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Anesthetic care of a pregnant patient for AICD battery change

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Keypoints

1. Approximately 1-2% of all parturients require non-obstetrical surgery due to appendicitis, gall bladder disease, ovarian torsion or trauma-related issues.
2. The perioperative goals when caring for a parturient for non-obstetrical surgery include consideration of the anatomical and physiologic changes related to pregnancy; avoidance of teratogenic agents; maintenance of placental blood flow and fetal perfusion; and monitoring of fetal status with prevention of premature labor.
3. Whenever feasible, regional anesthetic techniques are generally preferable to avoid the impact of anesthetic agents on fetal and maternal well-being and limit the incidence of preterm labor.
4. Uteroplacental perfusion is dependent on maternal blood pressure. Maternal hypotension may be corrected by increasing venous return with intravenous fluids, eliminating aortocaval compression by adjusting maternal position, or the administration of a vasoactive agent.
5. ACOG guidelines for fetal monitoring include assessing the fetal heart rate and uterine contraction before and after the surgical procedure. Intraoperative fetal monitoring is feasible only if the fetus is viable and the nature of surgical procedure allows room for an emergent Cesarean delivery when indicated.

Abstract

Urgent or emergent surgical procedures may be required during pregnancy. During this time, the perioperative care extends to include not only the patient but also monitoring and preservation of the fetal well-being. Assurance of adequate placental blood flow, avoidance of teratogenic agents, and prevention of preterm labor add to the complexity of perioperative management. We present a 35-year-old woman who required anesthetic care at 12 weeks gestation for exchange of a battery in her automatic implantable cardiac defibrillator (AICD). The physiologic changes induced by pregnancy are presented, their anesthetic impact reviewed, and specific perioperative considerations of the pregnant patient discussed.

Keywords

Pregnancy, tetratogenesis, dexmedetomidine, preterm labor.

Introduction

Given the physiologic changes induced by pregnancy, risks to the fetus related to potential teratogenic effects of anesthetic agents and potential to induce preterm labor, elective surgery should be delayed until at least six weeks postpartum. However, current guidelines from the American College of Obstetrics & Gynecology (ACOG) indicate that avoidance or delay of medically necessary surgery should not occur in pregnant women regardless of the trimester because this can adversely affect the woman and fetus. Approximately 1-2% of all pregnant women will require non-obstetrical surgery related to appendicitis, gall bladder disease, ovarian torsion or neoplasm, and trauma-related issues.[1-3] More than 75% of these patients will require surgical intervention during the vulnerable first or second trimester.[4] During this time, perioperative care extends to include not only safe care for the patient but also monitoring and preservation of the fetal well-being, assurance of adequate placental blood flow, avoidance of teratogenic agents, and prevention of premature labor. We present a 35-year-old woman who required anesthetic care at 12 weeks gestation for exchange of a battery in her automatic implantable cardiac defibrillator (AICD). The physiologic changes induced by pregnancy are presented, their anesthetic impact reviewed, and specific perioperative considerations of the pregnant patient discussed.

Case report

The patient was a 35-year-old nulliparous African American woman who presented at 12 weeks gestation with dichorionic diamniotic twins for an AICD generator replacement. Her past medical history included tetralogy of Fallot (TOF) repaired at age 2 years and pulmonary valve replacement at age 23 years. Shortly after pulmonary valve replacement, she was diagnosed with supraventricular tachycardia and wide complex tachycardia. An AICD was placed in the same year. Her past surgical procedure consisted of an intracardiac electrophysiologic study, which was unable to fully eliminate the supraventricular tachycardia. Additional comorbid conditions included a history of deep vein thrombosis of the upper extremity, right ventricular dilation, hypertension, and asthma. She was hospitalized out of state for both atrial and ventricular tachyarrhythmias and received multiple appropriate and inappropriate therapies from the AICD. The battery was brought to the end of life status and it was not expected to last until the end of pregnancy.

