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Bilateral Pneumothorax with Subcutaneous Emphysema During Apnea Testing: A Case Report

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ABSTRACT

Apnea testing (AT) is a critical component of the neurological determination of death. Although complications during AT are well documented, bilateral pneumothorax is an exceptionally rare and potentially life-threatening event. This case report highlights a rare occurrence of bilateral pneumothorax during AT, explores its clinical implications and underscores the need for refining procedural guidelines. We report the case of a 38-year-old female admitted with a brainstem bleed due to accelerated hypertension. Apnea testing was initiated to confirm brain death after meeting all prerequisites. During the test, high-flow oxygen insufflation was administered using a wide-bore catheter, partially occluding the endotracheal tube (ETT). Within minutes, the patient developed left-sided facial swelling, subcutaneous emphysema and hemodynamic instability, indicating tension pneumothorax. Immediate chest decompression with intercostal drains (ICDs) confirmed bilateral pneumothorax. Spontaneous respiratory efforts observed during the test, along with arterial blood gas analysis revealing a significant CO_2 rise, indicating residual brainstem activity. Hence the patient was not brain dead and subsequent management continued. His lungs were fully expanded within 24 hours. This case demonstrates the importance of prompt recognition and management of complications during AT. Bilateral pneumothorax, though rare, poses a significant risk to patient stability and can dramatically affect organ donation opportunities. This report highlights the need for heightened vigilance during AT, especially in managing oxygen delivery to prevent barotrauma. It calls for more detailed and standardized guidelines to reduce the risk of such rare complications, ensuring patient safety and optimizing organ donation outcomes.

INTRODUCTION

The apnea test (AT) is an essential procedure in determining neurological death. It involves temporarily disconnecting the patient from mechanical ventilation to allow hypercapnia to develop. Absence of spontaneous breathing with significant rise in CO_2 levels is suggestive of positive apnea testing and presence of brain stem activity. Hypoxemia and hypotension are commonly acknowledged as potential complications of this test[1,2]. Preventive measures, including preoxygenation and the insufflation of oxygen through the endotracheal tube (ETT) during the procedure, reduce the likelihood of hypoxemia[3]. However, if the administered gas does not adequately diffuse from the lungs, whether due to ETT obstruction or excessively high flow rates, it may lead to increased tension in the airways or alveoli and potentially result in pneumothorax[4]. Since pneumothorax during an apnea test is exceptionally rare, the resulting hypoxemia or hemodynamic disturbances might be misattributed to the test itself and go unnoticed. Failure to promptly identify pneumothorax, discontinue the test and initiate urgent decompression can result in hypoperfusion of potentially viable organs that could otherwise be suitable for transplantation following death. We report a rare case of sudden bilateral pneumothorax with subcutaneous emphysema during an apnea test.

Case Description: We present the case of a 38-year-old female admitted to the medical intensive care unit following brainstem bleed (Fig. 1) caused by accelerated hypertension. With suspicion of brain death, brainstem death testing was initiated. A comprehensive clinical examination revealed a Glasgow Coma Scale (GCS) score of E1M1VT and both pupils were 2 mm in size with no light reaction. Examination of cranial nerve reflexes showed no responses. Given the absence of brainstem reflexes, apnea testing was planned to confirm brain death. All prerequisite criteria for conducting the apnea test were met. To ensure adequate oxygenation during the apnea test, a 7-French catheter was inserted into the endotracheal (ET) tube, which had an internal diameter of 7.5mm. The catheter was connected to a flow meter set at 8 liters per minute and advanced until resistance was encountered, indicating that it was positioned near the tip of the ET tube above the carina. Approximately five minutes into the test, the patient developed a rapidly enlarging swelling over the left cheek, which quickly progressed to involve the left orbit (Fig. 2). Within 30 seconds, the patient's blood pressure spiked to 260/150mmHg, with a mean arterial pressure (MAP) of 160mmHg and her heart rate rose to 180 beats per minute. Simultaneously, her arterial oxygen saturation dropped from 100-90%. Swelling was also noted over the left chest. The patient had no prior history of chronic lung diseases. The apnea test was promptly aborted and the patient was reconnected to mechanical ventilation. Given the strong clinical suspicion of a left-sided pneumothorax with impending tension, a wide-bore cannula was immediately inserted into the second intercostal space along the midclavicular line to relieve the pressure. This was followed by the urgent placement of an intercostal drain (ICD) on the left side (Fig. 3). Upon connection to a closed-seal system, a significant gush of air was observed, confirming the diagnosis. A chest X-ray was ordered to verify the ICD position. The chest X-ray revealed a right-sided pneumothorax also along with extensive bilateral surgical emphysema across both sides of the chest. Consequently, a right-sided intercostal drain (ICD) was placed and connected to an underwater seal with a closed drainage system (Fig. 4). During the apnea testing, spontaneous breaths were observed approximately four minutes into the procedure, prompting plans to abort the test. However, before the test could be officially terminated, the described complications occurred within the following minute. Prior to reconnecting the patient to mechanical ventilation, a second arterial blood gas (ABG) sample was obtained, revealing a 21mmHg rise in CO_2 from the baseline level. This elevation in CO_2 was sufficient to stimulate the patient's respiratory centre. Our patient developed spontaneous breathing efforts during AT, indicating presence of brainstem activity. As a result, the patient was not brain dead. Within the next 24 hours, both lungs showed complete expansion and there was significant resolution of the subcutaneous emphysema.

