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CLINICAL VIGNETTE

Pneumomediastinum As a Complication of Robot-Assisted Radical Cystectomy

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Introduction

Robotic and robot-assisted surgery has many benefits that have been well described, including superior visualization, broader range of mechanical movements, more efficient ergonomics, and improved outcomes. The technique is of particular benefit in cases where the surgery involves entry into the retroperitoneal space. Reported complications from robotic surgery include hypercarbia, subcutaneous emphysema, pneumothorax and in worst cases gas embolism. Pneumomediastinum, defined as free air within the mediastinal space, is a rare complication.[1] If left untreated, however, it may lead to hemodynamic compromise and potential cardiac collapse. Although many cases resolve without major sequelae, an early diagnosis may reduce risk for more serious complications.

Case

A 54-year-old transgender male to female with history of gender reassignment surgery ten years prior initially presented with gross hematuria. She subsequently underwent transurethral resection of bladder tumor and was found to have muscle-invasive squamous cell carcinoma of the bladder. A surgical plan was developed for robot-assisted laparoscopic versus open radical cystectomy and ileal conduit urinary diversion. The patient had a history of hypercalcemia secondary to malignancy as well as hypokalemia and hypophosphatemia which were treated with supplementation. She was 177 centimeters tall and weighed 66 kilograms. The preoperative physical exam was unremarkable and airway assessment was reassuring. The patient was taken to the operating room and anesthesia was induced intravenously, direct laryngoscopy revealed a grade one view and the patient was intubated uneventfully. An arterial line was placed in the left radial artery and additional large bore intravenous access was obtained.

A Veress needle was placed in the umbilical region. The abdomen was then insufflated to 15 mmHg. An 8 mm port was placed just above the umbilicus and the camera lens was placed. Under direct visualization, additional ports were placed: 8 mm port 16 cm to the left of the umbilicus, 8 mm port 8 cm to the left of the umbilicus, 8 mm port 8 cm to the right of the umbilicus, 12 mm SurgiQuest port 16 cm to the right of the umbilicus and a 5 mm port above and to the right of the umbilicus. The patient was then positioned in steep Trendelenburg position and the robot was docked. Approximately 120 minutes hours after start of surgery, an increase in end-tidal carbon dioxide ($ETCO_2$) was noted from a baseline of 30-35 mmHg to a maximum of 50 mmHg, despite increasing ventilation. The patient was examined, which revealed diffuse crepitus, including at the angle of mandible, neck, anterior chest wall, abdomen, and bilateral thighs. An arterial blood gas revealed a partial pressure of CO_2 of 72 mmHg. The insufflation pressure was decreased to 12 mmHg and $ETCO_2$ quickly returned to baseline values and on repeat arterial blood gas partial pressure of CO_2 was 50 mmHg. The remaining robotic portion of the surgery was completed within 30 minutes at which time the pneumoperitoneum was discontinued, and the robot was undocked. The remainder of the surgery was performed in an open fashion with total surgical time of 514 minutes. A leak test of the endotracheal tube was performed after the completion of surgery and the patient was extubated uneventfully. Immediate post-operative chest x-ray revealed extensive chest wall soft tissue air and pneumomediastinum. Postoperatively, the patient was observed and treated with oxygen therapy, with no pulmonary complications and by post-operative day 8 the patient's subcutaneous emphysema was nearly completely resolved.

Figure 1. Extensive chest wall soft tissue air and pneumomediastinum seen on chest X-ray.

Discussion

Complications related to laparoscopic surgery, with or without the use of a robot, stem largely from physiologic changes during creation of pneumoperitoneum. Additional risks more specific to robotic surgery involve extreme patient positioning and certain surgical maneuvers required for the robotic approach. CO_2 insufflation, in either case, can lead to subcutaneous emphysema, and when CO_2 from the subcutaneous space tracks into the thorax and mediastinum, the rare complication of pneumomediastinum may occur. Pneumomediastinum, although uncommon, may progress to a life-threatening emergency secondary to hemodynamic compromise.[2]

The reported incidence of grossly detectable subcutaneous emphysema following laparoscopic surgery has ranged from 0.4% to 2.3%, while the rate for grossly undetectable subcutaneous emphysema has been reported to be significantly higher. The rates of subcutaneous emphysema following adoption of valveless trocars has been noted to be yet higher still. Risk factors for subcutaneous emphysema have been identified and include the following: low body mass index, surgery lasting longer than 200 minutes, the use of six or more surgical ports, and patient age greater than 65.[3] It has been suggested that the total gas volume of CO_2 may also be a risk factor for subcutaneous emphysema, although this is not commonly tracked and has not yet been formally studied.[2] Additionally, some surgeons recommend limiting insufflator flow rate to one sufficient to create adequate intra-abdominal space for visualization for surgery, suggesting that any unnecessary increases in flow rate or continuing flow rate despite adequate visualization increases the intra-abdominal pressure (IAP) while not necessarily improving intra-abdominal space. Further, they suggest that the increase in IAP can be transmitted to the interior abdominal wall and subsequently into the underlying tissue, increasing the likelihood of absorption of gas and subcutaneous emphysema.[4]

Subcutaneous emphysema is clinically significant because it can lead to hypercarbia and acidosis. Hypercarbia results in sympathetic discharge through a mechanism hypothesized to involve interaction with dorsal and ventral respiratory groups of the medulla with the sympathetic nervous system at the level of the pons. In addition to increasing minute ventilation, sympathetic stimulation can result in tachycardia and hypertension.[5] If severe, such physiologic derangement can culminate in cardiovascular collapse in susceptible patients with significant cardiopulmonary comorbidities.

A retroperitoneal approach in laparoscopic or robotic surgery is associated with a higher risk of subcutaneous emphysema progressing to pneumomediastinum. Due to the absence of a subdiaphragmatic peritoneum, retroperitoneal gas can enter the mediastinum via the diaphragmatic hiatus.[6] In rare cases where large amounts of free air exist in the mediastinum, the pressure from the free air may impact venous return and directly compress the heart, leading to tension pneumomediastinum. In such cases, thoracic decompression may be necessary. Typically, however, when pneumomediastinum is noted as a complication following laparoscopic or robotic surgery, treatment is usually conservative, including pain control and oxygen therapy.[7]

Our patient had several identified risk factors for developing subcutaneous emphysema as a complication of robot-assisted surgery. In addition to a low BMI, long operating time, numerous surgical ports and advanced age, additional factors that likely contributed to an increased risk included steep Trendelenberg position as well as the requirement for extensive retroperitoneal resection. In such cases, the anesthesiologist should be vigilant in monitoring for signs and symptoms of subcutaneous emphysema, such as worsening hypercarbia and crepitus. Following diagnosis, measures should be taken quickly to prevent progression such as decreasing insufflation pressure and elimination of pneumoperitoneum. Early diagnosis, immediate management and careful monitoring of subcutaneous emphysema and the rare complication of pneumomediastinum are critical to avoid more serious sequelae.

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