Case Report

Broad subcutaneous emphysema with airway obstruction during robot-assisted partial nephrectomy: A case report and literature review

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Abbreviations & Acronyms
BMI = body mass index
CT = computed tomography
FiO_2 = fraction of inspiratory oxygen
$PaCO_2$ = partial pressure of arterial carbon dioxide
PaO_2 = partial pressure of arterial oxygen
POD = postoperative day
RAPN = robot-assisted partial nephrectomy

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How to cite this article: Ono A, Nakamura M, Hayashi T *et al*. Broad subcutaneous emphysema with airway obstruction during robot-assisted partial nephrectomy: A case report and literature review. *IJU Case Rep*. 2023; 6: 461–464.

Received 29 March 2023; accepted 16 September 2023. Online publication 25 September 2023

Introduction: Subcutaneous emphysema is a relatively common complication in laparoscopic surgery. However, airway obstruction secondary to subcutaneous emphysema is rare.

Case presentation: A 63-year-old woman with a 56-mm left renal tumor underwent a robot-assisted partial nephrectomy. The operative time was 155 min, the insufflation time was 108 min, and the estimated blood loss was 70 mL. The pneumoperitoneum pressure was maintained at 12 mmHg, except at 15 mmHg for 19 min during tumor resection. The end-tidal CO_2 was 47 mmHg throughout the procedure. Postoperatively, broad subcutaneous emphysema from the thigh to the eyelid was observed. Computed tomography revealed airway obstruction, and extubation was aborted. On postoperative day 1, emphysema around the trachea and neck improved and the intubation tube was successfully removed.

Conclusion: Both laryngeal emphysema and physical compression secondary to emphysema can cause airway obstruction. To reduce gas-related complications, the risk of developing subcutaneous emphysema should be properly assessed during robot-assisted laparoscopic surgery.

Key words: airway obstruction, laparoscopic surgery, subcutaneous emphysema.

Keynote message

Robot-assisted laparoscopic surgery might increase the risk of developing subcutaneous emphysema, a relatively common complication in laparoscopic surgery. To reduce gas-related complications, the risk of developing subcutaneous emphysema should be properly assessed during robot-assisted surgery. Appropriate pivot settings are one of the requirements to reduce the risk.

Introduction

RAPN has become the standard of care for renal tumors 7 cm in diameter. Subcutaneous emphysema with carbon dioxide is a relatively common complication during laparoscopic surgery[1–3] with a reported incidence of 2.3–45%.[4] Although most subcutaneous emphysemas resolve without the need for intervention, extensive cases can lead to airway obstruction. Here, we report a case of emphysema-related airway obstruction after an otherwise uncomplicated RAPN.

Case report

A 63-year-old woman (height: 152.4 cm; weight 42.1 kg; BMI: 18.1) was referred to our hospital with suspicion of left renal cell carcinoma. Contrast-enhanced CT revealed a 56-mm hypervascular tumor in the upper pole of the left kidney (Fig. 1a,b). The R-E-N-A-L nephrometry score was 9 (2-2-3-p-2).[5] The patient underwent RAPN with the intraperitoneal approach. The operative time was 155 min, the insufflation time was 108 min, and the

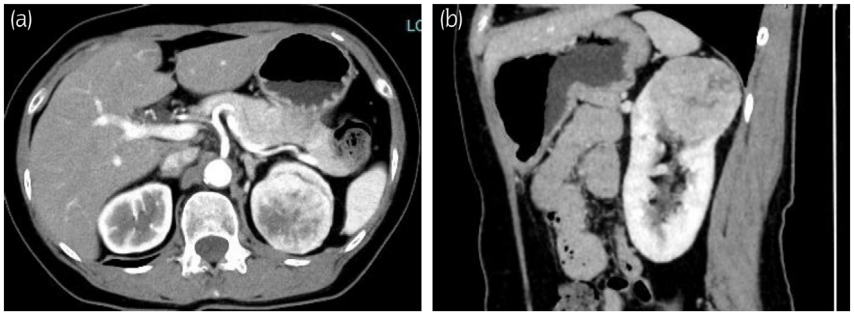

Fig. 1 (a) Left renal tumor on contrast-enhanced CT (axial view). (b) Left renal tumor on contrast-enhanced CT (sagittal view).

estimated blood loss was 70 mL. The pneumoperitoneum pressure was maintained at 12 mmHg, except at 15 mmHg for 19 min during tumor resection and hemostasis. RAPN was performed using the SOFT COAG system (VIO300D; ERBE, Tübingen, Germany), and both inner suture and renorrhaphy were omitted. Neither the renal calyx nor the large venous branch was opened during the surgical procedure. The end-tidal CO_2 was 47 mmHg throughout the procedure.

