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CASE REPORT

Ultrasound-guided, videolaryngoscopy-assisted percutaneous tracheostomy in a high-altitude patient. Case report

Traqueostomía percutánea guiada por ecografía y asistida por videolaringoscopia en paciente a gran altitud. Reporte de caso

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ABSTRACT

Introduction: Percutaneous dilation tracheostomy has largely replaced surgical tracheostomy in most intensive care units. Bronchoscopy remains the standard guidance method, although it partially obstructs the tube lumen, increases carbon dioxide levels, and requires equipment that is not always available. At high altitudes, where arterial oxygen levels are already reduced, these disadvantages are even more significant. Case report: An 82-year-old male patient, a permanent resident at 3650 meters above sea level, was admitted to the intensive care unit for a right hemisphere ischemic stroke, hemodynamic and ventilatory instability, atrial flutter, bilateral pleural effusion, and hospital-acquired pneumonia. After 16 days of invasive ventilation, a bedside tracheostomy was planned. A 5-10 MHz linear transducer identified the thyroid and cricoid cartilages, the tracheal rings, the pretracheal tissue, and the absence of vessels along the planned tracheostomy path. The videolaryngoscope allowed for the withdrawal of the endotracheal tube under direct vision until the cuff was positioned immediately below the vocal cords. The cannula was inserted using a modified Seldinger technique, with oxygenation goals appropriate for high altitude. Discussion: Ultrasound and videolaryngoscopy address different problems: the former defines the extraluminal anatomy of the anterior neck, while the latter monitors the endolaryngeal position of the tube and its cuff. Their combination reproduces much of the information provided by bronchoscopy without inserting an instrument into the tube lumen, a significant advantage in a patient whose baseline arterial oxygen pressure is approximately 56 mmHg. Conclusions: Ultrasound-guided, videolaryngoscopy-assisted percutaneous tracheostomy by dilation proved feasible at the bedside of a neurocritically ill patient residing at 3650 meters above sea level, without immediate complications and respecting the oxygenation goals specific to high altitude.

Keywords: Percutaneous tracheostomy; POCUS; videolaryngoscopy; high altitude; intensive care; bronchoscopy.

RESUMEN

Introducción: La traqueostomía percutánea por dilatación ha desplazado a la traqueotomía quirúrgica en la mayoría de las unidades de terapia intensiva. La broncoscopia sigue siendo el método de guía habitual, aunque ocupa parcialmente la luz del tubo, eleva el dióxido de carbono y exige un equipamiento que no siempre está disponible. En la altitud, donde el contenido arterial de oxígeno ya se encuentra reducido, esas desventajas pesan más. Caso clínico: Paciente masculino de 82 años, residente permanente a 3650 msnm, internado en terapia intensiva por accidente cerebrovascular isquémico del hemisferio derecho, inestabilidad hemodinámica y ventilatoria, flutter auricular, derrame pleural bilateral y neumonía intrahospitalaria. Tras 16 días de ventilación invasiva se programó traqueostomía a la cabecera. Un transductor lineal de 5-10 MHz identificó los cartílagos tiroides y cricoides, los anillos traqueales, el tejido pretraqueal y la ausencia de vasos en el trayecto previsto. El videolaringoscopio permitió retirar el tubo endotraqueal bajo visión directa hasta situar el balón inmediatamente por debajo de las cuerdas vocales. La cánula se colocó mediante técnica de Seldinger modificada, con metas de oxigenación propias de la gran altitud. Discusión: La ecografía y la videolaringoscopia resuelven problemas distintos: la primera define la anatomía extraluminal del cuello anterior, la segunda vigila la posición endolaríngea del tubo y de su manguito. Su combinación reproduce buena parte de la información que aporta la broncoscopia sin interponer un instrumento dentro de la luz del tubo, ventaja apreciable en un paciente cuya presión arterial de oxígeno basal se aproxima a 56 mmHg. Conclusiones: La traqueostomía percutánea por dilatación guiada por ecografía y asistida por videolaringoscopia resultó factible a la cabecera de un paciente neurocrítico residente a 3650 msnm, sin complicaciones inmediatas y respetando las metas de oxigenación propias de la gran altitud.

