Massive Intraoperative Hypercarbia and Subcutaneous Emphysema in A Geriatric Patient with Cardiorespiratory Comorbidities Undergoing Laparoscopic Cholecystectomy: A Case Report

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Abstract

Laparoscopic cholecystectomy in geriatric patients imposes risk due to carbon dioxide (CO_2), especially in patients with cardiovascular comorbidities. This report presents a 87 years old female with body mass index (BMI) of 17.09 kg/m² undergoing laparoscopic cholecystectomy due to gallbladder empyema. Patient had history of biliary sepsis, cardiomegaly, atelectasis of left lung apex, and chronic kidney disease. Severe inflammation of gallbladder necessitated higher pneumoperitoneum pressure up to 17 mmHg to facilitate visibility. The elevated intra-abdominal pressure combined with poor tissue turgor triggered extensive subcutaneous emphysema and massive hypercarbia, indicated by a surge in End-Tidal CO_2 ($ETCO_2$) reaching >70 mmHg, whereas arterial blood gas analysis revealed a $PaCO_2$ of 45 mmHg. This gradient anomaly occurred without an accompanying tachycardic response or oxygen desaturation. Temporary cessation of insufflation successfully stabilized the patient clinically. This case highlights the importance of vigilance regarding weak fascial turgor in underweight geriatric patients subjected to high intra-abdominal pressure, the impairment of CO_2 elimination due to atelectasis, and the crucial role of implementing multimodal analgesia with regional anesthesia techniques to prevent postoperative hypoventilation caused by opioid administration.

Keywords: *Geriatric, Laparoscopic Cholecystectomy, Pneumoperitoneum, Regional Anaesthesia, Severe Hypercarbia, Subcutaneous Emphysema.*

A. INTRODUCTION

Minimally invasive surgery, particularly laparoscopic cholecystectomy (LCC), has been globally recognized as the standard in the management of gallbladder disorders (Neudecker et al., 2002). This approach offers various significant clinical advantages over open surgery, including reduced surgical tissue trauma, decreased postoperative pain intensity, shorter hospital stays, and accelerated patient functional recovery (Yetkin et al., 2009). These advantages make laparoscopy the primary choice across various age demographics, ranging from young adults to the geriatric population (Lim & Lee, 2020).

Despite minimizing abdominal wall incisions, laparoscopy requires the creation of an artificial working space through gas insufflation into the peritoneal cavity (pneumoperitoneum) (Atkinson et al., 2017). Carbon dioxide (CO_2) is the standard insufflation agent due to its non-flammable nature, high blood solubility, and its ability to be normally excreted through the respiratory system (Gutt et al., 2004). However, systemic CO_2 absorption and increased intra-abdominal mechanical pressure during the procedure trigger a series of significant intraoperative pathophysiological changes in the cardiovascular and pulmonary systems (O'LEARY et al., 1997).

In the geriatric patient population, physiological changes resulting from pneumoperitoneum present much more complex anesthesiological challenges (Lim & Lee, 2020). The natural aging process causes a massive decline in functional organ reserves (Smetana et al., 2006). Decreased chest wall compliance, progressive atrophy of respiratory muscles, and loss of pulmonary parenchymal elasticity reduce functional residual capacity (FRC) and alveolar diffusion capacity.[4] Consequently, elderly patients have a very low tolerance threshold for intraoperative hemodynamic and respiratory disturbances (Garcia-Delgado et al., 2014).

The recommended elevation of intra-abdominal pressure (IAP) is generally within the range of 12–15 mmHg (Neudecker et al., 2002). However, in certain pathological conditions where surgical visibility is compromised, such as severe gallbladder inflammation or tissue adhesions, operators often increase the insufflation pressure.[6] Elevating intra-abdominal pressure beyond physiological limits poses a serious risk of mechanical complications, as gas can be forced to migrate outside the abdominal cavity (Ott, 2014).

