


Percutaneous Dilatation Tracheostomy with Real-Time Ultrasonography Guidance in a Critically Ill Patient

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ABSTRACT

Introduction: Tracheostomy is a common procedure in intensive care units for critically ill patients with mechanical ventilation. **Case:** This case report describes the use of real-time ultrasonography (USG) guidance for percutaneous dilatational tracheostomy (PDT) in a 63-year-old female with prolonged mechanical ventilation following craniotomy. The patient had relative contraindications including short neck and morbid obesity (BMI 40.8). On day 7 of ICU admission, a PDT was successfully performed using real-time ultrasonography (USG) guidance. USG was utilized to identify key anatomical landmarks, such as tracheal rings and vascular structures, ensuring safe and accurate needle placement. The use of real-time USG significantly reduced the risk of complications including hemorrhage, tracheal injury, or pneumothorax. The procedure was completed without incident, and the patient showed clinical improvement post-intervention, including enhanced respiratory function and gradual weaning from mechanical ventilation. **Conclusion:** This report highlights the safety and efficacy of USG-guided PDT, especially in high-risk patients with difficult neck anatomy. It also underlines the importance of ultrasound as a widely available and cost-effective tool in ICU settings. The case supports further implementation of real-time USG-guided techniques in percutaneous tracheostomy to improve procedural success and patient outcomes. Further research involving a larger cohort is needed to establish standardized protocols and evaluate long-term outcomes of this approach.

Keywords: Mechanical ventilation, percutaneous dilatation tracheostomy (PDT), tracheostomy.

ABSTRAK

Pendahuluan: Trakeostomi umum dilakukan di unit perawatan intensif untuk pasien sakit kritis dengan ventilasi mekanik. **Kasus:** Laporan kasus ini mengenai penggunaan panduan ultrasonografi (USG) waktu nyata untuk trakeostomi dilatasi perkutan (PDT) pada wanita berusia 63 tahun dengan ventilasi mekanis berkepanjangan setelah kraniotomi. Pasien memiliki kontraindikasi relatif leher pendek dan obesitas tidak wajar (IMT 40,8). Pada hari ke-7 perawatan ICU, PDT dilakukan dengan bantuan panduan ultrasonografi waktu nyata (USG). USG digunakan untuk mengidentifikasi struktur anatomi penting seperti cincin trakea dan pembuluh darah, sehingga memungkinkan penusukan jarum secara akurat dan aman. Penggunaan USG secara signifikan mengurangi risiko komplikasi seperti perdarahan, cedera trakea, atau pneumotoraks. Prosedur berjalan lancar tanpa kejadian merugikan, dan pasien menunjukkan perbaikan klinis berupa fungsi pernapasan yang membaik serta penyapihan ventilator secara bertahap. **Simpulan:** Kasus ini menekankan keamanan dan efektivitas PDT dengan panduan USG, khususnya pada pasien berisiko tinggi dengan anatomi leher yang sulit. Selain itu, teknik ini menonjolkan peran USG sebagai alat yang tersedia luas dan hemat biaya di ICU. Diperlukan penelitian lebih lanjut dengan jumlah pasien yang lebih besar untuk menyusun protokol baku dan mengevaluasi hasil jangka panjang dari pendekatan ini. **Fachrizal Rikardi, Bowo Adiyanto. Trakeostomi Dilatasi Perkutan dengan Panduan *Real-Time Ultrasonography* pada Pasien Kritis.**

Kata Kunci: Ventilasi mekanik, *percutaneous dilatation tracheostomy* (PDT), trakeostomi.

