgeon then supplemented the TAP block with 20 mL 0.25% Bupivacaine with Epinephrine injected in a periumbilical fashion, to maximize anesthetic efforts.

A curvilinear, midline incision was made by the surgeon. Oxygen delivery via nasal cannula was maintained to optimize respiratory status with current resolving CHF and pulmonary edema. Patient comfort and adequate sensory block was confirmed by the patient after initial incision was made. At this time, 1,000 mg ofirmev was given intravenously via piggy back administration to aide in analgesic efforts. The patient' s vital signs were maintained well within the baseline, with little to no fluctuation in blood pressure, heart rate, or oxygen saturation. The surgeon successfully dissected the hernia sac and surrounding fascial structures to identify the defect. At this time, the surgeon placed 11cm × 14 cm mesh patch within the identified defect. During placement of the mesh, the patient had complaints of feeling pressure as the surgical site was retracted for optimal visualization. As a result of the discomfort associated with the feeling of pressure, a total of 37.5 µg of fentanyl was given intravenously in the form of 12.5 µg boluses. By administering the fentanyl in the form of small bolus doses, the patient's cardiovascular and respiratory status were unchanged after administration. With the sensation of pressure being noted, the patient however confirmed that no sensation of pain or sharp stimuli was felt during this particular part of the procedure. The incision was closed with sutures after a total surgical length of 123 minutes. Estimated blood loss was 20 mL, with 750 mL crystalloid administered to the patient. In total, the patient received 2.5 mg midazolam, 87.5 µg fentanyl, and 1,000 mg ofirmev during the entire procedure. Approximately 15 minutes after dressing was applied to the surgical site, the patient was transferred to the post anesthesia care unit (PACU) for observation of respiratory and cardiovascular status. The patient's vital signs on arrival to the PACU were well within 20% of baseline, with minimal to no change to pre-operative vital sign values. The patient's pain rating utilizing the 0-10 pain scale, was rated at 0 after arrival to the PACU.

Discussion

When caring for patients with advanced cardiac disease such as severe diastolic dysfunction and congestive heart failure, multimodal anesthetic plans should be considered to ensure maximum patient safety. General anesthesia has been widely used for surgical procedures since first being publicly demonstrated in 1846 by William T. G. Morton at Massachusetts General Hospital.[7] General anesthesia can be simply defined as a medication induced suppression of consciousness, affecting the entire body. When this anesthetic is delivered, many alterations take place within the patients respiratory and cardiovascular systems. Assistive breathing devices such as endotracheal tubes, often accompany the administration of general anesthetics. With the patient experiencing an acute exacerbation of CHF and bilateral atelectasis, general anesthesia utilizing an endotracheal tube was unfavorable choice in anesthetic as the likelihood of requiring post-operative mechanical ventilation was greatly increased. Anesthesia for abdominal procedures can be achieved without creating a general anesthetic state by employing the use of various regional anesthesia techniques. Spinal anesthesia may be utilized for many procedures involving the abdomen, as this type of neuraxial blockade results in a desensitization of various dermatome levels below the fourth thoracic vertebrae (T4) dependent upon volume of anesthetic injected. Patients presenting to the peri-operative setting with pre-existing cardiovascular disease are at a higher risk of developing complications associated with spinal anesthesia. In elderly patients, sympathetic tone and sympathetic activity increases with age, as well as those patients with underlying congestive heart failure and as a result, are more prone to develop greater reductions in systemic vascular resistance (SVR), myocardial contractility, and blood pressure.[8] It has been reported, that spinals achieving sensory blockade at a T4 dermatome level, can reduce SVR by as much as 21% in elderly patients as a result of the sympathetctomy associated with spinal anesthesia.[8] In this particular case, a spinal anesthetic would provide optimal respiratory preservation; however, the resultant cardiovascular effects related to decreased sympathetic tone and SVR, made this approach undesirable due to the patient's failing heart. Truncal and fascial plane blocks have become more popular in recent times with abdominal procedures due to the absence of a complete sympathectomy in at risk patients, while providing adequate sensory blockade and maintaining optimum cardiovascular function.

