This case report discusses an unlikely occurrence of massive subcutaneous emphysema in an elective robotic-assisted laparoscopic total hysterectomy in a 45-year-old, ASA class 1 woman. The patient’s perioperative course was otherwise uncomplicated, with the subcutaneous emphysema developing at surgical closure. The patient presented with substantial crepitus spanning from her face to her lower extremities and hypercarbia with end-tidal carbon dioxide readings persistent between 60 and 70 mm Hg. This case did not result in clinically significant airway obstruction because of provider vigilance. However, undiagnosed subcutaneous emphysema without a secured airway may lead to respiratory distress, respiratory depression, airway obstruction, tracheal deviation, and tension pneumothorax.

Keywords: Certified Registered Nurse Anesthetist, CRNA, robotic-assisted laparoscopic surgery, subcutaneous emphysema.

The robotic-assisted laparoscopic approach has become a preferred surgical method when minimally invasive surgery is indicated for colorectal, urologic, and gynecologic patients. The benefits of robotic laparoscopic minimally invasive surgery have been well documented over the last 2 decades, which include decreased length of hospital stay, reduced perioperative blood loss, and decreased postoperative pain scores.1,2 With data continuing to show superior patient outcomes and increasing cost-effectiveness, it is logical that robotic-assisted laparoscopic surgery continues to be adopted by healthcare facilities.3 However, many of the potential perioperative risks of a robotic laparoscopic procedure are overlooked because of their rarity, including massive subcutaneous emphysema. Subcutaneous emphysema occurs when a gaseous substance infiltrates the subcutaneous tissues in the body. During a laparoscopic procedure, the gas is carbon dioxide, which is used for the creation of the pneumoperitoneum required to achieve surgical exposure. Other reported complications of laparoscopic procedures include hematoma, hernia at the trocar site, infection, urinary retention, paralytic ileum, abdominal organ perforation, acute pulmonary edema, and death.4,5 This case report discusses the presentation and anesthetic management of acute massive subcutaneous emphysema during the perioperative and postoperative periods of an elective robotic-assisted laparoscopic hysterectomy.

Case Summary
An ASA class 1, 45-year-old woman with the diagnosis of uterine fibroids presented for an elective robotic-assisted laparoscopic total hysterectomy. Findings of the preoperative assessment revealed that the patient was of normal body habitus (157 cm, 62 kg); had ingested nothing by mouth for greater than 8 hours; and reported no allergies, current daily medications, or remarkable medical history. Her surgical history included dilation and curettage, appendectomy, and cesarean delivery with no procedural or anesthetic complications. Evaluation of the patient’s airway predicted easy airway management with the following supportive findings: a Mallampati score of 1, dentition in good condition, and a thyromental distance greater than 6 cm. All phlebotomy laboratory test results were reported within normal limits, and the human chorionic gonadotropin test was negative. The electrocardiogram reported a normal sinus rhythm (heart rate of 76/ min) and was current within 30 days. A chest radiograph completed 1 week before the scheduled surgery was also available for review, with no acute findings.

The patient gave consent for general anesthesia with endotracheal intubation and an ultrasound-guided transverse abdominal plane (TAP) block for postoperative pain management. The local anesthetic dosing for the TAP consisted of 10 mL of 1.3% bupivacaine liposome injectable suspension (Exparel), 10 mL of 0.5% bupivacaine, 1 mL of dexamethasone (4 mg/mL), and 4 mL of sterile normal saline bilaterally. The total case duration spanned from 12:04 to 4:40 PM, with surgical time accounting for the period from 12:38 to 3:41 PM.

In the operating room, all standard monitors were applied. Preinduction vital signs were the following:
heart rate normal sinus rhythm at 72/min, blood pressure of 110/61 mm Hg, respiratory rate (RR) of 16/min, 100% oxygen saturation measured by pulse oximetry (SpO₂) on room air, and a temperature of 36.5°C. During the preinduction timeframe, the patient received 2 g of cefazolin (Ancef) for surgical infection prophylaxis as well as 2 mg of midazolam and 50 μg of fentanyl, and she was preoxygenated for 2 minutes.

Induction of general anesthesia was achieved with the administration of 100 mg of lidocaine, 100 μg of fentanyl, and 150 mg of propofol. After confirmation of easy mask ventilation, 50 mg of rocuronium was administered. A single,atraumatic direct laryngoscopy with a Macintosh size 3 laryngoscope blade was performed, with attainment of a grade 1 view of the vocal cords. Subsequently, a 7.5-cm cuffed endotracheal (ET) tube was placed and secured at 22 cm at the lip. The ET tube placement was confirmed via end-tidal carbon dioxide (ETCO₂) capnography and lung auscultation. Volume control ventilation was instituted with targeted tidal volumes (Vₜ) of 550 mL, positive end-expiratory pressure of 5 cm H₂O, initial RR of 10/min, fraction of inspired oxygen (FIO₂) of 60%, and sevoflurane at 2.0% to maintain general anesthesia. After intubation, 4 mg of dexamethasone and 4 mg of ondansetron were given for postoperative nausea and vomiting prophylaxis, followed by a 1-g injection of acetaminophen (Oxirmev) for nonopioid pain management. Vital signs were a temperature of 36°C, blood pressure of 104 mm Hg and 64 mm Hg, heart rate of 89/min normal sinus rhythm, and SpO₂ of 100% with the previously stated ventilatory settings. Preceding surgery, the TAP block was performed by the pain management specialist using ultrasonography guidance, with no evidence of complication.