INTRODUCTION

Tracheostomy is a critical procedure frequently performed in the intensive care unit (ICU) for patients who require prolonged mechanical ventilation and have weaning difficulty.[1,2] Traditionally, tracheostomy was performed using either a surgical approach or a percutaneous dilatation technique (PDT).[3] The latter has gained popularity due to its minimally invasive nature and lower complication rates.[1,4,5] However, PDT can be challenging in patients with difficult neck anatomy, such as those with short necks, obesity, or previous neck surgeries.[5] The use of real-time ultrasonography (USG) during PDT has emerged as a valuable tool to enhance the safety and accuracy of the procedure by providing clear visualization of anatomical structures, thereby reducing the risk of complications such as bleeding, tracheal injury, and pneumothorax.[6]

Real-time USG guidance in PDT allows for precise identification of the trachea,

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surrounding vessels, and other critical structures, facilitating accurate needle placement and reducing the likelihood of inadvertent injury.[6] Studies have demonstrated that USG-guided PDT is not inferior to bronchoscopy-guided PDT in terms of safety and efficacy, with comparable rates of major and minor complications and similar procedure durations.[6] Additionally, USG equipment is more readily available in ICUs compared to bronchoscopes, and its use requires fewer personnel and is more cost-effective.[6,7] This case report highlights the successful application of USG-guided PDT in a critically ill patient, emphasizing its potential benefits in improving patient outcomes and minimizing procedural risks.

CASE

Clinical History

A 63-year-old female with BMI 40.8, was admitted to the surgical intensive care unit (SICU) following craniotomy for tumor removal, suspected to be a vestibular schwannoma. Post-operatively, she was placed on mechanical ventilation. During her stay in the SICU, she experienced recurrent seizures and developed pneumonia. Despite stable hemodynamics without inotropic support, the attempt to wean from the ventilator after seven days was unsuccessful.

Physical Examination

The general condition was moderate, drowsy but oriented (DPO) in terms of consciousness. Blood pressure 126/67 mmHg, heart rate 90 beats per minute, respiratory rate 12 breaths per minute, and temperature 36.7°C. Oxygen saturation was 98% on ventilator support (PS mode, Psupp 12 cmH2O, PEEP 8, FiO2 60%). Examination revealed no anemia nor jaundice, both pupils were 3 mm in diameter and reactive. The patient had a short neck. Auscultation showed vesicular breath sounds with rhonchi and regular S1S2 with no murmurs. Abdominal examination was unremarkable with normal bowel sounds and no tenderness or distension. Neurological assessment showed intact brainstem reflexes, no meningeal signs, and no lateralization.

Laboratory Findings

Hemoglobin level of 12.6 g/dL, hematocrit of 40.2%, white blood cell count of 17,790/µL, and platelet count of 400,000/µL. Blood glucose was 160 mg/dL, and renal function

Figure 1. PDT insertion location (blue arrow).

tests showed blood urea nitrogen/creatinine levels of 17.01/0.46 mg/dL. Electrolyte levels were within normal ranges (Na 138 mmol/L, K 3.99 mmol/L, Cl 114 mmol/L). Arterial blood gas analysis showed pH 7.40, pCO_2 51.9 mmHg, pO_2 90.2 mmHg, HCO_3 19.9 mmol/L, BE 2.1, and SaO_2 98%. Lactate level was 1.4 mmol/L.

Diagnostic Assessment

Based on the patient's clinical presentation, prolonged mechanical ventilation, and development of pneumonia, she was assessed as a candidate for percutaneous dilatation tracheostomy (PDT). The decision to perform PDT was further supported by her drowsiness and the need for ongoing ventilatory support.

Therapeutic Intervention

The patient underwent PDT on the seventh day of ICU admission. The procedure was performed with real-time ultrasonography guidance, overcoming challenges posed by her short neck and morbid obesity. The PDT was successfully completed without any immediate complications. Given the patient's short neck and morbid obesity, real-time ultrasonography (USG) was chosen to guide the PDT procedure to minimize complications.

