Tension Pneumothorax During Apnea Testing for the Determination of Brain Death

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Introduction

The apnea test (AT) is considered as the 'condition sine qua non' by most of the intesivists for determining brain death (BD) as it provides an important information for a definitive loss of brainstem function. It is the most difficult clinical test in BD protocols and is also potentially harmful and lengthy. The possible complications of this test include severe decrease in blood pressure, pneumothorax, excessive CO_2 retention, hypoxia, acidosis, and cardiac arrhythmia or asystole. It is important to abort the test in the setting of any of the above mentioned complication, which will compromise BD diagnosis. It is important to ensure that certain prerequisites are satisfied before the AT is carried out. These include body temperature 32°C or more, normal PO_2 or preoxygenation to obtain an arterial $PO_2 \geq 200$ mmHg, arterial PCO_2 or $PaCO_2$ normal or above 40 mmH, blood pH normal or in the low basic range, pretest systolic blood pressure of at least 90 mmHg, Euvolemia or a positive fluid balance during the previous 6 hours, no drug that can paralyze the respiratory muscles. If continuous or intermittent oxygen supply is preceded by decreasing nitrogen levels of blood gases, high PaO_2 levels can be maintained for very long periods of time. Preoxygenation removes alveolar nitrogen stores and helps oxygen transport. There are several techniques for ascertaining that there is sufficient oxygenation during AT .[1-5]

Case Report

A 17 year old male with prior history of chronic kidney disease was admitted to hospital due to impaired conscious level. Haemodialysis was advised due to suspicion of pulmonary edema and patient was shifted to nephrology department with the facility of dialysis. During dialysis patient went into cardiac arrest secondary to decreased saturation. CPR was initiated and rhythm was reverted to normal sinus rhythm after CPR of thirty minutes. After dialysis session of two hours patient was shifted to medical ICU(MICU). When brought into MICU patient was having fixed dilated pupils, absent Dolls eye reflex, absent Gag reflex and absent corneal reflex. Patient was put on ventilator support and after 48 hours of ventilator support again above mentioned brainstem reflexes were checked with addition of caloric test which was also found negative. So, apnea test was advised after taking approval from senior intensives and consent from the legal heirs' apnea test was performed, making sure that all prerequisites for the apnea test were fulfilled. Patient was oxygenated wit 100 % FIO2 for fifteen minutes via ventilator. Baseline ABGs were done with showed PCO2 of 42 mmHg. Ventilator support was discontinued and patient was oxygenated via a 12-french catheter inserted down into the endotracheal tube to the level of carina to provide an oxygen flow of 10 L/min. Five minutes later, oxygen saturation decreased to 60% and blood pressure to \70/30. At this moment, bradycardia ensued. Lung auscultation revealed bilateral absence of breath sounds. Abdominal distension and signs of cyanosis were observed. The oxygen catheter was removed and the patient was immediately connected again to the ventilator, although he continued to deteriorate. Bedside chest X-ray was done which showed massive surgical emphysema extending up to eyes, left sided pneumothorax and pneumoperitoneum. Immediately needle 18 french gauge cannula was inserted in to via 2nd intercostal space and the cannula was connected to underwater seale via I.V set which showed bubbles of air. He did not respond to an IV epinephrine bolus and cardiac arrest occurred before the pneumothorax was completely treated. "Cardiac" death was declared after cardiopulmonary resuscitation maneuvers failed.

Discussion

BD patients in ICU are a source of public money wastage and also hindrance to more deserving patient for ICU admission. For that reason, it is essential to establish BD diagnosis via apnea test. Any complication during this procedure may impair organ

perfusion.The established AAN prerequisites for performing the apnea test are: core temperature > 36.5C, systolic blood pressure > 90 mmHg, corrected diabetes insipidus, pCO2 > 40 mmHg, and PO2 >200 mmHg after preoxigenation.[1]

The conventional technique consists in connecting a pulse oximeter and disconnecting the ventilator. Subsequently, a cannula is placed at the level of the carina and 100% O_2 is delivered at a rate of 8-10 liters per minute while looking closely for respiratory movements. PO_2, CO_2, and pH are measured at baseline and 8-10 minutes after. Subsequently, the ventilator is connected again. If respiratory movements remain absent and arterial PCO_2 is >60 mmHg (or there is a 20 mmHg increase over a normal baseline PCO_2), the apnea test is positive (supporting the diagnosis of BD). Artificial CO_2 augmentation showed that the required time to perform the apnea test is markedly reduced when compared with the conventional technique. Apnea denotes loss of brainstem function. Central chemoreceptors sense arterial PO2 and the pH of the CSF changes. Thus, they control the stimulus for neurons in the reticular and dorsal vagal nerve nuclei. There also are other mechanical and chemical influences on the respiratory neurons in the brainstem.

