so doing, the pressures resulting from distortions as well as those arising from rib cage muscle contraction can be estimated. During quiet breathing, distortions are an important source of pressure expanding the costal surface of the lung. They relieve the rib cage muscles of work because they supply approximately 50% of the pressures required to expand the pulmonary rib cage and lung.

REFERENCES

Neck and Pectoral Girdle Muscle Contribution to Intrathoracic Pressure*


The neck and pectoral girdle muscles apply forces that distort the rib cage (RC) and may contribute to changes in intrathoracic pressure (Pes). We assessed the contribution of neck and pectoral girdle muscles to the development of Pes during maximal static inspiratory efforts. Neck flexion (NF) was used to decrease the mechanical advantage of the neck muscles. Arm elevation (AE) to 45° was used to enhance the mechanical advantage of the pectoral girdle muscles. Control posture was head level, hands folded in lap. Five normal subjects were studied at FRC and seated in all postures. Pes and gastric (Pga) pressures were measured with balloon catheters and RC displacement with a calibrated Respitrace (isovolume maneuver). In 2 subjects integrated diaphragm EMG (Edi) was recorded using esophageal electrodes. Results as shown in Table 1 (x ± SE).

Table 1—Pressure Measurements in 5 Subjects

<table>
<thead>
<tr>
<th>Posture</th>
<th>Pes (cm H₂O)</th>
<th>Pga (cm H₂O)</th>
<th>Pdi (cm H₂O)</th>
<th>RC (mm)</th>
<th>Edi* (AU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>109±15</td>
<td>26±8</td>
<td>136±8</td>
<td>4±5</td>
<td>10±1</td>
</tr>
<tr>
<td>NF</td>
<td>98±18</td>
<td>26±11</td>
<td>125±17</td>
<td>5±6</td>
<td>12±2</td>
</tr>
<tr>
<td>AE</td>
<td>120±15</td>
<td>21±6</td>
<td>141±16</td>
<td>14±7</td>
<td>10±1</td>
</tr>
</tbody>
</table>

*Measured in only 2 subjects.

Neck flexion and arm elevation altered Pes but not Pdi and Edi. Pes was less than control with NF, and greater than control with AE (p<0.05). RC displacement was greater than control with AE (p<0.05) but unchanged from control with NF. Peak Edi was similar in all postures, indicating that changes in Pes and RC expansion did not result from diaphragm activity. We hypothesize that changes in mechanical advantage of neck and pectoral girdle muscles alter intrathoracic pressure development and expansion of the rib cage during maximal static inspiratory efforts.

Contribution of Rib Cage and Abdominal Expiratory Muscles to Tidal Volume in Head-up Dogs

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When anesthetized dogs are tilted from the supine to the head-up posture, the diaphragm shortens and operates on a less efficient portion of its length-tension curve. If uncompensated, therefore, tidal volume will decrease. In head-up dogs, however, there is considerable recruitment of the rib cage and abdominal expiratory muscles. When this postural change is produced over a 2-3 s period, there is initial apnea during which all muscles are silent; quiet breathing subsequently resumes with phasic expiratory muscle activation. We took advantage of this initial electrical silence to establish the change in end-expiratory lung volume (relative to passive FRC) produced by the expiratory muscles in head up posture; this change, in turn, represents the expiratory muscle contribution to tidal volume (Vt). Eight animals were studied. Vt in head up posture was (mean ± SE) 515 ± 77 ml, and the expiratory muscle contributed amounted to 329 ± 70 ml (62 ± 6% Vt). When the internal intercostal nerves in interspaces 3 to 8 were sectioned at the rib angles to denervate the rib cage expiratory muscles, the expiratory muscle contribution to Vt was still 243 ± 84 ml (49 ± 10% Vt). Therefore, the contribution of the rib cage expiratory muscles initially was only 54 ± 19 ml (11 ± 4% Vt).

We conclude that in head-up tilted dogs the abdominal muscles, but not the rib cage expiratory muscles, contribute a very substantial fraction of tidal volume and take on the work of the shortened diaphragm.

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