Palabras clave: Traqueostomía percutánea; POCUS; videolaringoscopia; Gran Altitud; Cuidados intensivos; Broncoscopia.

INTRODUCTION

Percutaneous tracheotomy was described in 1957, and its dilatational variant was incorporated into intensive care practice 3 decades later.(1,2) The displacement of the surgical technique was supported by comparative data; the meta-analysis by Delaney and colleagues showed a lower incidence of stoma infection with the percutaneous approach, with no relevant differences in mortality or major hemorrhage.(3) Subsequent reviews and series of more than 3 thousand procedures consolidated this safety profile when the operator accumulates experience and patient selection is careful.(4,5) Common indications include prolonged mechanical ventilation, airway protection in severe neurological disease, reduction of sedation requirements, and facilitation of weaning.(6,7) Neurocritical illness occupies a distinct place within these indications. The SETPOINT2 trial, which randomized patients with severe stroke to early tracheostomy or to standard strategy from the tenth day, found no functional benefit at six months with the earlier procedure (8). This finding shifts the discussion from timing to execution: if tracheostomy is decided after a reasonable weaning attempt, it matters less when it is performed than the safety margin with which it is performed. Flexible bronchoscopy is the most widely used guidance method and allows confirmation of the puncture site by transillumination, monitoring of the posterior tracheal wall, and verification of the cannula position (9). Its use has a physiological cost. The bronchoscope occupies part of the endotracheal tube lumen, increases airway pressure, reduces effective tidal volume, and raises arterial carbon dioxide pressure during the minutes the maneuver lasts (10). Added to this are the limited availability of the equipment, the need for a second trained operator, and the risk of damaging the instrument with the needle or the dilator.

Point-of-care ultrasound emerged as an alternative to those limitations. The TRACHUS trial demonstrated non-inferiority of ultrasound guidance compared with bronchoscopic guidance in terms of procedure failure and major complications, a result consistent with the meta-analysis of randomized trials published subsequently. Compared with external anatomical reference, ultrasonography improves the accuracy of puncture in the midline and in the intended intercartilaginous space.(11,12,13) The basis is anatomical rather than instrumental: CT angiography identifies a vessel crossing the insertion region between C6 and T1 in approximately 41% of adults (14), and prospective examination of the anterior neck modifies the chosen site in a considerable proportion of cases.(15,16) The probe also documents the pretracheal course and prevents involuntary ascent of the cannula toward the cricoid cartilage.(17)

Two problems escape ultrasonography: the posterior tracheal wall, hidden by the acoustic shadow of air, and the position of the endotracheal tube within the larynx. Accidental puncture of the cuff and extubation during tube removal are among the most frequent intraprocedural incidents, and both depend on a maneuver that is usually performed blindly. Gillies and colleagues proposed the videolaryngoscope for that specific purpose (18). The device improves glottic visualization without requiring alignment of the airway axes (19,20), keeps the screen outside the sterile field, and leaves the lumen of the tube free, unlike the bronchoscope. The same logic supports tubes with an integrated camera, whose randomized comparison with bronchoscopy showed better gas exchange during the procedure with equivalent visualization quality (10).