The patient was sedated with propofol and sufentanil, and muscle relaxation was achieved with cisatracurium. Hemodynamic monitoring was established, including ECG, blood pressure, heart rate, and oxygen saturation. USG was used to perform both longitudinal and transverse scans of the neck to identify anatomical landmarks such as the cricoid cartilage, tracheal rings, thyroid gland, and carotid and jugular vessels. The ideal puncture site was determined to be between the second or third tracheal rings as seen on **Figure 1**. Puncturing between the cricoid cartilage and the first tracheal ring is generally avoided due to the risk of subglottic stenosis and potential damage to the only complete cartilaginous ring in the airway.[8] Tracheostomy below the fourth tracheal ring

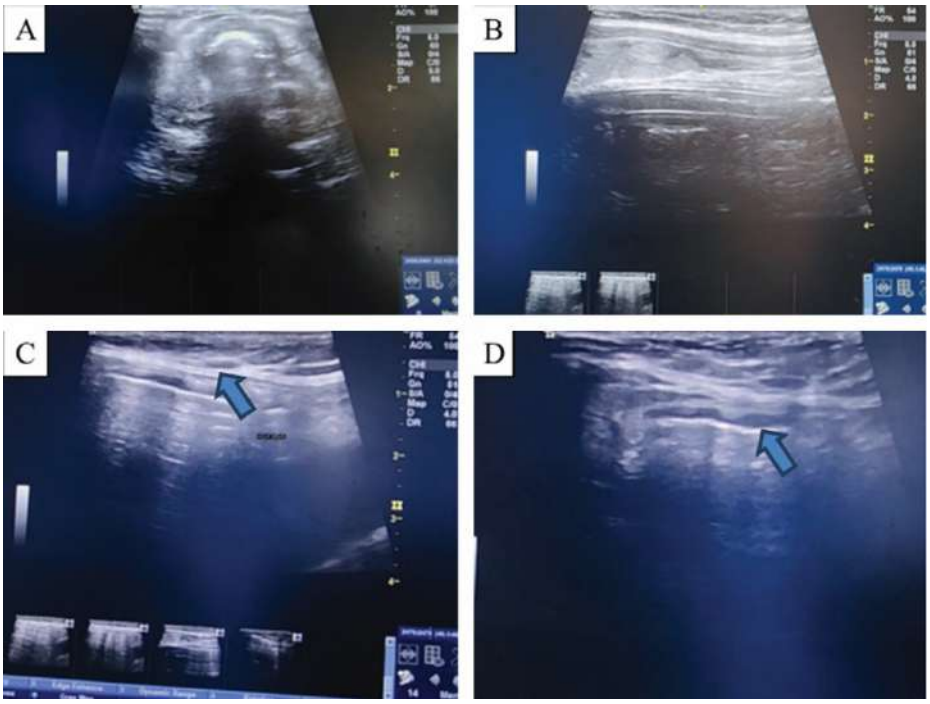

Figure 2. PDT with Real-Time USG Guidance. (A) Anatomical identification of trachea in longitudinal section, (B) Anatomical identification of trachea in Sagittal section (blue arrow), (C) PDT Needle Puncture, and (D) Tracheal intralumen wire evaluation (blue arrow).


is typically avoided due to the increased risk of vascular complications, particularly injury to the brachiocephalic artery.[8,9] Needle puncture was performed under USG guidance, followed by the insertion of a guide wire. A small horizontal incision was made at the puncture site, and sequential dilation was carried out using small and large dilators. Finally, the tracheostomy tube was inserted over the guide wire (**Figure 2**).

Follow-up and Outcomes

Post-procedure, the patient was monitored continuously for respiratory and hemodynamic stability. Regular dressing changes were performed, and the site was monitored for signs of infection or bleeding. The patient showed improvement in pneumonia and a gradual reduction in ventilator settings, indicating successful weaning from mechanical ventilation. Real-time USG guidance during PDT facilitated precise needle placement and minimized the risk of complications, demonstrating the procedure's safety and efficacy in a patient with challenging neck anatomy. Her vital signs remained stable, and she continued to receive appropriate medical management, including antibiotics, antiepileptics, and supportive care. The patient's condition was closely monitored for any potential complications related to the PDT.

