# Apnea test

Apnea test AKA apnea challenge (assesses function of medulla). Disconnection from ventilator causes an increase in PaCO2 (the most potent stimulus for respirations, except in patients with severe COPD whose respiratory drive is simultaed by low PaO2). Apnea is confirmed if there are no spontaneous respirations after disconnection from ventilator. Respirations are defined as abdominal or chest excursions that produce adequate tidal volumes; if there is any question, a spirometer may be connected to the patient [1)]

Since elevating PaCO2 increases ICP which could precipitate herniation and vasomotor instability, this test should be reserved for last and only used when the diagnosis of brain death is reasonably certain

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The apnea test, also known as the apnea challenge or apnea provocation test, is a medical procedure used to determine brain death or to assess the respiratory function of a person who has experienced a severe brain injury. It is typically performed in a hospital setting under strict medical supervision.

During the apnea test, the patient's respiratory function is evaluated by temporarily disconnecting them from the ventilator or respiratory support. The purpose is to assess whether the patient exhibits spontaneous breathing and to observe the response of the respiratory centers in the brain to increased levels of carbon dioxide (CO2).

Here's a general outline of how the apnea test is conducted:

Preparations: The patient is placed in a controlled environment, usually an intensive care unit (ICU). The medical team ensures that the patient is adequately monitored and prepared for the test.

Baseline assessment: The patient's vital signs, including heart rate, blood pressure, and oxygen saturation levels, are recorded before the test begins.

Ventilation withdrawal: The patient is temporarily disconnected from the ventilator, and respiratory support is withheld. The exact duration may vary but is typically around 8-10 minutes.

Observation: The medical team closely monitors the patient during the apnea period. They observe for any signs of spontaneous breathing efforts, such as chest movement or attempts to take a breath.

Blood gas analysis: At the end of the apnea period, blood samples are collected to measure arterial blood gases, including carbon dioxide levels. This helps assess the patient's response to increased CO2 levels, which normally trigger the respiratory centers in the brain to initiate breathing.

Reconnection: If there are no signs of spontaneous breathing or other responses during the apnea period, the patient is reconnected to the ventilator to restore respiratory support.

It's important to note that the apnea test is a complex and critical procedure performed in specialized medical settings by a skilled medical team. It is typically reserved for cases involving a severe brain injury or when determining brain death based on established protocols and guidelines.

# Guidelines

a) to prevent hypoxemia during the test (with the danger of cardiac arrhythmia or myocardial infarction):

● preoxygenate for ≥ 10 minutes before the test with 100% FIO2 to PaO2 > 200 mm Hg

● monitor oxygen saturation continuously with pulse oximeter during test

● prior to the test, reduce the ventilator rate to bring the PaCO2 to normocarbia (35–40 mm Hg) (to shorten the test time and thus reduce the risk of hypoxemia)

● during the test, administer passive O2 flow at 6 L/min through either a pediatric oxygen cannula or a No. 14 French tracheal suction catheter (with the side port covered with adhesive tape) passed to the estimated level of the carina b) starting from normocapnea, the average time to reach PaCO2 = 60 mm Hg is 6 minutes (classic teaching is that PaCO2 rises 3 mm Hg/min, but in actuality the rate at which PaCO2 rises varies widely, with an average of 3.7 ± 2.3 [2] or 5.1 mm Hg/min if starting at normocarbia [3] Sometimes as long as 12 minutes may be necessary

c) apnea is confirmed if no respirations for > 2 minutes with PaCO2 > 60 mm Hg or PaCO2 > 20 mm Hg over baseline or pH < 7.3 (if patient does not breathe by this point, they won't breathe at a higher PaCO2)

d) the test is aborted if:

● the patient breathes (chest or abdominal movement, gasps): incompatible with brain death

● SBP < 90 mm Hg (hypotension)

● if O2 saturation drops < 80% for > 30 seconds (on pulse oximeter)

● significant cardiac arrhythmias occur

e) if patient does not breathe, send ABG at regular intervals and at the completion of test, regardless of reason for termination. If the patient does not breathe for at least 2 minutes after a PaCO2 > 60 mm Hg is documented, then the test is valid and is compatible with brain death (if the patient is stable and ABG results are available within a few minutes, the apnea challenge may be continued while waiting for results, in case the PaCO2 is < 60)

f) if PaCO2 stabilizes below 60 mm Hg and the pO2 remains adequate, try reducing the passive O2 flow rate slightly (O2 flow may be washing out CO2 from lungs)

g) the test is positive (i.e., compatible with brain death) if there are no respirations and PaCO2 is ≥ 60 mm Hg (or there is a 20 mm Hg rise in PaCO2 above baseline)

# Prerequisites

normotension

normothermia

euvolemia

eucapnia (PaCO2 35–45 mm Hg)

absence of hypoxia

no prior evidence of CO2 retention (i.e., chronic obstructive pulmonary disease, severe obesity).