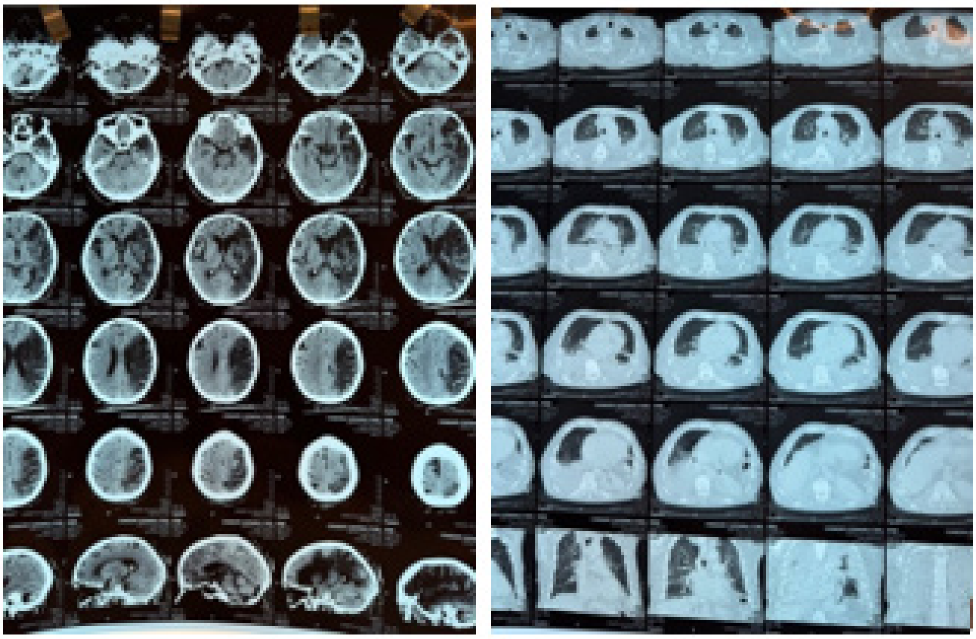
Altitude modifies the available margin for any of these maneuvers. The Committee of Experts on Critical Care Medicine at Altitude of the Pan American and Iberian Federation of Critical Care Medicine and Intensive Therapy places high altitude between 3500 and 5800 msnm and warns that applying sea-level blood gas criteria in that range leads to erroneous diagnoses of respiratory failure. (21) The reference values described in healthy residents of La Paz, at 3600 msnm, include a PaO_2 close to 56 mmHg, a $PaCO_2$ of 28 mmHg, and an SaO_2 near 86%, (21,22) figures consistent with the systematic review of PaO_2 values in healthy adults residing at altitude. (26) With these values, the critically ill patient operates on the steep portion of the hemoglobin dissociation curve and tolerates periods of apnea or hypoventilation less well. The consensus proposes SaO_2 targets of 88% and PaO_2 of 60 mmHg for high altitude, avoids saturations above 92%, and recommends maintaining $PaCO_2$ around its normal value at altitude. (21) The restriction is not theoretical: liberal oxygen therapy is associated with increased mortality in the acutely ill patient and at altitude, limiting peripheral saturation to the range of 89 to 93% was associated with better survival in critically ill patients with COVID-19. (23,24)

The combination of ultrasound and videolaryngoscopy for percutaneous tracheostomy has not been described in populations residing above 3500 meters above sea level. We present the management of one neurocritical patient with prolonged ventilation in whom both tools were used complementarily at the bedside, with particular attention to oxygenation decisions during the procedure.

CASE REPORT

82-year-old male patient, permanent resident at 3650 msnm, with a history of systemic arterial hypertension, dyslipidemia, hyperuricemia, hypertensive heart disease, atrial flutter with elevated ventricular response, pulmonary fibrosis, and left nephrectomy. He was admitted to the intensive care unit due to an ischemic stroke of the right hemisphere with hemodynamic and ventilatory instability. Computed axial tomography (TAC) of the skull showed hypodense images in the right hemisphere and in both lung bases (Figure 1A-B).

Figure 1. Head CT A: hypodense images are observed in the right hemisphere. B: Chest CT, hypodense images are observed in projection of both pulmonary bases.



The clinical course was complicated by bilateral pleural effusion, severe hospital-acquired pneumonia, and grade III sacral ulcer. The patient received neuroprotective management, vasoactive support, antiarrhythmics, and broad-spectrum antibiotic therapy directed by culture and antibiogram. After 16 days of invasive mechanical ventilation, tracheostomy was indicated because of severe neurological sequelae and no near-term prospect of weaning. Transfer to the operating room was ruled out owing to the risk of hemodynamic and ventilatory deterioration during transport. Informed consent was obtained from the legal representative.