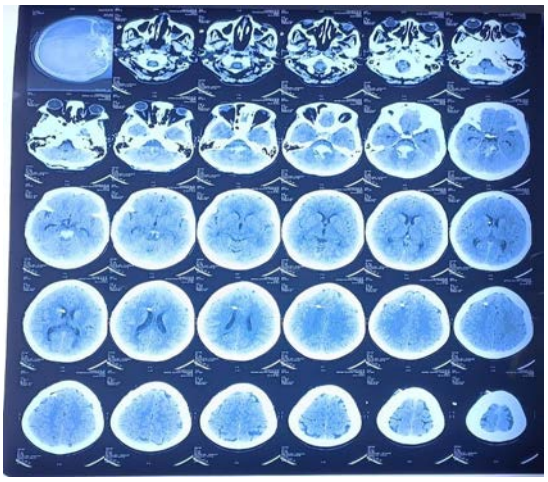

Fig. 1: Non Contrast Computed Tomography (CT) Images of the Patients Showing Hyper-Dense Area in Pons with Extension into Mid Brain and 4th Ventricle. VP Shunt is Seen in Right Lateral Ventricle

Fig. 2: Photograph Showing Asymmetrical Swelling of Left Eyelid and Left Cheek Immediately During Apnoea Test, Giving a Strong Clinical Suspicion of Pneumothorax

Fig. 3: Chest X-Ray Showing Bilateral Pneumothorax with Subcutaneous Emphysema. Left Intercostal Drain Seen on Left Side with Almost Complete Expansion of Left Lung

Fig. 4: Chest X Showing Bilateral Intercostal Drains in Situ with Bilateral Subcutaneous Emphysema and Expanded Lungs

Our patient experienced bilateral pneumothorax during apnea testing, a rare complication with an incidence rate of <0.8%[4]. Pneumothorax was suspected and treated based on clinical findings, as it was an emergency where confirming the diagnosis with chest ultrasound or X-ray was not feasible. The sudden onset of left cheek and chest swelling, palpable subcutaneous emphysema, hemodynamic instability and oxygen denaturation strongly indicated pneumothorax. The exact mechanism of pneumothorax associated with apnea testing remains unclear. One potential cause is direct trauma to the tracheobronchial tree during catheter insertion, which usually leads to symptoms appearing almost immediately after advancing the catheter beyond the ETT[4]. Another likely mechanism involves excessive air trapping, either due to high flow rates or the inability of gases to escape the lungs following insufflation[5,6]. High oxygen flow rates (≥6L/min) may also induce a "wiggling" effect of the catheter, potentially causing trauma to the tracheobronchial region. In many cases of apnea testing, flow rates exceeding 6-10 L/min have been reported. While unproven, it is plausible that such high flow rates contribute to the occurrence of PAT in these scenarios. Additionally, air trapping could occur if the oxygen cannula obstructs or occupies most of the ETT's diameter[7,8]. In our patient, pneumothorax might have developed as a result of partial occlusion of the endotracheal tube lumen. This airway obstruction was caused by the use of a large, wide-bore insufflation cannula for oxygen delivery. The obstruction led to significant air trapping and hyperinflation of the lungs, resulting in barotrauma, bilateral pneumothorax and surgical emphysema. The high oxygen flow rate of 8 liters per minute further heightened the risk of this complication. A significant gap in the existing literature on apnea testing is the lack of detailed discussion on the technique of oxygen insufflation. While the importance of maintaining adequate oxygenation is frequently emphasized, the specific methods for oxygen delivery, along with their potential complications are inadequately described. Guidelines from the United States (US), United Kingdom (UK) and Australia/New Zealand (ANZICS) regions differ in their recommendations for oxygen insufflation during apnea testing. The US and UK guidelines recommend an oxygen flow rate of up to 6 L/min[1,9]. The American Academy of Neurology (AAN) and Canadian guidelines advise positioning the oxygen insufflation cannula at or above the carina, whereas the UK guidelines do not provide specific recommendations regarding cannula placement[1,9,10]. The ANZICS guidelines are the most detailed, suggesting a lower oxygen flow rate of 2 L/min, ensuring that the cannula remains above the carina and explicitly addressing the potential risk of barotrauma during apnea testing[11]. These variations highlight the need for standardized practices to minimize risks and ensure patient safety. Apnea testing is associated with various complications, including cardiovascular issues. Goudreau *et al.* reported that

nearly one in four apnea tests resulted in cardiovascular complications. Furthermore, the incidence of complications almost doubled when the tests were conducted without meeting the necessary prerequisites. This highlights the critical importance of adhering to established guidelines and ensuring all prerequisite conditions are met to minimize risks during the procedure[2]. The occurrence of complications during apnea testing, such as bilateral pneumothorax leading to tension pneumothorax and cardiac arrest, has a profound impact on the potential for organ donation, reducing opportunities by as much as 50%[12]. Such serious complications should not be regarded as trivial, as they not only jeopardize patient stability but also significantly hinder the successful procurement of viable organs for transplantation. This underscores the critical need for meticulous technique, adherence to guidelines and prompt recognition and management of complications to safeguard both patient outcomes and organ donation opportunities.

CONCLUSIONS

This case report underscores the rare yet significant complication of bilateral pneumothorax during apnea testing, highlighting critical considerations for patient safety. It draws attention to the potential risks associated with high-flow oxygen insufflation and the use of large-bore cannulas, emphasizing the importance of careful technique and vigilant monitoring during the procedure.

Clinical Significance: By showcasing the clinical presentation, rapid diagnosis and effective management of pneumothorax during apnea test, this case serves as a valuable reminder of the need for prompt recognition of this complication, especially in emergency settings where diagnostic confirmation may be challenging. Additionally, it highlights gaps in existing guidelines regarding the technique and risks of oxygen insufflation during apnea testing, advocating for more detailed protocols to prevent similar incidents. This report contributes to the literature by providing insights that can inform safer practices and improve patient outcomes in future cases.

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