Date :

Title : RESPIRATORY MECHANICS DURING PROGRESSIVE CURARIZATION

Authors : T. J. Gal, M.D. and N. S. Arora, M.D.

Affiliation: Departments of Anesthesiology and Internal Medicine, University of Virginia Medical Center, Charlottesville, Virginia 22908

Introduction. Progressive respiratory muscle weakness is common in neuromuscular disorders and exists to a variable extent in patients with partial neuromuscular blockade. The effects of such weakness on respiratory mechanics have not been well defined, largely because patients with neuromuscular disease have accompanying parenchymal lung disease and structural deformities. This study was performed to examine the effects of varying levels of respiratory muscle weakness on the static and dynamic properties of the lungs and airways in healthy awake subjects made progressively weak by incremental doses of intravenous d-Tubocurarine (dTc).

Methods. Six healthy males (aged 21-32) gave informed consent and participated in this institutionally approved study. The supine subjects received four incremental doses of dTc 0.05 mg/kg each (total dose 0.20 mg/kg) at 7 minute intervals to produce progressive muscle weakness. Grip strength, forced vital capacity (FVC), maximal static inspiratory and expiratory pressures (PImax, PEmax), maximum inspiratory and expiratory flow-volume curves, and pleural pressures during the maximal forced inspiration and expiration (Ppl I, Ppl E) were recorded prior to dTc (control) and during quasi-steady states 4-6 minutes after each dose. Lung recoil pressure (PstL), measured with an esophageal balloon, and open circuit N_2 estimates of functional residual capacity (FRC) were measured in the control state and at the maximal level of partial curarization (dTc dose #4).

Results. At all levels of partial curarization (Table 1), PEmax and Ppl E decreased significantly more than PImax and Ppl I ($P<.01$). Maximum mid-inspiratory flow ($\dot{V}I$ 50) decreased at all levels of weakness ($P<.01$); it also decreased out of proportion to Ppl I ($P<.01$, paired t-test). Estimates of inspiratory resistance (Ppl I/$\dot{V}I$ 50) increased from a mean control value of 4.8 (cm H_2O/L/sec to 8.6 after dTc dose #4. In contrast, FVC, peak expiratory flow, and expiratory flow at mid-vital capacity ($\dot{V}E$ 50) were significantly below control only after the last dose of dTc, and the ratio $\dot{V}E$ 50/VC actually increased over control by 16% ($P<.05$). After this final dTc dose when head lift was abolished and grip strength was only 3% of control, TLC was decreased to 85% of control and PstL was 46% of that at control TLC. FRC was unchanged, but residual volume increased by 38% because of a decreased expiratory reserve volume.

Discussion. Our findings indicate that supine curarized subjects are able to maintain relatively normal expiratory flow rates in the face of severe expiratory muscle weakness. Inspiratory flows on the other hand are markedly reduced, but the changes are not accounted for solely by reduced negative pleural pressures during forced inspirations since relative changes in Ppl (I) were significantly less than flow. The flow patterns and ratio of $\dot{V}E$ 50/$\dot{V}I$ 50 suggest that a variable upper airway obstruction was present during forced inspiration since Ppl (I) was sufficiently maintained to produce normal maximal inspiratory flow. We therefore conclude that the disproportionate decrease in $\dot{V}I$ 50 with increasing muscle weakness (dTc doses #3 and 4) results from an increased upper airway resistance because of paresis of pharyngeal and laryngeal muscles. During the forced inspiration, effort was sufficient to produce dynamic narrowing of the upper airway at these sites and possibly in the extrathoracic airway below. These findings indicate the likelihood of upper airway obstruction in the partially curarized patient, particularly when increased levels of breathing effort are required.

Table 1

dTc #	PImax	PEmax	FVC	$\dot{V}I50$	$\dot{V}E50$	Ppl (I)	Ppl (E)
1	94±3	90±4*	99±1	86±4*	95±4	90±1	84±8*
2	87±5*	74±6*	95±2	71±7*	94±6	86±1*	78±7*
3	71±6*	33±3*	87±1*	58±8*	92±5	81±1*	51±3*
4	42±4*	21±1*	71±2*	41±6*	85±3*	75±1*	31±3*

Values are percent of control (Mean ± SEM); (P<.01 denotes significant difference from control (paired t test).

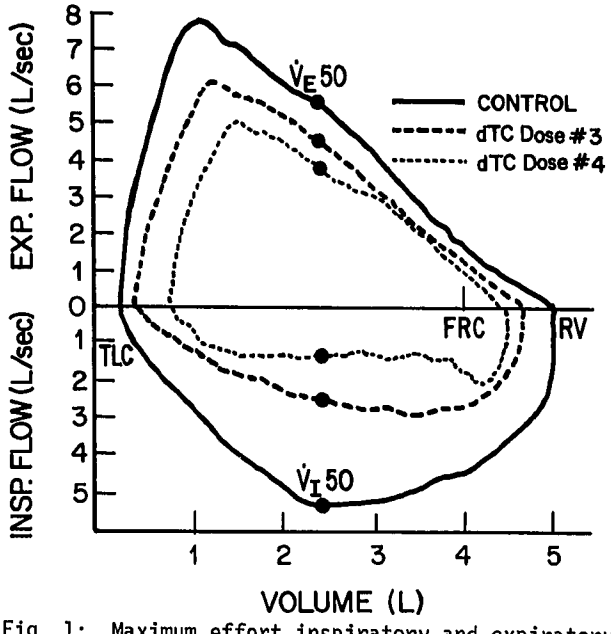

Fig. 1: Maximum effort inspiratory and expiratory flow-volume curves in a single subject to illustrate the severe reductions in inspiratory flow which occurred after the last two dTc doses.

This work supported in part by NIH-USPHS Grant HL 22022.