Due to the time sensitive nature of her AICD battery, the patient was admitted for AICD generator replacement. The patient had known allergies to nuts, egg products, intravenous contrast, lisinopril, sotalol, and sulfonamide antibiotics. Outpatient medications included amiodarone (200 mg, once a day), aspirin (80 mg, once a day), enoxaparin (120 mg by subcutaneous injection, every 12 hours), metoprolol succinate (150 mg in the morning and 200 mg at night), amoxicillin (500 mg) prior to dental procedures, fluticasone inhaler (twice a day), albuterol (as needed), and prenatal vitamins. There was no history of complications with anesthesia during previous surgical procedures. Of note, the patient was of Jehovah's Witness faith and refused transfusion of blood products. The patient was held *nil per os* (NPO) for 8 hours. Preoperative vital signs included a weight of 98.9 kg, heart rate (HR) of 64 beats/minute, respiratory rate (RR) of 18 breaths/minute, blood pressure (BP) of 122/76 mmHg, and oxygen saturation of 99% in room air. Physical examination revealed a Mallampati Class II airway and a thyromental distance of greater than 3 fingerbreadths. Cardiovascular examination revealed a regular rate and rhythm. No other significant physical findings were noted. The patient was transported to the operating room and standard American Society of Anesthesiologists' monitors were placed. A 20-gauge peripheral intravenous cannula was placed in the left hand. Supplemental oxygen was administered via a nasal cannula. Two initial bolus doses of propofol (total of 40 mg) were administered, a propofol infusion started at 100 µg/kg/min, and a remifentanil infusion started at 0.05 µg/kg/min. After an appropriate depth of sedation had been achieved, pectoralis blocks (PECs 1 and II) were performed with a total

of 30 mL of ropivacaine 0.5% with epinephrine and dexamethasone. Additionally, a superficial cervical plexus block was performed with 7 mL of ropivacaine 0.5% with epinephrine. The patient tolerated these without incident. During the procedure, there were no adverse hemodynamic or respiratory events. One additional bolus of 40 mg of propofol was administered. The HR varied from 54 to 72 beats/minute and the BP from 108/60-157/128 mmHg. The removal and replacement of the implantable defibrillator pulse generator procedure took approximately 110 minutes. The patient tolerated the procedure well and she was transported to the post-anesthesia care unit (PACU). No additional analgesic agents were administered in the PACU. She was discharged home the same day. The AICD was interrogated 3 days later, both pacing and sensing thresholds were deemed satisfactory. Further evaluation with an echocardiogram revealed new findings of moderate right atrial dilation, mild right ventricle hypertrophy, mild tricuspid valve regurgitation, moderate pulmonary valve stenosis and regurgitation, and a mildly diminished right ventricular systolic function (27.9%). The patient did not experience any inappropriate discharges from the AICD. At 27 weeks gestation, a Cesarean section was performed due to fetal concerns including intrauterine growth retardation. The procedure was completed without any surgical or anesthesia complications under spinal anesthesia. Both neonates were transported to the neonatal intensive care unit (NICU) immediately after delivery and required the use of continuous positive airway pressure for 12-24 hours. The remainder of their neonatal course was unremarkable.

Discussion

Surgery during pregnancy mandates the provision of anesthetic care with consideration of the requirements of two patients including the mother and the fetus. Intraoperative goals when caring for the pregnant patient requiring surgery include: 1) care of the patient including a consideration of the anatomical and physiologic changes related to pregnancy; 2) avoidance of anesthetic agents with teratogenic or pro-apoptotic effects; 3) assurance of adequate placental blood flow and avoidance of fetal hypoxia; 4) ongoing monitoring of fetal status; and, 5) prevention of premature labor. As with all anesthetic care, the initial step includes a thorough preoperative examination, identification of chronic comorbid conditions, and anesthetic implications of acute conditions.

Of primary concern to the anesthesia provider is the potential for anatomic changes that may increase the difficulty of airway management and endotracheal intubation.[5,6] Airway changes during pregnancy include swelling, engorgement, and increased friability of the tissues of the nasopharynx and oropharynx.[7] The former generally precludes the use of nasal intubation techniques due to an increased risk of bleeding. These airway changes, which are present from the middle of second trimester, may increase the incidence of a difficult airway and the likelihood of a higher Mallampati score, especially in association with greater weight gain.[8-10] In addition to a thorough evaluation of the airway to identify high-risk patients, simulation training, appropriate patient positioning, ready access to difficulty airway equipment and adjuncts, and attention to standard difficult airway algorithms is suggested.[11]