Transversus Abdominis Plane Block

The transversus abdominis plane is referred to as the fascial plane that is located between the internal oblique and transversus abdominis muscle layers within the abdominal wall. The TAP block has widely been known to be very effective in providing post-operative analgesia and reducing narcotic requirements in post-operative patients undergoing lower abdominal surgery.[9,10,11] In the TAP plane, the intercostal, subcostal, and L1 segmental nerves communicate to form the upper and lower TAP plexuses, which innervate the anterolateral abdominal wall, including the parietal peritoneum.[12] When the needle tip is correctly identified within the fascial plane between the internal oblique and transversus abdominis muscle, injection of local anesthetic will create a sensory blockade between dermatomes T10-L1.[13] Anesthetic spread can be easily visualized under ultrasound guidance. As illustrated in Figure 3, the local anesthetic spread will elevate and separate the fascial plane from the internal oblique from the transversus abdominis muscle, clearly delineating the TAP plane. As with many fascial plane or infiltration blocks, level of blockade is highly dependent upon volume of solution administered. Modifications of the traditional tap block approach can result in higher or lower level dermatome blockade, due to the local anesthetic travelling more caudal or cephalad within this fascial plane. With the injection of local anesthetic solution within the tap fascial plane, alterations in sympathetic tone would be minimal, resulting in minimal changes in the patient's baseline cardiovascular status.

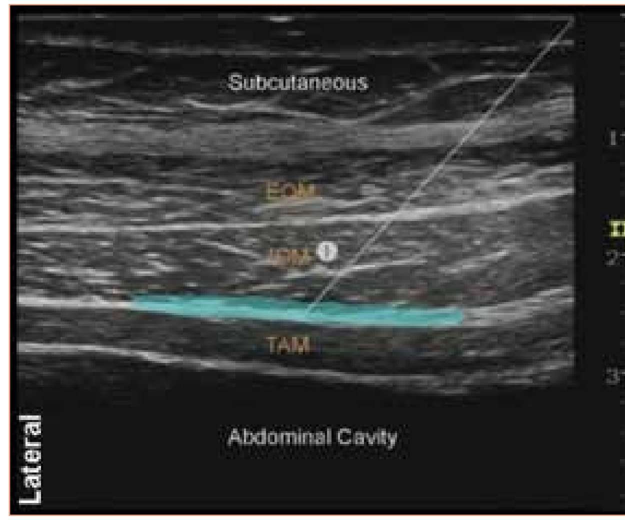

Figure 3. Anesthetic Spread
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This case presented a unique situation, in that the defect in and around the patient's umbilicus created a Richter type hernia. Richter type hernias pose a serious concern, as the angulation is great enough to cause incarceration of small bowel and resultant bowel obstructions. The entrapped bowel becomes strangulated and may rapidly progress to gangrene, even in the absence of signs of intestinal obstruction.[14] The associated mortality rate of Richter's type hernia is approximately 17% when these conditions are present.[14] The patient was admitted for the bowel obstruction, and subsequent CHF exacerbation with dyspnea present. By proceeding with the TAP block, the patient was able to undergo this hernia repair with very minimal sedation and communicate throughout the entire procedure, which allow strict adherence to baseline vital sign parameters to avoid any potential complications from the severe left ventricular diastolic dysfunction. This surgery was successfully performed under a bilateral TAP block as the sole anesthetic. To knowledge, there have been few reports discussing the use of the TAP block as the sole anesthetic, but in high risk surgical candidates, this block can be very advantageous in managing the anesthesia delivery in critically ill patient populations.[15] In the anesthetic management of patients with underlying cardiac disease, optimizing and maintaining cardiac function is essential to patient outcomes. Under ultrasound guidance, the TAP block effectively blocks abdominal somatic innervation while leaving sympathetic efferent innervation unaffected, ultimately reducing the cardiovascular effects of the block for these already compromised patients.[16] Documented case studies and reports utilizing the TAP block as a sole anesthetic may be limited due to the recent emergence of this block, as it has been most commonly utilized for post-operative pain management in abdominal surgeries. Prior to the advances made in ultrasound guidance, this block was performed via injection of local anesthetic solution between the internal oblique abdominal muscle (IOAM) and the transversus abdominal muscle (TAM) by way of the triangle of Petit, which is the external landmarks located between the latissimus dorsi, external oblique abdominal muscle, and iliac crest. The limitations of using the landmark techniques for this particular block reside in the anesthesia providers ability to successfully and adequately feel a pop, signifying that the needle tip has advanced through the fascial plane located between the IOAM and the TAM. Morbidly obese patients or patients with higher adipose tissue may create a difficulty in obtaining clear and precise ultrasound images. In the obese patient, a curved linear ultrasound probe may be more beneficial in obtaining images located deeper within the abdomen. Many adverse outcomes related to the TAP block are direct consequences of the pop technique, whereas inadvertent colonic puncture or unpredictable spread of local anesthetic occurred due to the inability to visualize the needle tip and injection. Under ultrasound guidance, direct visualization of the needle tip, anatomical abdominal structures, and the spread of local anesthetic solution, the margin of safety for the TAP block is drastically increased along with higher success rates for optimal block qualities.[17] As the use of ultrasound guidance continues to grow within the various aspects of regional anesthesia, the role of TAP blocks in multimodal anesthetic plans will continue to evolve ensuring the highest quality care for each patient.

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