Apnea Test in Diagnosis of Brain Death: Comparison of Two Methods and Analysis of Complications

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AN APNEA TEST (AT) is considered a main test in neurological evaluation leading to a diagnosis of death under neurological criteria.\(^1\)–\(^4\) This test, performed according to strict procedures, is requested in most of the standardizations about this matter. The test objective is to show the lack of function of the respiratory centers of the brainstem when physiological stimulus takes place, that is, the arterial carbon dioxide (\(\text{CO}_2\)) concentration increase and the corresponding \(\text{pH}\) decrease. There is no complete agreement about the minimal partial pressure (tension) of \(\text{CO}_2\) and the corresponding \(\text{pH}\) decrease. Therefore, it is demanded.\(^2\)–\(^8\) The test must also be performed assuring to prevent any harmful effects to the subject and his organs that may be eventually used for the transplant. The possible complications of this test (hypoxia, hypotension, arrhythmias, etc)\(^9\)–\(^13\) cause resistance among medical teams in charge of the procedure, creating a conflictive situation about the indication of the test. The presented indication is necessary to confirm a legal diagnosis.

There are several methods to perform the test, among the most popular is the so-called apneic oxygenation method (AO);\(^14\)–\(^16\) however, other methods have been proposed,\(^17\)–\(^18\) such as the one in which \(\text{CO}_2\) is artificially administered. The latter, known as artificial \(\text{CO}_2\) augmentation (ACO\(_2\)A), is easier to perform and might have fewer risks of serious complications.\(^17\)

This study retrospectively analyzes the staff performance of our organ procurement organization regarding the AT for the AO and the ACO\(_2\)A methods. These to determine the relative risk of complication occurrence in each one, their causes, and their respective possible prevention.

MATERIALS AND METHODS

We conducted a retrospective review of the medical records available from the organ procurement activity in patients who had been reported in our institution as possible donors between January 1998 and September 2000 at intensive care units in Buenos Aires. The AT method performed was analyzed along with data of neurological evaluations and maintenance parameters. A neurologist and a critical care specialist attended the procedures to confirm the diagnosis of death according to neurological criteria. The AT was prescribed when the patient developed the remaining criteria of death, according to neurological criteria, including a supplementary study (usually an electroencephalogram [EEG]) according to the recommendations of the protocol of diagnosis of death under neurological criteria in force in Argentina.

Apneic Oxygenation Procedure

The AO procedure is as follows: Previous ventilation with \(\text{FiO}_2\) of 1 and reduction of the minute respiratory volume to get basal normocapnia, disconnection from the ventilator, introduction of a cannula into the endotracheal tube to the level of the carina through which \(\text{O}_2 / 100\%\) to a 6 L flow per minute is administered. The disconnection is maintained long enough to reach a \(\text{PaCO}_2\) level of 60 mm Hg, which is usually achieved in 5 to 10 minutes depending on the initial \(\text{PaCO}_2\) level and the degree of hypothermia. If the patient did not present any respiratory movements, the trial was considered positive in terms of diagnosis for brain death.

Artificial \(\text{CO}_2\) Augmentation Procedure

The ACO\(_2\)A procedure is as follows: Pure \(\text{CO}_2\) administration into the inspiratory airway of the ventilator to a 1 L/min during 1 minute, without modifying the previous parameters of ventilation other than 100\% oxygen delivery, blood sample extraction for gases at the end of insufflation, and disconnection of the patient from the ventilator during a minute. If the arterial \(\text{CO}_2\) level in the time of disconnection was between 60 and 100 mm Hg and the patient did not do any respiratory effort, the test was considered positive in terms of brain death.

The data were collected from a specially designed protocol and was included into an Excel 97 spread sheet. The statistical analysis was done through SPSS (Version 8.0) and EPIINFO (Version 6.03) software. The cases in which significant data were incomplete, or when the method used was not one of the two analyzed or when tests results were negative, was excluded from the study.

RESULTS

Two hundred forty-three organ procedures, which included 404 neurological evaluations, were analyzed. Two hundred AT completed the inclusion requirement, performed in 142 patients. Of 200 tests assessed, 132 were performed using the ACO\(_2\)A method (66\%) and 68 using the AO method (34\%). The groups were compared regarding their demographic features and pretest state, and no statistically significant differences were found when analyzing the fol-
Although the higher difference found was the 206.0 mm Hg and 223.0 mm Hg in the uncomplicated patients (n = 11005) in relation to those in whom test for ACO2A was used: 19 patients presented complications (14%) with a P .00172 and an odds ratio of 3.04 with a confidence interval of 1.43 to 6.49.

The relative incidence of complications in the AO method included the following: hypotension: 8 cases, reversible cardiac arrest: 1 case; arrhythmias: 1 case; and hypoxaemia: 17 cases. In the ACO2A group, the complications were: hypotension: 10 cases; reversible cardiac arrest: 4 cases; arrhythmias: 1 case; hypoxaemia: 8 cases, and acidemia: 3 cases (in both groups some patients presented more than one type of complication).

In the group of all patients who presented complications (n = 42), the mean values for PaO2 (186.1 mm Hg), as well as those for the relation PaFiO2 (230) pre-test were significantly lower than in the rest (247 mm Hg and 305.5, respectively), with P = .012 and P = .002, respectively. Although the higher difference found was the final PaO2 and the pH value average between the two groups (108.1 versus 218.8 mm Hg-P = .000 and 7.08 versus 7.14 P = .004).

If the data are analyzed by the method used to perform the test, we found that these values show a higher gap, and therefore higher statistical significance, when the method used is AO, except for the final pH, that presents an inverse pattern, being that, in this group, the mean value for final PaO2 was 77.7 mm Hg in the complicated patients (n = 23) and 223.0 mm Hg in the uncomplicated patients (n = 45) (P = .000). In the ACO2A group, for the patients who had complications (n = 19) the mean final PaO2 value was 135.0 mm Hg and 206.0 mm Hg in the rest (n = 113) (P = .027). Instead; for the ACO2A group the mean value for final pH was 7.00 in the complicated patients versus 7.12 in the rest (P = .06); in the AO group the ratio was 7.16 versus 7.19 (P = .16) respectively.

No statistically significant differences were found when analyzing the following variables between complicated and noncomplicated patients for each method: sex, age, temperature, last of mechanical ventilation, initial hemodynamic state, pH value, PaO2 value, PaCO2 value, PaFiO2 value, presence of hypokalaemia, hypernatremia, and hyperglycemia.

If we study specifically the hypokalaemic patients, we observe that when the test with ACO2A is performed, statistically significant differences are presented between the group of patients who presented with complications and those who did not, suggesting that this factor has importance in the physiopathology of complications when using this method. In this group the 30.4% of the hypokalaemic’s patients (n = 23) presented complications, instead, only the 11.1% of the patients with a normal level of potassium (n = 99) were complicated (P = .04). On the other hand, in the AO group, the 27.7% of the hypokalaemic patients (n = 18) presented complications against the 31.0% of the normokalaemic ones (n = 42) (P = .8).

CONCLUSIONS

Our results suggest that, in our organ procurement organization, the method of AO to perform the AT has higher risk of serious complications, probably due to the hypoxaemia, than the ACO2A method. In the latter, the risk of complications was correlated, besides hypoxaemia, with a remarkable decrease of pH and with the presence of pretest hypokalaemia. Thus, we recommend performing the AT with ACO2A, especially in the cases with low PaFiO2 and risk of developing hypoxemia, having assured pretest normokalaemia. Further trials should assess these and others risk factors so as to state strict prerequisites that allow a decrease in complications with the AT by any method used.

REFERENCES

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