

**TITLE:** RECOVERY OF AIRWAY PROTECTION IN HUMANS AFTER PARALYSIS WITH CURARE

**AUTHORS:** E. G. Pavlin, M.D., R. Holle, M.D., and R. Schoene, M.D.

**AFFILIATION:** Departments of Anesthesiology, and Division of Pulmonary Medicine, University of Washington, Seattle, Washington 98195

**Introduction.** After anesthesia in which non-depolarizing muscle relaxants are administered, the decision to extubate is made on the patients ability (a) to adequately ventilate and (b) to prevent airway obstruction and aspiration of oral-pharyngeal contents. A prediction of adequate ventilation is often made from measurement of maximum inspiratory pressure (MIP) or vital capacity (V.C.), maneuvers which measure the strength of inspiratory muscles - chiefly the diaphragm. An MIP of -25 torr is often utilized as sufficient for maintenance of spontaneous ventilation. At what point of recovery from muscle relaxation have the muscles responsible for protection of airway recovered sufficiently to permit extubation? It is known that different muscle groups show different sensitivities to muscle relaxants with the diaphragm showing a relative resistance to paralysis. The object of this study was to determine the rate of recovery from curare of protective function of the upper airway and relate their return to MIP and other clinical indicators of the degree of paralysis.

**Method.** Six healthy adults took part in the study after signing informed consent of a protocol approved by the Human Subjects Review Committee of the University of Washington. After an intravenous route was established, esophageal and gastric balloons were placed. Subjects were then supine for the duration of the experiment. Control measurements of hand grip strength (HGS), MIP, VC, and end tidal PCO<sub>2</sub> (P<sub>ET</sub>CO<sub>2</sub>) were made. Curare was administered I.V. in 3 mg increments to achieve a predetermined decrease in MIP which was then maintained with an infusion of curare. Testing of VC, P<sub>ET</sub>CO<sub>2</sub> were done at MIP's of -65, -40, and -20 torr. At these and intermediate points of MIP, patients were tested for HGS, sustained head lift, leg lift and "airway measurements:" 1) ability to swallow, 2) ability to approximate the vocal cords in the face of a Valsalva maneuver to an esophageal pressure of approximately 35 cm H<sub>2</sub>O (either voluntarily or by manual pressure on the abdomen); 3) ability to maintain airway - (a) the point at which jaw thrust had to be maintained by the investigator to prevent complete obstruction and (b) the ability of the supine patient to approximate upper and lower incisors. These tests were carried out with increasing degrees of paralysis and during recovery. For each test, a mean MIP was calculated midway between the highest MIP at which a maneuver could not be accomplished (e.g. head lift, swallowing) and the lowest MIP at which it could. These were then averaged for the group (MIP<sub>50</sub>). The subjects were awake throughout the experiments.

**Results.** P<sub>ET</sub>CO<sub>2</sub> was maintained at normal levels throughout the experiment (Table I) and vital capacity was decreased to only 35% of maximum

at the weakest level corresponding to a MIP of approximately -20 [to -25]. However, although ventilatory parameters were adequate at this low MIP, airway protective ones were not (Table II). A Valsalva could not be maintained until after an MIP of -33 torr was surpassed while jaw thrust had to be maintained to prevent complete airway obstruction past an MIP of -39. Swallowing required the greatest degree of recovery from curare. In our study, every subject who could sustain a head lift for 5 sec could successfully perform the other maneuvers.

**Discussion.** An MIP of -25 has been shown to be a good predictor of the ability of a patient to breathe spontaneously while recovering from the effects of curare. Our data shows that while this appears true for ventilatory ability (Table I) with an adequate reserve of lung volume (VC) and a normal P<sub>ET</sub>CO<sub>2</sub>, this threshold may be too low for adequate airway protection from obstruction by the tongue or for the ability to swallow oral secretions. Thus the patient should remain intubated until higher levels of MIP are obtained, or at least steps should be taken to clear secretions and maintain airway until strength of the appropriate muscles return. We found that in every subject who could maintain a head lift for 5 seconds, all functions of cord closure, swallowing and airway maintenance were normal. Therefore, this simple clinical indicator of degree of relaxation is a valuable index to the ability of the awake patient recovering from muscle relaxants to protect his or her airway.

TABLE I (n=6)

	MIP (Cm H <sub>2</sub> O)	HGS (% of max)	V.C. Litres (% max)	P <sub>ET</sub> CO <sub>2</sub> (torr)
Control	90±5	100	5.9±.26 (100)	41.7
Curare (low)	63±6	38	5.7±.4 (96)	42.9
Curare (med)	38±2	16	4.5±.4 (77)	42.0
Curare (high)	20±1	2	2.0±.2 (35)	40.7

TABLE II

MIP for Maneuvers under Curare (Mean ± S.E.)

	(cm H <sub>2</sub> O)
Head Lift	- 53 ± 2.4
Leg Lift	- 50 ± 2.8
Swallow	- 42 ± 4.8
'Touch Teeth'	- 43 ± 5.3
Airway Obst.	- 39 ± 4.9
Valsalva	- 33 ± 4.4

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