Subcutaneous emphysema is one of the mechanical complications resulting from such ectopic intra-abdominal gas migration.[16] In geriatric patients, particularly those who are underweight or malnourished, subcutaneous tissues and abdominal muscles experience extreme weakness (Murdock et al., 2000). This fragile fascial integrity acts as an area of low resistance, facilitating massive CO_2 gas dissection into the subcutaneous space, extending to the thoracic and cervical regions (Kent, 1991).

A secondary complication of extensive subcutaneous emphysema is the increased surface area for CO_2 gas absorption into the systemic capillary circulation.[7] This expansion of the diffusion area exponentially increases the carbon dioxide load in venous blood, exceeding the absorption from the peritoneal cavity alone (Gutt et al., 2004). This condition rapidly leads to massive hypercarbia, which can potentially trigger respiratory acidosis, myocardial depression, and cardiac arrhythmias (Beverly et al., 2017; Özdemir-van Brunschot et al., 2016).

Under normal conditions, the body compensates for this surge in CO_2 absorption by automatically increasing the rate and volume of alveolar ventilation (Wahba et al., 1995). However, in patients with pre-existing pulmonary comorbidities, such as atelectasis or infiltrative pneumonia, the lungs lose their ability to adapt (Miskovic & Lumb, 2017a). Alveolar collapse in atelectasis creates a ventilation-perfusion imbalance (V/Q mismatch) and enlarges the alveolar dead space, effectively thwarting CO_2 elimination (Garcia-Delgado et al., 2014).

Monitoring using capnography (End-Tidal CO_2 / $ETCO_2$) and Arterial Blood Gas (ABG) analysis is highly crucial.[18] Under ideal circumstances, the arterial partial pressure of CO_2 ($PaCO_2$) correlates closely with $ETCO_2$.[19] The increased alveolar dead space due to atelectasis can cause CO_2 trapping in the lungs, which is exhaled slowly (delayed washout) (Wahba et al., 1995). This condition can create a clinical anomaly in the form of a reversed $PaCO_2$-$ETCO_2$ gradient, where the $ETCO_2$ reading surges much higher than the actual gas level in the arterial blood at that moment (Özdemir-van Brunschot et al., 2016).

The use of high-dose opioids to manage incisional and referred pain in laparoscopic procedures for geriatric patients must be limited, considering their depressive effect on the respiratory center, which can cause hypoventilation and exacerbate CO_2 retention (Chou et al., 2016). Therefore, a multimodal analgesia approach combined with regional anesthesia techniques is recommended to reduce opioid requirements and maintain spontaneous ventilation function postoperatively (Peng et al., 2016).

Based on this background, this case report aims to describe the incidence of massive intraoperative hypercarbia and subcutaneous emphysema triggered by the use of high pneumoperitoneum pressure in an extreme geriatric patient complicated by cardiorespiratory comorbidities. Furthermore, this report aims to evaluate the diagnostic challenges of the $PaCO_2$-$ETCO_2$ gradient anomaly and outline the rationale for perianesthetic management, specifically the application of multimodal analgesia with regional anesthesia techniques to prevent postoperative respiratory failure complications and support successful patient recovery.

B. METHOD

This study was conducted as a single-patient case report following the CARE (CAse REport) guidelines. Clinical data were retrospectively collected from the patient's medical records, including demographic characteristics, medical history, preoperative investigations, intraoperative anesthetic records, ventilatory parameters, arterial blood gas analysis, and postoperative outcomes. Continuous intraoperative monitoring included electrocardiography, non-invasive blood pressure, pulse oximetry, capnography, and airway pressure, with particular attention to changes in End-Tidal CO_2 ($ETCO_2$), arterial $PaCO_2$, pneumoperitoneum pressure, hemodynamic responses, and the occurrence of subcutaneous emphysema. The case was analyzed descriptively to describe the perioperative management and the pathophysiological mechanisms underlying severe hypercarbia in this underweight geriatric patient while maintaining patient confidentiality in accordance with institutional ethical standards.