Procedure:

Adjust vasopressors to a systolic blood pressure _100 mm Hg.

Preoxygenate for at least 10 minutes with 100% oxygen to a PaO2 _200 mm Hg.

Reduce ventilation frequency to 10 breaths per minute to eucapnia.

Reduce positive end-expiratory pressure (PEEP) to 5 cm H2O (oxygen desaturation with decreasing PEEP may suggest difficulty with apnea testing).

If pulse oximetry oxygen saturation remains_95%, obtain a baseline blood gas (PaO2, PaCO2, pH, bicarbonate, base excess).

Disconnect the patient from the ventilator.

Preserve oxygenation (e.g., place an insufflations catheter through the endotracheal tube and close to the level of the carina and deliver 100% O2 at 6 L/min).

Look closely for respiratory movements for 8–10 minutes. Respiration is defined as abdominal or chest excursions and may include a brief gasp.

Abort if systolic blood pressure decreases to _90 mm Hg.

Abort if oxygen saturation measured by pulse oximetry is _85% for _30 seconds. Retry procedure with T-piece, CPAP 10 cm H2O, and 100% O2 12 L/min.

If no respiratory drive is observed, repeat blood gas (PaO2, PaCO2, pH, bicarbonate, base excess) after approximately 8 minutes.

If respiratory movements are absent and arterial PCO2 is _60 mm Hg (or 20 mm Hg increase in arterial PCO2 over a baseline normal arterial PCO2), the apnea test result is positive(i.e., spports the clinical diagnosis of brain death).

If the test is inconclusive but the patient is hemodynamically stable during the procedure, it may be repeated for a longer period of time (10–15 minutes) after the patient is again adequately pre-oxygenated.

# Brain death determination

Brain death determination.

Apnea test (AT) in patients on extracorporeal membrane oxygenation (ECMO) support is challenging, leading to variation in determining death by neurologic criteria (DNC).

A retrospective review of a prospective observational standardized neuromonitoring study was conducted in adult VA- and VV-ECMO patients at a tertiary center from June 2016 to March 2022. Brain death was defined according to the 2010 American Academy of Neurology guidelines and following the 2020 World Brain Death Project recommendations for performing AT in ECMO patients.

Results: Eight (2.7%) ECMO patients (median age = 44 years, 75% male, 50% VA-ECMO) met criteria for DNC, six (75%) of whom were determined with AT. In the other two patients who did not undergo AT due to safety concerns, ancillary tests (transcranial doppler and electroencephalography) were consistent with DNC. An additional seven (2.3%) patients (median age = 55 years, 71% male, 86% VA-ECMO) were noted to have absent brainstem reflexes but failed to complete determination of DNC as they underwent withdrawal of life-sustaining treatment (WLST) before a full evaluation was completed. In these patients, AT was never performed, and ancillary tests were inconsistent with either neurological exam findings and/or neuroimaging supporting DNC, or with each other.

Conclusion: AT was used safely and successfully in 6 of the 8 ECMO patients diagnosed with DNC and was always consistent with the neurological exam and imaging findings, as opposed to ancillary tests alone [4)]

1)
Wijdicks EF. Determining Brain Death in Adults. Neurology. 1995; 45:1003–1011
2)
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3)
Benzel EC, Mashburn JP, Conrad S, et al. Apnea Testing for the Determination of Brain Death: A Modified Protocol. Journal of Neurosurgery. 1992; 76:1029–1031
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Zhao DX, Caturegli G, Wilcox C, Stephens RS, Kim BS, Keller S, Geocadin RG, Suarez JI, Whitman GJ, Cho SM. Challenges in determining death by neurologic criteria in extracorporeal membrane oxygenation - A single center experience. Perfusion. 2023 Jun 30:2676591231187548. doi: 10.1177/02676591231187548. Epub ahead of print. PMID: 37387124.