Pitfalls in performing the apnea test could be encountered in clinical practice.[1,9] A few studies using small numbers of individuals have been performed in order to standardize this method[10]. There are anecdotal reports of medical complications during or after performing the apnea test. However, prospective studies are lacking in the literature.

Gad Bar et al. reported two patients with tension pneumothorax during the apnea test. One of them was a 55-year-old man who had intracerebral hemorrhage and developed pneumothorax when the catheter was at the level of the carina. The second case was a 14-year-old girl who had a severe head injury. One minute after starting the apnea test, the chest looked insufflated. Both patients had arterial hypotension, bradycardia, and finally cardiac arrest. [2] Marks and Zisfein mentioned a case with subcutaneous emphysema and thoracic insufflation. [3]

Wijdicks warned about the hypercarbia, acidosis, hypoxemia, and pulmonary edema that may appear during the apnea test. He questioned the safety of this procedure specially when the cited prerequisites were not considered.

Cardiovascular adverse effects related to the apnea test have been reported in small series of patients, such as 30% decrease of the systemic vascular resistance, increment of the cardiac index, hypoxemia, arterial hypotension, and pulmonary hypertension. Appropriate perfusion is a cardinal condition to preserve the organ function. Thus, prophylactic treatment with epinephrine or dopamine has been suggested to prevent hemodynamic complications, even though there is no evidence favoring this management.

Complications related to the AT were studied in 129 BD individuals. The researchers found major and minor complications during the AT in more than two thirds of patients, including: arterial hypotension (12%), acidosis (68%), and hypoxemia (23%). Baseline hypotension (systolic blood pressure < 100 mmHg or median arterial blood pressure < 60 mmHg) and pH <7.30 were the most common predicting risk conditions.

One of the researcher report a 55-year-old man with intracranial hemorrhage with no previous lung abnormalities, who developed thoracic and abdominal insufflation during the apnea test. This complication occurred even when following the recommendations for performing this test. The difference between our patient and other cases was the presence of abdominal insufflation. To our knowledge, this is the first documented-report of pneumoperitoneum associated with pneumothorax during this procedure. The pathophysiological bases are difficult to explain. Although no increase in peak airway pressure was detected, this may be the underlying clue. Several conditions may predispose to this complication, such as, a) mechanical factors e.g.: external diameter of the cannula, and length of the endotracheal tube, b) time between BD diagnosis and apnea test, and c) patient condition, e.g.: age, COPD, arterial hypotension, hypothermia, or acidosis. Thus, risk factors such as COPD, pneumonia, arterial hypotension, or acidosis should be taken into account and considered before performing this test. We also suggest delaying the apnea test in high-risk patients, especially in those with severe acidosis (pH <7.20) due to the risk of subsequent arterial hypotension and organ hypo perfusion.

In our country, as well as in others, an isoelectric EEG is a legal requirement for the diagnosis of BD. The apnea test is usually performed at the end of the clinical exam and before the EEG. Thus, a cardiac arrest due to a complication of this procedure may have legal implications because the BD diagnosis has not been definitely established in the individual yet.

Because of the documented complications during the apnea test, we do not consider this procedure as

innocuous. On the other hand, it is a cardinal requisite that should not be avoided to complete the diagnosis of BD. For this reason, we believe this test should be done at a more adequate time. Thus, we suggest the apnea test should be performed after the neurological evaluation and the EEG.

It is appropriate to use another method of apnea test for pre oxygenation rather than inserting catheter down to carina. In this procedure the patient is not disconnected from the respirator but the minute volume is decreased to a very low level (0.5–2 l/min), with the respirator in the synchronized intermittent mandatory volume ventilation mode and with pure oxygen provided for inspiration. In this procedure, the patient is not disconnected until the required $PaCO_2$ is achieved. We used this method on five BD patients with no complication, so we suggest to prefer this method as it prevents tracheopulmonary complications and allows the examiner to detect any spontaneous respiratory effort. In summary, medical complications may occur during the apnea test. Prospective studies are necessary in order to establish high-risk conditions and to define the frequency of complications during this procedure.

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