C. RESULT AND DISCUSSION

An 87-year-old female weighing 40 kilograms with a height of 153 centimeters (BMI 17.09 kg/m^2, underweight) was scheduled for a laparoscopic cholecystectomy (LCC). The preoperative diagnosis was acute calculous cholecystitis with gallbladder hydrops. The patient had a history of biliary sepsis, which was clinically resolving. Preoperative evaluation revealed several comorbidities, including cardiomegaly with aortosclerosis, suspected pulmonary tuberculosis accompanied by left apical lung atelectasis and bilateral secondary fibroinfiltrates, stage 2 chronic kidney disease (CKD), normocytic anemia (Hb 11 g/dL), and hypoalbuminemia (3.3 g/dL).

General anesthesia with endotracheal intubation was administered. Intraoperative findings confirmed gallbladder empyema with severely hyperemic and edematous tissue. This condition made instrumental manipulation highly difficult, prompting the surgeon to increase the pneumoperitoneum insufflation pressure to 17 mmHg. Mid-procedure, the team detected abdominal and thoracic wall crepitus, indicating extensive subcutaneous emphysema, simultaneously with a surge in End-Tidal CO_2 ($ETCO_2$) levels. Temporary cessation of the procedure (pause) and abdominal desufflation successfully reduced the $ETCO_2$ gradually.

Figure 1. Intraoperative Finding

Towards the end of the surgery (total anesthesia duration of 2 hours and 45 minutes), as the residual tissue CO_2 gas was reabsorbed, the $ETCO_2$ surged again, reaching >70 mmHg. An arterial blood gas (ABG) sample drawn at that time revealed a $PaCO_2$ of 45 mmHg. Despite the remarkably high $ETCO_2$, the patient's hemodynamics remained stable without any tachycardic response (heart rate stable at 60–80 beats/minute), and oxygen saturation was maintained at 99–100%. Upon completion of the surgery, the patient was successfully extubated in the operating room. She was subsequently transferred to the High Care Unit (HCU) for respiratory monitoring and received aggressive antibiotic therapy (Daryaven, Metronidazole, Fluconazole) as well as a non-opioid multimodal analgesia strategy utilizing an intravenous paracetamol drip.

The incidence of extensive subcutaneous emphysema in this case directly correlates with the patient's physical profile and age. The 87-year-old underweight patient had thin abdominal muscle mass and lax fascia. A mechanical insufflation pressure of 17 mmHg (exceeding the safe limit of 12–15 mmHg) triggered microscopic ruptures in the peritoneum, forcing CO_2 gas to migrate freely into the subcutaneous space (Neudecker et al., 2002). The greater the subcutaneous volume filled with gas, the larger the surface area available for systemic CO_2 diffusion, which massively increases the influx of CO_2 into the bloodstream and induces hypercarbia (Ott, 2014).

This gas accumulation evolved into a potential respiratory acidosis crisis due to the failure of pulmonary compensation mechanisms.(Atkinson et al., 2017) Medical records indicated that the patient had comorbidities of left apical atelectasis and fibroinfiltrates. The collapse of pulmonary functional units created an extensive alveolar dead space.[9] Consequently, the increased minute ventilation from the anesthesia machine did not optimally excrete the extra CO_2 load due to a ventilation-perfusion imbalance (V/Q mismatch) (Mukhtar & Singh, 2009).

A significant clinical finding in this case was the discrepancy in monitoring values, wherein $ETCO_2$ surged above 70 mmHg, while arterial $PaCO_2$ was simultaneously recorded at 45 mmHg. This phenomenon of a reversed physiological gradient can be explained by a delayed washout mechanism in the atelectatic alveolar units (Miskovic & Lumb, 2017a; Peng et al., 2016). The trapped volume of CO_2 gas is slowly excreted and accumulates at the end of the expiratory phase, thus being dominantly detected by the capnograph sensor (Sosa et al., 2022). Conversely, the continuously circulating arterial blood flow still undergoes gas clearance processes in the remaining functional lung parenchyma, resulting in a lower $PaCO_2$ profile compared to the machine's reading.