The perioperative period was primarily uneventful. The patient's hemodynamic parameters remained within 20% of baseline vital signs, ventilatory settings were not changed, peak inspiratory pressures (PIPs) were never greater than 33 cm H₂O during the case, even with pneumoperitoneum, and ETCO₂ values remained within 30 to 35 mm Hg. For achievement of the required surgical exposure, 5 trocar sites were used, with carbon dioxide insufflation pressures never breaching 18 mm Hg.

At 3:30 PM, ETCO₂ values began to deviate from the patient's baseline of 30 to 35 mm Hg on the programmed ventilatory settings. At this time, ETCO₂ was recorded at 41 mm Hg. In response, the RR was increased to 12/min, and ETCO₂ values initially responded appropriately, returning to 35 mm Hg. At 3:38 PM, the patient achieved spontaneous ventilation with an intrinsic RR of 14/min, and a train-of-four ratio of 0.9 was assessed in preparation for extubation. At this time, ETCO₂ values were sustained in the 50s mm Hg. The surgery concluded at 3:41 PM, and simultaneously the patient was given 0.8 mg of glycopyrrolate and 4 mg of neostigmine for full reversal of paralysis. The surgical time was uneventful, and the estimated blood loss was 25 mL.

At 3:50 PM, the patient continued with adequate spontaneous ventilation with a RR of 12/min to 16/min; however, ETCO₂ values remained in the 50s to 60s mm Hg. At 3:55 PM, the patient was unable to control ETCO₂, with values in the 60s to 70s mm Hg and with spontaneous ventilatory efforts regardless of the RR spanning 16/min to 20/min and Vₜ between 400 and 600 mL. The patient was assessed for alternative diagnoses to explain hypercarbia and was found to have extensive subcutaneous emphysema characterized by crepitus on palpation in her face, the upper chest area and shoulders, and her lower extremities down to the feet. On further assessment, the patient exhibited the ability to follow commands and move all extremities equally.

At 4:05 PM, the anesthesia care team decided to keep the patient intubated and sedated for further evaluation in the postanesthesia care unit (PACU) for a potential overnight admission. A chest radiograph was ordered to assess tracheal deviation, airway obstruction, or additional respiratory sequelae. The patient received a propofol infusion (50 μg/kg/min) in the operating room until the PACU and support staff members were equipped to receive the patient properly. The ETCO₂ values remained in the 60s to 70s mm Hg.

At 4:25 PM, the patient was transferred to the PACU, hemodynamic parameters remained stable, ETCO₂ values were sustained in the 50s mm Hg, and the subcutaneous emphysema was unchanged. While the patient was in recovery, a chest radiograph was obtained and showed no evidence of airway obstruction. Additionally, the critical care medicine specialist examined the patient and confirmed she was an appropriate candidate for extubation once sedation was weaned, neurologic status returned to normal limits, and she successfully demonstrated airway protective measures (airway reflexes and ability to maintain normocarbia).

By 11 PM, the patient was successfully extubated in the PACU, received placement of a simple face mask, and was admitted overnight to a medical-surgical floor for observation of pulmonary status and subcutaneous emphysema resolution. Minimal subcutaneous emphysema remained in the upper chest area and shoulders and portions of the lower extremities.

On postoperative day 1, the patient ambulated while breathing room air and maintained an SpO₂ of 97%. The subcutaneous emphysema remained minimally in the upper chest area and shoulders. There was no evidence of any additional postoperative complications. The patient was discharged home that afternoon.

**Discussion**

In most instances, subcutaneous emphysema, even when extensive, is a benign complication that requires in-
termittent monitoring. However, in severe cases, subcutaneous emphysema may cause airway obstruction, respiratory distress, tension pneumothorax, and potential pacemaker malfunction. With the ever-growing popularity of robotic-assisted laparoscopic procedures, it is important to note that subcutaneous emphysema has the potential to be a more frequent complication of this surgical technique. The current incidence of subcutaneous emphysema following a robotic laparoscopic procedure is currently 0.3% to 2.3%.7

There are several known risk factors for the development of subcutaneous emphysema in a patient undergoing robotic-assisted laparoscopic surgery. Operative time exceeding 200 minutes, use of 6 or more surgical ports, multiple attempts at abdominal entry, type of trocar and pressure system (AirSeal, SurgiQuest, now ConMed Corp), high insufflation gas flows and pressure settings exceeding 15 mm Hg, age over 65 years, body mass index greater than 35 kg/m², and maintaining an ETCO₂ greater than 50 mm Hg perioperatively all have been shown to predispose the patient to the development of subcutaneous emphysema.8

Preventive strategies primarily take aim at targeting potential risk factors for subcutaneous emphysema during robotic procedures. Anesthesia provider vigilance and awareness of subcutaneous emphysema presentation are key in early recognition. Potential differential diagnoses that must be ruled out can range anywhere from the simple fix of an exhausted carbon dioxide absorbent canister to malignant hyperthermia. Additional methods of prevention and differential diagnoses are listed in the Table.