The case highlights the successful application of USG-guided PDT in a critically ill patient with difficult neck anatomy. The procedure was performed without complications, and the patient showed significant clinical improvement post-procedure. This case supports the use of USG guidance in PDT to enhance safety and accuracy, particularly in patients with anatomical challenges.

DISCUSSION

Percutaneous dilatational tracheostomy (PDT) is a commonly performed procedure in the intensive care unit (ICU) environment, and is often preferred over surgical tracheostomy due to its lower incidence of wound infection and cost-effectiveness. However, performing PDT in patients with certain risk factors, such as tracheal deviation or high bleeding tendency, requires meticulous planning and the use of specialized techniques and tools to mitigate risks.[10]

The use of real-time ultrasonography (USG) guidance in percutaneous dilatation tracheostomy (PDT) offers significant advantages, particularly in patients with challenging neck anatomy, such as those with short necks or morbid obesity.[4,7,10,11] The decision to use USG was driven by the need to enhance the safety and accuracy of the procedure, given the patient's complex anatomical features.[12] Real-time USG allowed for precise identification of the trachea, surrounding vessels, and other critical structures, facilitating accurate needle placement and reducing the likelihood of inadvertent injury.[6]

Studies have shown that USG-guided PDT is not inferior to bronchoscopy-guided PDT in terms of safety and efficacy.[6] A randomized controlled trial (RCT) demonstrated that the rates of major and minor complications were not statistically different between USG-guided and bronchoscopy-guided PDT, and the procedure duration was similar in both groups.[6] Additionally, USG-guided PDT was described as being as easy to perform as bronchoscopy-guided PDT.[6] The use of USG also offers practical advantages, such as greater availability of USG equipment in ICUs, quicker and more cost-effective cleaning processes, and the requirement for fewer personnel compared to bronchoscopy.[6] These factors contribute to the growing preference for USG-guided PDT in critical care settings.

Challenges in performing PDT include overcoming tracheal deviation, which complicates landmark identification and determination of the insertion pathway, which usually requires a comprehensive pre-procedural assessment, often supplemented by imaging modalities such as ultrasound.[13,14] In addition, patients with a high risk of bleeding, including coagulopathy or anatomical variations such as aberrant blood vessels, show increased susceptibility to bleeding during PDT, thus requiring careful consideration and potentially requiring adjustments in technique or conversion to open surgical methods.[5,10]

Techniques and tools used to facilitate PDT include various strategies aimed at improving the safety and efficacy of the procedure. Ultrasound guidance helps in visualizing the anatomy of the neck before the procedure, optimizing insertion site selection and minimizing the risk of vascular injury. Bronchoscopic guidance offers real-time visualization of the tracheal lumen, helping to avoid posterior tracheal wall injury and ensure proper tracheostomy tube placement. One-step dilatation technique (SSDT) is emerging as the preferred method due to its association with lower complication rates. Moreover, pre-procedural assessment of bleeding risk and coagulation status, along with the expertise of an experienced operator, is crucial in minimizing complications.[5,10]

The successful outcome in this case underscores the potential benefits of USG-guided PDT in improving patient safety and procedural accuracy. The patient showed significant clinical improvement post-procedure, with stable vital signs and gradual weaning from mechanical ventilation. This aligns with findings from other studies that have reported lower rates of minor complications and similar procedural efficacy when using USG guidance compared to traditional landmark-based techniques.[6] The ability of USG to visualize vascular structures and ensure proper needle placement is particularly valuable in patients with difficult neck anatomy, as it minimizes the risk of complications such as bleeding, tracheal injury, and pneumothorax.

CONCLUSION

The use of real-time USG guidance in PDT represents a valuable advancement in the management of critically ill patients requiring prolonged mechanical ventilation. This case highlights the importance of operator proficiency in USG-guided procedures and the need for adequate training to maximize the benefits of this approach. Further research and larger studies are warranted to fully evaluate the long-term outcomes and potential advantages of USG-guided PDT in various patient populations.