Postoperatively, broad subcutaneous emphysema from the thigh to the eyelid was observed, and a CT scan was performed. Pneumothorax was not detected (Fig. 2a). CO_2 was flowing into the dorsal side of the sternocleidomastoid muscle and around the trachea (Fig. 2b). As deflation of the intubation tube cuff resulted in normal ventilation without air leakage, the anesthesiologist decided to abort extubation. Blood gas analysis at the end of the surgery showed a pH of 7.502, PaO_2 of 220 mmHg, $PaCO_2$ of 32.3 mmHg, and HCO_3^- 25.1 mEq/L at FiO_2 of 40%. On POD 1, the blood gas analysis showed a pH of 7.431, PaO_2 of 156 mmHg, $PaCO_2$ of 37.4 mmHg, and HCO_3^- 24.5 mEq/L at FiO_2 of 30%. Follow-up CT showed improvement of the emphysema around the trachea and neck (Fig. 2c,d). Under preparation for tracheal reintubation and tracheotomy, the intubation tube was successfully removed. Laryngeal emphysema was not observed at this point. On POD 7, the patient was discharged without further complications.

Discussion

Subcutaneous emphysema, pneumothorax, and pneumomediastinum are typical laparoscopic surgery-related gas complications, leading to an airway obstruction (Table 1). Predictors for developing subcutaneous emphysema include age 65 years, BMI 25, high end-tidal CO_2 (>50 mmHg), retroperitoneal surgical approach, number of surgical ports (>six ports), and longer surgical times (>200 min).[4,6,7] Our case met two of these predictors with a BMI of 18.1 and the use of six ports. Notably, the patient's muscle layer was extremely thin, and the fascial membrane was fragile (Fig. 1a,b).

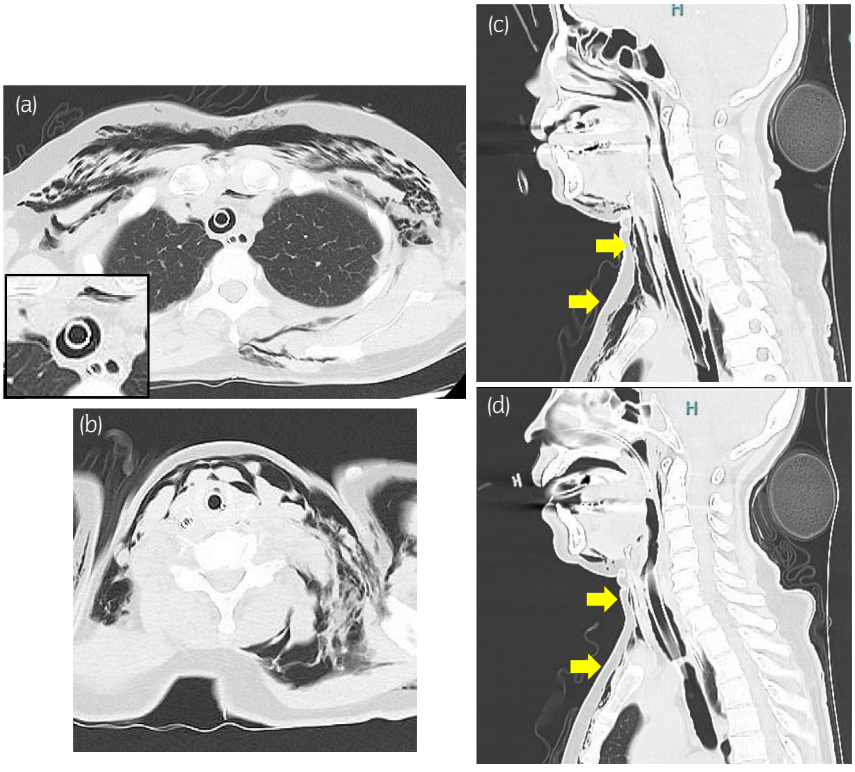

Fig. 2 (a) CT image at the lung apex level. (b) CT image at the seventh cervical vertebra level. (c) CT image on POD 0 (sagittal view) yellow arrows indicate pretracheal emphysema. (d) CT image on POD 1 (sagittal view) yellow arrows indicate pretracheal emphysema.