The anesthetic implications and management of subcutaneous emphysema are focused around airway protection strategies. If subcutaneous emphysema is recognized intraoperatively, the patient should be returned to the supine position immediately. Early interventions of hyperventilation, increasing FIO₂ to 100% for adequate oxygenation, and alerting the surgical team to the proposed diagnosis expedite appropriate management of subcutaneous emphysema. If insufflation pressures are above 15 mm Hg, they should be decreased and potentially ceased until a detailed assessment has been conducted.9 The surgical time should be limited or the operation ceased, to diminish the severity of subcutaneous emphysema. Positive pressure ventilation should be maintained with the patient under sedation. Ventilatory strategies are targeted at maintaining normocarbia and lung protection, which include hyperventilation and V₅ of 6 to 8 mL/kg to maintain normocarbia, titration of FIO₂ to maintain oxygen saturation greater than 95%, and limitation of PIP to no greater than 30 mm Hg. If nitrous oxide is being used as an anesthetic, it should be discontinued to limit expansion of the subcutaneous emphysema. Evaluation of potential airway obstruction, tracheal deviation, and pneumothorax should be completed using chest radiography before the removal of a secured airway. Arterial blood gas analysis may be done to assess severity of respiratory acidosis and potential electrolyte imbalances if hypercarbia cannot be managed effectively via positive pressure ventilation.10 Exubation should not occur until airway obstruction has been ruled out, neurologic status is intact, and the patient can maintain normocarbia with intrinsic RR and minimal work of breathing. In a scenario in which subcutaneous emphysema is identified after the removal of a secured airway, establishment of a patent airway is the top priority. Reintubation may be necessary to circumvent subcutaneous emphysema–induced airway obstruction or respiratory depression secondary to severe hypercarbia. In rare instances, needle decompression may be required to establish airway patency and hemodynamic stability.11

In the case discussed, the patient did not present with any of the listed risk factors. However, several surgical risk factors were present, specifically a surgical time approaching the 200-minute mark and the use of insufflation pressures greater than 15 mm Hg. The brand of trocar used during the case was unclear. However, the use of valveless trocars, such as AirSeal, has been found

<table>
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<th>Prevention strategies</th>
<th>Differential diagnoses for perioperative hypercarbia</th>
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<tr>
<td>• Provider awareness/vigilance</td>
<td>• Excessive hyperthermia</td>
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<td>• Intra-abdominal pressure &lt; 15 mm Hg</td>
<td>• Equipment malfunction (faulty expiratory valve)</td>
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<td>• Low insufflation gas flows</td>
<td>• Drug toxicity</td>
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<tr>
<td>• ≤ 5 trocar sites</td>
<td>• Tourniquet release</td>
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<td>• Snug trocar cannulas</td>
<td>• Problems with ventilation (kinked endotracheal tube)</td>
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<tr>
<td>• Limiting surgical insufflation times &lt; 200 minutes</td>
<td>• Contrast dye</td>
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<tr>
<td>• Monitoring continuous ETCO₂ and maintaining &lt; 50 mm Hg</td>
<td>• Disease related (muscular dystrophy, diabetic coma, hyperthyroidism, pheochromocytoma, rhabdomyolysis, sepsis)</td>
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<tr>
<td>• Reduction of aggressive operator torquing of trocars</td>
<td>• Malignant hyperthermia</td>
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Table. Prevention Strategies and Differential Diagnoses for Subcutaneous Emphysema
Abbreviation: ETCO₂, end-tidal carbon dioxide.
to carry a 16.4% higher incidence of the development of subcutaneous emphysema. This is 6.3 times the normal documented rate of subcutaneous emphysema development during a robotic-assisted laparoscopic procedure. After identification of subcutaneous emphysema, our patient was managed appropriately and did not experience any adverse sequelae postoperatively.

**Conclusion**

The occurrence of subcutaneous emphysema as a complication of robotic-assisted laparoscopic surgery is rare. However, if misdiagnosed or overlooked, subcutaneous emphysema may result in hypercarbic respiratory depression, severe airway obstruction, and respiratory distress with subsequent cardiopulmonary collapse. Swift recognition and management are key to prevent further patient decompensation during the perioperative period, postoperative period, or both. With proper anesthetic management, subcutaneous emphysema can resolve with minimal to no detriment to the patient’s postsurgical status. As robotic-assisted surgery continues to gain momentum as the future innovative approach to elective surgeries, proficiency with subcutaneous emphysema management will be a necessary skill set for the anesthesia provider.

**REFERENCES**


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**DISCLOSURES**

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