Furthermore, the absence of a sympathetic nerve surge response (tachycardia and acute hypertension) amidst the highly elevated $ETCO_2$ levels is a physiological characteristic of the aging process (Ljungqvist & de Boer, 2023). Geriatric patients experience a blunted sympathetic response, where central chemoreceptor sensitivity decreases drastically (Kruljc et al., 2003a, 2003b; Paria et al., 2014). This causes the patient's clinical vital signs to appear "normal and stable," masking the true severity of the ongoing gas retention.(Chaouch et al., 2026)

To mitigate postoperative complications, analgesia management becomes highly vital. The slowly eliminated residual CO_2 requires the patient to maintain a strong spontaneous respiratory drive (Kehlet, 1997; Ljungqvist et al., 2017). The administration of systemic opioid analgesics can cause respiratory center depression, leading to the exacerbation of hypercarbia and delayed recovery (delayed emergence) (Miskovic & Lumb, 2017b; Nassar & Schmidt, 2017; Neudecker et al., 2002). Therefore, the adoption of postoperative multimodal analgesia, which can be optimized through local tissue infiltration or a fascial plane block (regional anesthesia), proves to be crucial (Cheng et al., 1999; Dahl & Raeder, 2003). This approach fulfills the Enhanced Recovery After Surgery (ERAS) criteria by minimizing opioid requirements, preventing secondary pulmonary complications, and accelerating mobilization in the elderly(Alsharari et al., 2022; Ghani et al., 2024; Mukhtar & Singh, 2009).

D. CONCLUSION

Laparoscopic cholecystectomy in an extreme geriatric patient with malnutrition and cardiorespiratory comorbidities presents a significantly high risk of perianesthetic complications. The application of pneumoperitoneum pressure exceeding standard limits on poor fascial turgor causes massive subcutaneous emphysema. The CO_2 absorption load from the extensive supporting tissues fails to be compensated due to the comorbidity of atelectasis, which triggers a surge in $ETCO_2$ levels without classic autonomic responses such as tachycardia.

This case demonstrates the necessity for vigilant capnography monitoring, strategic communication with the surgeon to perform periodic desufflation interventions, and profound clinical interpretation regarding the discrepancy between $PaCO_2$ and $ETCO_2$ values. Furthermore, the implementation of multimodal analgesia with the principle of reducing opioid consumption, through the utilization of regional anesthesia block techniques, is a mandatory strategy to consider in geriatric patients to ensure the stability of airway clearance and a safe postoperative recovery.

REFERENCES

1. Alsharari, A. F., Abuadas, F. H., Alnassrallah, Y. S., & Salihu, D. (2022). Transversus Abdominis Plane Block as a Strategy for Effective Pain Management in Patients with Pain during Laparoscopic Cholecystectomy: A Systematic Review. *Journal of Clinical Medicine*, *11*(23), 6896. https://doi.org/10.3390/jcm11236896
2. Atkinson, T. M., Giraud, G. D., Togioka, B. M., Jones, D. B., & Cigarroa, J. E. (2017). Cardiovascular and ventilatory consequences of laparoscopic surgery. *Circulation*, *135*(7), 700–710.
3. Beverly, A., Kaye, A. D., Ljungqvist, O., & Urman, R. D. (2017). Essential elements of multimodal analgesia in enhanced recovery after surgery (ERAS) guidelines. *Anesthesiology Clinics*, *35*(2), e115–e143.
4. Chaouch, M. A., Abdelhamid, A. Ben, Daghmouri, M. A., da Costa, A. C., Mazzotta, A., Gouader, A., Rguez, A., Mili, E., Jemli, F., & Benayoun, L. (2026). Laparoscopic-Assisted Versus Ultrasound-Guided Transversus Abdominis Plane Block in Adult Laparoscopic Abdominal Surgery: A Systematic Review and Meta-Analysis. *Perioperative Care and Operating Room Management*, 100686.
5. Cheng, K. I., Tang, C. S., Tsai, E. M., Wu, C. H., & Lee, J. N. (1999). Correlation of arterial and end-tidal carbon dioxide in spontaneously breathing patients during ambulatory gynecologic laparoscopy. *Journal of the Formosan Medical Association*, *98*(12), 814–819.
6. Chou, R., Gordon, D. B., de Leon-Casasola, O. A., Rosenberg, J. M., Bickler, S., Brennan, T., Carter, T., Cassidy, C. L., Chittenden, E. H., & Degenhardt, E. (2016). Management of Postoperative Pain: a clinical practice guideline from the American pain society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' committee on regional