These airway concerns are magnified by the presence of a “full stomach” scenario regardless of the NPO time frame and the risk of aspiration of gastric contents. During pregnancy, the risk of aspiration is greater due to a reduced lower esophageal sphincter pressure, an elevated intra-abdominal pressure, and an increased gastric volume and acidity.[12-14] These changes are generally present at 18-20 weeks gestation and beyond. Due to these concerns and the potential impact of anesthetic agents on the fetus, regional anesthesia is preferred when possible.[15] When general anesthesia is necessary, rapid sequence intubation is generally recommended to mitigate the risk of aspiration.[16] Additional measures to decrease gastric volume (metoclopramide) or increase its pH (H_2-antagonists or non-particulate antacids) may be included, although

their efficacy have not been proven in rigorous clinical trials.[17]

Pregnancy induces physiological changes that affect all organ systems with an overall increase in metabolic demands. Of the respiratory system, minute ventilation increases. A relative hyperventilation induced by the central effects of progesterone on respiratory drive results in a mild respiratory alkalosis and an elevation in the CO_2 production.[18-20] A decrease of expiratory reserve volume (ERV), decreased functional residual capacity (FRC), and increased closing capacity escalates the potential for hypoxemia. The FRC is further reduced with increased abdominal pressure as the uterus expands with the growing fetus, decreased skeletal muscle tone due to anesthesia, or administration of neuromuscular blocking agents.[21,22] These factors speed the onset of hypoxemia during periods of apnea and may lead to increased ventilation-perfusion mismatch during positive pressure ventilation.

With the addition of fetal circulation, stroke volume and heart rate increases during the second and third trimesters. Consequently, maternal cardiac output increases by 30-50%.[5,6] Tissue oxygen delivery is generally maintained by the increased cardiac output although it may be impacted by a decrease in hematocrit during the first two trimesters. Additionally, cardiac output may be impacted by aortocaval compression during the second trimester and beyond. These effects can be mitigated by appropriate positioning of the patient in supine with a left lateral tilt of 20-30° and placement of a wedge under the patient's right hip. Intravenous and inhalation anesthetic agents may lead to a reduction in systemic vascular resistance (SVR) and a decreased cardiac output with the potential to compromise placental and fetal perfusion.[3,6] If dictated by clinical scenario, intravenous anesthetic agents with the potential for signficant negative inotropic effect (propofol or barbiturates) can be avoided in favor agents such as etomidate or ketamine that have limited effects on myocardial function and SVR.[23]

When acute changes in blood pressure are related to induction or maintenance of general anesthesia or placement of regional anesthesia (spinal or epidural anesthesia), the administration of short-acting vasoactive agents (phenylephrine, epinephrine or ephedrine) may be indicated to restore cardiac output and blood pressure thereby maintaining placental perfusion. Classic teaching had been to avoid phenylephrine, as its pure α-adrenergic agonistic effects may cause vasoconstriction of the placental vascular bed and decrease blood flow to the fetus.[24] However, recent literature and evidence-based medicine supports the safety and efficacy of all 3 vasoactive agents in the treatment of hypotension in parturient.[25]

The gravid uterus induces renal changes consisting of an increased glomerular filtration rate and a constant state of volume expansion. Physiological effects are manifested as peripheral edema, urinary stasis, and increased excretion of urinary proteins and glucose. Hormonal effects from elevated levels of estrogen and progesterone alter hepatic enzymatic activities including the cytochrome P450 enzyme system.[26] A progressive decrease of serum albumin may further alter pharmacodynamics by increasing the free unbound concentration of various medications.