Table 1 Reported cases of subcutaneous emphysema with airway obstruction

Reference	Age	Sex	Surgical procedure	Approach	Maximum $EtCO_2$ (mmHg)	Insufflation time (min)	Pharyngeal/laryngeal findings
6	53	Male	Laparoscopic herniorrhaphy	Intraperitoneal	43	205	Emphysematous pharyngeal
6	58	Male	Laparoscopic herniorrhaphy	Intraperitoneal	43	140	Pharyngeal fullness
6	51	Male	Laparoscopic herniorrhaphy	Intraperitoneal	43	242	Pharyngeal fullness
7	76	Female	Laparoscopic nephroureterectomy	Retroperitoneal	55	300	Laryngeal edema Pneumomediastinum
8	55	Male	Laparoscopic unroofing of renal cyst	Retroperitoneal	56	230	Buccopharyngeal submucosal emphysema
9	51	Female	Laparoscopic hysterectomy	Intraperitoneal	50	229	None
Our case	63	Female	RAPN	Intraperitoneal	47	108	None

We used valveless insufflation systems (AirSeal®; Conmed, Largo, FL, USA), which are associated with a lower risk of subcutaneous emphysema than conventional insufflation systems.[8] Additionally, the transperitoneal approach has been reported to reduce the risk of subcutaneous emphysema compared to the retroperitoneal approach.[8]

Despite the absence of laryngeal emphysema, CT revealed airway narrowing. Airway narrowing can be caused by physical compression secondary to emphysema around the trachea. To date, seven cases of severe subcutaneous emphysema accompanied by airway obstruction have been reported.[9–12] Apart from one case, all of these had either pharyngeal or laryngeal edema or emphysema.

When considering initial trocar insertion, open entries are associated with lower occurrences of subcutaneous emphysema, extraperitoneal insufflation, and omental emphysema than Veress needle entry.[13] However, all other trocar port sites are often attributed to carbon dioxide entry into the subcutaneous plane, since a gas inlet could be formed by physical damage to the peritoneum, muscle, and fascia. In robot-assisted laparoscopic surgery, misalignment of pivot settings can easily result in damage to the port site tissue by the moving robotic arms. However, this does not occur in manual laparoscopic surgery. Moreover, a possible increase of gas-related complications was indicated in robotic sacrocolpopexy when compared with laparoscopic procedures.[14] Surgeons should thus ensure that pivot settings are accurate in procedures that involve a wide range of robot arm movements. In our case, the tumor was on the dorsal side of the left kidney and required extensive movement of the robotic arms for resection. The initial trocar used as the camera port was relatively static. Hence, we suspect that port sites other than the entry site were responsible for the subcutaneous emphysema. We underscore the importance of appropriate pivot settings as much as other predictive factors of subcutaneous emphysema. To reduce gas-related complications, the risk of developing subcutaneous emphysema should be properly assessed and managed during robot-assisted laparoscopic surgery.

Conclusion

A case of broad subcutaneous emphysema and airway obstruction during RAPN was reported. In this case, low BMI and the number of ports were risk factors for subcutaneous emphysema. Therefore, both laryngeal emphysema and physical compression secondary to emphysema can cause airway obstruction.

Author contributions

Akihiro Ono: Data curation; writing – original draft. Masaki Nakamura: Conceptualization; resources; writing – original draft; writing – review and editing. Tomoe Hayashi: Writing – review and editing. Ibuki Tsuru: Writing – review and editing. Taro Izumi: Writing – review and editing. Masashi Kusakabe: Writing – review and editing. Kazunari Nakao: Writing – review and editing. Masanori Kashiwagi: Writing – review and editing. Haruki Kume: Supervision; writing – review and editing. Yoshiyuki Shiga: Supervision; writing – review and editing.

Acknowledgments

We would like to thank Drs. Yasushi Inoue, Hiroki Inatsu, Ryo Amakawa, and Tadashi Yoshimatsu for their informative discussions and critical review of our manuscript. We would like to thank Editage (www.editage.com) for English language editing.

Conflict of interest

The authors declare no conflict of interest.

Approval of the research protocol by an Institutional Reviewer Board

Not applicable.

Informed consent

Written informed consent for publication was obtained from the patient.

Registry and the Registration No. of the study/trial

Not applicable.

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