The procedure was performed at the bedside, with the patient under sedation, analgesia, and neuromuscular blockade until reaching an RASS of -4. Ventilation was adjusted to the oxygenation goals recommended for high altitude, with a target SaO_2 of 88% and PaO_2 of 60 mmHg, avoiding saturations above 92%. Minor surgical instruments were available, and asepsis and antisepsis of the cervical region were performed according to the standard technique. The sequence was as follows. With the head positioned in cervical hyperextension, the anterior region of the neck was insonated with a 5-10 MHz linear transducer, orienting the notch in a cephalic direction. The examination ruled out masses and vascular structures in the intended path and identified the anterior wall of the trachea, the thyroid and cricoid cartilages, the tracheal rings, the peritracheal tissue, and the endotracheal tube with its cuff (Figure 2).

Subsequently, the cuff was deflated to mobilize the tube below the acoustic shadow of the cricoid cartilage and then reinflated in the new position. Under direct vision with the videolaryngoscope, the epiglottis and vocal cords were verified; the cuff was inflated immediately below the glottic plane, confirming the adequate position of the tube and ruling out its displacement (Figure 3A-B-C).

With that reference, the tracheal puncture and dilation were completed using a modified Seldinger technique, and the tracheostomy tube was placed. During the procedure, no cuff puncture, accidental extubation, bleeding requiring prolonged compression, desaturation below the established target, or conversion to the surgical technique was recorded. The follow-up radiograph showed no complications.

Figure 2. Cervical ultrasound. A: Longitudinal insonation of the neck. B: Identification of the endotracheal tube and its cuff, cricoid cartilage, and tracheal rings.

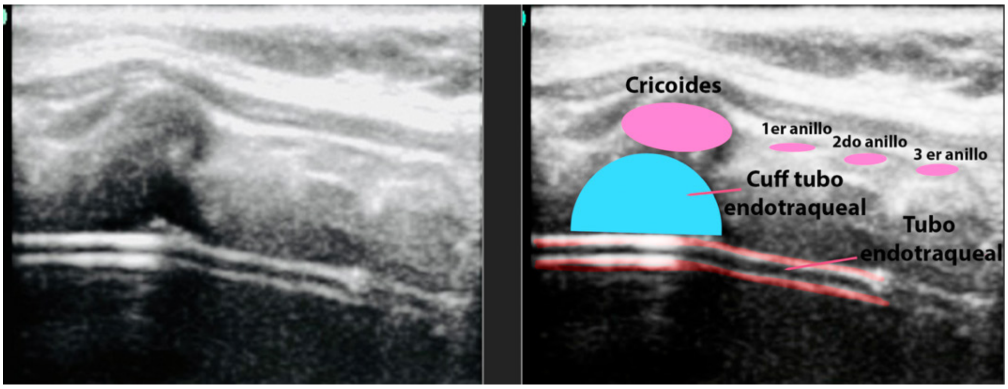
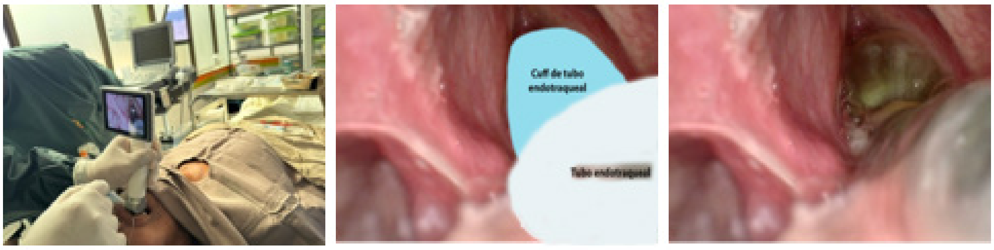


Figure 3. A: Videolaryngoscopy being performed. B: Assessment of the vocal cords prior to mobilization of the endotracheal tube. C: Cuff visualized below the glottic plane, in adequate position.



DISCUSSION

The interest of this case lies not in percutaneous tracheostomy, a well-established procedure, but in the approach to providing optical guidance in an environment where a flexible bronchoscope is not consistently available and oxygen reserve is limited. Ultrasound and videolaryngoscopy do not compete with each other; each answers a different question of the same procedure. The first question is where to puncture. Palpation identifies the cricoid cartilage with frequent error in short, obese, or edematous necks and does not provide information about the contents of the pretracheal plane. Ultrasound resolves both issues in less than 2 minutes and also allows estimating the distance between the skin and the anterior tracheal wall, information that guides the choice of cannula length. In this patient, the examination ruled out vessels in the chosen path, a condition that cannot be assumed: CT angiography documents vessels over the insertion region in about 41% of adults, with venous predominance, and prospective series describe changes in the puncture site after ultrasound examination (14,15,16). The relevance increases in patients receiving thromboprophylaxis or anticoagulation, a common situation in intensive care and present in the context of atrial fibrillation or flutter.