Potential for teratogenic effects may impact the choice of medications and anesthetic agents used. Rapid tissue differentiation during the first trimester with organogenesis at its peak increases the susceptibility to structural anomalies, whereas exposure to teratogens later in the pregnancy is more likely to result in fetal growth restrictions or preterm labor. Historically, benzodiazepines are avoided due to their postulated association with cleft lip and palate; however, more recent data suggests an additional association with lower birth weight and increased risk for preterm birth.[27] The safety of nitrous oxide has also been questioned given its effects on DNA synthesis and inhibition of methionine synthase, an essential mechanism for vitamin B_{12} and folate synthesis.[28] Based on animal models and clinical data, volatile anesthetic agents,

opioids, and intravenous agents (propofol and ketamine) are free of teratogenic effects. [29]

More recently, concern has been expressed that prolonged or repeated exposure to specific general anesthetic agents may have deleterious effects on the developing brain. This concern has arisen primarily from studies in neonatal and juvenile animals, which have consistently shown to increase in apoptosis after anesthesia exposure.[30-32] However, to date, there are no clinical studies to justify any mandates regarding changes in the choice of anesthetic agents during delivery or during anesthesia for neonates.[33,34] In a retrospective database analysis, regional anesthesia was associated with a reduced risk of negative neurocognitive effects when compared to spontaneous vaginal delivery, while both vaginal delivery and Cesarean section with general anesthesia shared similar risks.[34]

Uteroplacental perfusion relies primarily on maternal blood pressure to ensure adequate blood flow and oxygen delivery to the fetus. Maternal hypotension may be corrected by increasing venous return with administration of isotonic intravenous fluids, eliminating aortocaval compression by adjusting maternal position as mentioned above, or administration of a vasoactive agent.[35] In our patient, intravenous sedation and regional anesthesia were used thereby eliminating the need for general anesthesia including endotracheal intubation with positive pressure ventilation and its impact on hemodynamic function. To ensure fetal well-being during non-obstetrical surgery, fetal heart rate monitoring and assessment for the onset of preterm labor may be indicated. Continuous fetal heart rate monitoring has been used as early as 16-18 weeks gestation, but proper assessment of fetal heart rate variability is generally not feasible until 25-27 weeks.[36] ACOG guidelines for fetal monitoring include assessing the fetal heart rate and uterine contractions before and after the surgical procedure. Intraoperative fetal monitoring is feasible only if the fetus is viable and the nature of surgical procedure allows for an emergent Cesarean delivery when indicated.[37] Non-obstetric surgical procedures carry the risk for spontaneous abortion, preterm labor, and preterm delivery. This risk increases with gestational age and may be related to manipulation of the uterus during surgery, associated comorbid conditions, and anesthetic techniques. Ongoing postoperative monitoring for preterm labor may be indicated and short-term use of tocolytic agents may be required to prevent preterm labor following non-obstetrical surgery.[38,39] Once a fetus is viable, non-obstetric surgical procedures should only be performed at institutions capable of delivering and caring for obstetrical patients.

We have previously reported the successful use of regional anesthesia techniques for the placement of pacemaker/AICD systems.[40] Pectoralis type I and II blocks provide anesthesia to the area of the chest supplied by the lateral pectoral nerves. The local anesthetic is deposited between the fascial planes of the pectoralis major and minor muscles (targeting the lateral pectoral nerve) for a PEC I block and between the pectoralis minor and serratus anterior muscle (targeting the medial pectoral nerve) for a PEC II block. These blocks were developed to provide an alternative to the paravertebral block for chest wall procedures, specifically breast surgery.[41,42] Placement of transvascular intracardiac devices also necessitates accessing the subclavian vein below the clavicle. As this region is not anesthetized by the PEC blocks, a superficial cervical block was also used in our patient to anesthetize the mid-portion of the clavicle and the cutaneous area directly below it.

In summary, the perioperative care of a parturient undergoing non-obstetric surgical procedure requires multiple considerations. The necessity of a procedure must be evaluated along with the anesthetic techniques and consideration of the specific physiologic goals. Intraoperative goals include primary care of the parturient with consideration of the anatomical and physiologic changes related to pregnancy; avoidance of anesthetic agents with teratogenic effects; assurance of adequate placental blood flow; and avoidance of fetal hypoxia. Depending on the gestational age of the fetus and the type of surgery,

intraoperative fetal monitoring may be used along with postoperative monitoring for premature labor and pharmacologic treatment to stop it as needed. Given its limited effects on hemodynamic function and the ability to avoid or limit the need for inhalational or intravenous anesthetic agents, regional anesthetic techniques may be indicated. Given the location of the procedure and its limited invasiveness, we were able to provide surgical anesthesia using PEC blocks with supplemental intravenous sedation.

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