REFERENCES

1. Mehta C, Mehta Y. Percutaneous tracheostomy. Ann Card Anaesth. 2017;20(Suppl):S19–25. doi: 10.4103/0971-9784.197793.
2. Zouk AN, Batra H. Managing complications of percutaneous tracheostomy and gastrostomy. J Thorac Dis. 2021;13(8):5314–30. doi: 10.21037/jtd-19-3716.
3. Gualtieri G, Imperatore F, Cafora C, Liguori G, Gritti F, Tolone S, et al. Ultrasound guided percutaneous dilatation tracheotomy (US-PDT) to prevent potentially life-threatening complications: A case report. Int J Surg Case Rep. 2020;77S:S125–8. doi: 10.1016/j.ijscr.2020.09.031.
4. Siagian N, Bramantono B, Hadi U. Tuberculous lymphadenitis coexists with non-hodgkin lymphoma. Curr Intern Med Res Pract Surabaya J. 2020;1(2):52. doi: http://dx.doi.org/10.20473/cimrj.v1i2.21458.
5. Pilarczyk K, Haake N, Dudasova M, Huschens B, Wendt D, Demircioglu E, et al. Risk factors for bleeding complications after percutaneous dilatational tracheostomy: a ten-year institutional analysis. Anaesth Intensive Care. 2016;44(2):227–36. doi: 10.1177/0310057X1604400209.
6. Kang HT, Kim SY, Lee MK, Lee SW, Baek A, Park KN. Comparison between real-time ultrasound-guided percutaneous tracheostomy and surgical tracheostomy in critically ill patients. Crit Care Res Pract. 2022;2022:1388225. doi: 10.1155/2022/1388225.
7. Mayo PH, Copetti R, Feller-Kopman D, Mathis G, Maury E, Mongodi S, et al. Thoracic ultrasonography: a narrative review. Intensive Care Med. 2019;45(9):1200–11. doi: 10.1007/s00134-019-05725-8.
8. Park J, Chung W, Song S, Kim YH, Lim CS, Ko Y, et al. Identifying the ideal tracheostomy site based on patient characteristics during percutaneous dilatational tracheostomy without bronchoscopy. Korean J Anesthesiol. 2019;72(3):233–7. doi: 10.4097/kja.d.18.00276.
9. Khaja M, Haider A, Alapati A, Qureshi ZA, Yapor L. Percutaneous tracheostomy: a bedside procedure. Cureus. 2022;14(4):e24083. doi: 10.7759/cureus.24083.
10. Sasane SP, Telang MM, Alrais ZF, Alrahma AH, Khatib KI. Percutaneous tracheostomy in patients at high risk of bleeding complications: a retrospective single-center experience. Indian J Crit Care Med. 2020;24(2):90–4. doi: 10.5005/jp-journals-10071-23341.
11. Nadia R, Elvira D, Raveinal. HIV drug resistance mutations. Biosci Med J Biomed Transl Res. 2020;6(7):2006–13. doi:10.37275/bsm.v6i7.547.
12. Haron A, Li L, Davies EA, Alexander PDG, McGrath BA, Cooper G, et al. Increasing the precision of simulated percutaneous dilatational tracheostomy—a pilot prototype device development study. iScience. 2024;27(3):109098. doi: 10.1016/j.isci.2024.109098.
13. de Kleijn BJ, Wedman J, Zijlstra JG, Dikkers FG, van der Laan BFAM. Short- and long-term complications of surgical and percutaneous dilatation tracheotomies: a large single-centre retrospective cohort study. Eur Arch Otorhinolaryngol. 2019;276(6):1823–8. doi: 10.1007/s00405-019-05394-9.
14. Agenor A, Dvoracek L, Leu A, Hunter DA, Newton P, Yan Y, et al. Hyaluronic acid/carboxymethyl cellulose directly applied to transected nerve decreases axonal outgrowth. J Biomed Mater Res B Appl Biomater. 2017;105(3):568–74. doi: 10.1002/jbm.b.33576.