The second question is where the endotracheal tube is located. Withdrawal of the tube to the subglottis is traditionally performed blindly, with 2 potential consequences: if it remains too deep, the needle punctures the cuff and forces an urgent replacement in an already open field; if it ascends excessively, the patient is extubated at the moment of least tolerance. The videolaryngoscope makes this maneuver a visual act. Visualization of the inflated cuff below the vocal cords, as documented in this case, provides the same information as bronchoscopic transillumination regarding the proximal position of the tube, without occupying its lumen. The proposal is not new (18), but its application remains poorly documented outside of brief communications. Neither of the 2 tools visualizes the posterior tracheal wall, and this should be made explicit. Bronchoscopy retains an advantage in that specific point and in the immediate endoluminal confirmation of the cannula. Available trials indicate that this advantage does not translate into fewer major complications when the guide is replaced by ultrasound (11,12), although the statistical power of the studies is limited for infrequent events. The randomized comparison between bronchoscopy and a tube with an integrated camera showed better gas exchange with the device that respects the tube lumen (10), an observation consistent with the principle supporting the approach described here.

Altitude provides the physiological argument. A person living at 3650 m above sea level starts from a PaO2 close to 56 mmHg and a PaCO2 near 28 mmHg (21,22); therefore, any reduction in minute volume during the procedure translates into faster desaturation and a greater relative increase in carbon dioxide than at sea level (25). Preoxygenation with a high inspired fraction, a common practice before puncture, poses an additional tension here: it increases the margin against apnea but contradicts the oxygenation goals established for high altitude and the demonstrated harm of liberal oxygen exposure in the acutely ill patient (23,24).

The clinical case illustrates one care decision with clinical consequences. Transporting a patient with vasoactive support, mechanical ventilation, and supraventricular arrhythmia to the operating room involves disconnections, ventilator changes, and periods of degraded monitoring. Performing the procedure at the bedside eliminates that segment of risk, and the availability of ultrasound and videolaryngoscope, equipment present in most intensive care units, makes this alternative not depend on a scarce resource.

The limitations are considerable. One single case does not allow estimating safety or efficacy, and the favorable outcome may be attributed to the team's experience as much as to the technique. No systematic measurement of arterial blood gases was performed at predefined time points, which prevents quantifying the effect of the strategy on gas exchange, which is precisely the theoretical advantage invoked. Nor was there one comparison group or late follow-up to detect tracheal stenosis, granulomas, or tracheomalacia. The patient had pulmonary fibrosis, a condition that reduces functional reserve and limits extrapolation to populations with preserved respiratory mechanics. Evaluation of this combination at altitude requires prospective series with recording of PaO2, PaCO2, peak pressure, number of punctures, procedure time, and complications at 24 hours, compared against bronchoscopic guidance.

CONCLUSIONS

Ultrasound-guided and videolaryngoscopy-assisted percutaneous dilatational tracheostomy proved feasible at the bedside of one neurocritical patient residing at 3650 meters above sea level, with no immediate complications and respecting the oxygenation goals typical of high altitude. The usefulness of the combination comes from the complementarity between both tools: ultrasound defines the anatomy that palpation cannot discriminate, and the videolaryngoscope monitors the moment when the endotracheal tube is no longer protected. Compared with bronchoscopy, the most relevant practical difference is not the image quality but the preservation of the tube lumen, a condition that acquires another meaning when the patient's baseline arterial oxygen pressure is near 56 mmHg. The relevance of the clinical case justifies that ICUs located at altitude, with irregular access to flexible bronchoscopy, consider this strategy within a protocol with systematic recording of blood gas variables and complications, the only way to turn an isolated observation into usable evidence.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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