anesthesia, executive committee, and administrative council. *The Journal of Pain*, *17*(2), 131–157.

7. Dahl, V., & Raeder, J. (2003). Regional anaesthesia in ambulatory surgery. *Current Opinion in Anaesthesiology*, *16*(5), 471–476. https://doi.org/10.1097/00001503-200310000-00006
8. Garcia-Delgado, M., Navarrete-Sanchez, I., & Colmenero, M. (2014). Preventing and managing perioperative pulmonary complications following cardiac surgery. *Current Opinion in Anesthesiology*, *27*(2), 146–152.
9. Ghani, S. A., Hussain, H. U., Wahid, M. A., Majeed, N., Burney, S., Tanveer, A., & Asghar, M. S. (2024). Laparoscopic-assisted versus ultrasound-guided transversus abdominis plane block for laparoscopic cholecystectomy: a systematic review and meta-analysis. *BMC Surgery*, *24*(1), 400. https://doi.org/10.1186/s12893-024-02706-7
10. Gutt, C. N., Oniu, T., Mehrabi, A., Schemmer, P., Kashfi, A., Kraus, T., & Büchler, M. W. (2004). Circulatory and respiratory complications of carbon dioxide insufflation. *Digestive Surgery*, *21*(2), 95–105.
11. Kehlet, H. (1997). Multimodal approach to control postoperative pathophysiology and rehabilitation. *British Journal of Anaesthesia*, *78*(5), 606–617. https://doi.org/10.1093/bja/78.5.606
12. Kent, R. B. (1991). Subcutaneous emphysema and hypercarbia following laparoscopic cholecystectomy. *Archives of Surgery*, *126*(9), 1154–1156.
13. Kruljc, P., Alenka, N., Neli, V., & Butinar, J. (2003a). Relation between end-tidal and arterial carbon dioxide partial pressure during general anaesthesia with spontaneous breathing and controlled ventilation in dogs: An experimental study. *Acta Veterinaria*, *53*(5–6), 283–296.
14. Kruljc, P., Alenka, N., Neli, V., & Butinar, J. (2003b). Relation between end-tidal and arterial carbon dioxide partial pressure during general anaesthesia with spontaneous breathing and controlled ventilation in dogs: An experimental study. *Acta Veterinaria*, *53*(5–6), 283–296.
15. Lim, B.-G., & Lee, I.-O. (2020). Anesthetic management of geriatric patients. *Korean Journal of Anesthesiology*, *73*(1), 8–29.
16. Ljungqvist, O., & de Boer, H. D. (2023). Enhanced recovery after surgery and elderly patients: advances. *Anesthesiology Clinics*, *41*(3), 647–655.
17. Ljungqvist, O., Scott, M., & Fearon, K. C. (2017). Enhanced Recovery After Surgery: A Review. *JAMA Surgery*, *152*(3), 292–298.
18. Miskovic, A., & Lumb, A. B. (2017a). Postoperative pulmonary complications. *BJA: British Journal of Anaesthesia*, *118*(3), 317–334.
19. Miskovic, A., & Lumb, A. B. (2017b). Postoperative pulmonary complications. *British Journal of Anaesthesia*, *118*(3), 317–334.
20. Mukhtar, K., & Singh, S. (2009). Transversus abdominis plane block for laparoscopic surgery. *British Journal of Anaesthesia*, *102*(1), 143–144. https://doi.org/10.1093/bja/aen338

21. Murdock, C. M., Wolff, A. J., & Van Geem, T. (2000). Risk factors for hypercarbia, subcutaneous emphysema, pneumothorax, and pneumomediastinum during laparoscopy. *Obstetrics & Gynecology*, *95*(5), 704–709.
22. Nassar, B. S., & Schmidt, G. A. (2017). Estimating Arterial Partial Pressure of Carbon Dioxide in Ventilated Patients: How Valid Are Surrogate Measures? *Annals of the American Thoracic Society*, *14*(6), 1005–1014. https://doi.org/10.1513/AnnalsATS.201701-034FR
23. Neudecker, J., Sauerland, S., Neugebauer, E., Bergamaschi, R., Bonjer, H. J., Cuschieri, A., Fuchs, K. H., Jacobi, C., Jansen, F. W., & Koivusalo, A.-M. (2002). The European Association for Endoscopic Surgery clinical practice guideline on the pneumoperitoneum for laparoscopic surgery. *Surgical Endoscopy*, *16*(7), 1121–1143.
24. O'LEARY, E., Hubbard, K., Tormey, W., & Cunningham, A. J. (1997). Laparoscopic Cholecystectomy: Haemodynamic and Neuroendocrine Responses After Pneumoperitoneum and Changes in Position. *Survey of Anesthesiology*, *41*(3), 177.
25. Ott, D. E. (2014). Subcutaneous emphysema—beyond the pneumoperitoneum. *JSLS: Journal of the Society of Laparoendoscopic Surgeons*, *18*(1), 1.
26. Özdemir-van Brunschot, D. M. D., van Laarhoven, K. C., Scheffer, G.-J., Pouwels, S., Wever, K. E., & Warlé, M. C. (2016). What is the evidence for the use of low-pressure pneumoperitoneum? A systematic review. *Surgical Endoscopy*, *30*(5), 2049–2065.
27. Paria, R., Surroy, S., Majumder, M., Paria, B., Sengupta, S., Paria, A., & Das, G. (2014). Sacral Saddle Block for Day Care and Ambulatory Surgery in Anorectal Procedure. *Journal of Dental and Medical Sciences*, *13*(9).
28. Peng, K., Ji, F., Liu, H., & Wu, S. (2016). Ultrasound-guided transversus abdominis plane block for analgesia in laparoscopic cholecystectomy: a systematic review and meta-analysis. *Medical Principles and Practice*, *25*(3), 237–246.
29. Smetana, G. W., Lawrence, V. A., & Cornell, J. E. (2006). Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for the American College of Physicians. *Annals of Internal Medicine*, *144*(8), 581–595.
30. Sosa, I., Cardetti, M., Favareto, V., Maure, C., Ceballos, E., Abona, H., Martínez, F., Gigli, M., Rodríguez, S., & Sola, A. (2022). Capnografía en recién nacidos en ventilación mecánica y su relación con la medición de CO2 en muestras sanguíneas. *Anales de Pediatría*, *97*(4), 255–261.
31. Wahba, R. W. M., Bëïque, F., & Kleiman, S. J. (1995). Cardiopulmonary function and laparoscopic cholecystectomy. *Canadian Journal of Anaesthesia*, *42*(1), 51–63.
32. Yetkin, G., Uludag, M., Oba, S., Citgez, B., & Paksoy, I. (2009). Laparoscopic cholecystectomy in elderly patients. *JSLS: Journal of the Society of Laparoendoscopic Surgeons*, *13*(4), 587.