the spontaneously breathing patient, 2) the level of superimposed work is dependent on the system's structural and operational design, and 3) systems with lower superimposed work seem to be tolerated the best by patients.

In a very recent article, Dr. Viale et al measured the work superimposed by the Siemens 900B, 900C and the Engstrom Erica ventilators as compared to a continuous high flow system. The results of Dr. Viale (using patients) and Dr. Katz (simulated patient) were disturbingly different. This is probably because there is no standard method of calculating or measuring the work of breathing.

If one of the objectives of delivering CPAP is to do it with as little superimposed work as possible, we suggest that the inspiratory assist function be used. The Engstrom Erica was the first ventilator to have this function for use in clinical practice. It was designed for the specific purpose of decreasing the work of breathing.

We duplicated the study in our lab at Engstrom using the same set-up as Dr. Katz. We found that, if an inspiratory assist level of 19 cm H2O (only 9 cm H2O above CPAP level) was used, the "reduced work" was almost as high as the "additional work." This resulted in a net inspiratory work of zero.

We understand that the role of inspiratory assist and work of breathing will be clarified, discussed and published in the near future—hopefully in your journal.

Rome Iturralde, R.R.T.; and Brian Hogman, Gambro Engstrom, Lincolnshire, Illinois

REFERENCES

1 Katz JA, Kraemer RW, Gjerde GE. Inspiratory work and airway pressure delivery systems. Chest 1985; 88:519-26

To the Editor:

When comparing different CPAP delivery systems, it is important to standardize the testing conditions, and these conditions should reflect those found in the clinical setting. In our study, patient demand (sine-wave inspiratory flow of 20, 40 and 60 L/min peak flow at a tidal volume of 500 ml) and patient condition (lung compliance, 50 ml/cm H2O and airway resistance, 5.45 ml H2O/L/sec) were simulated using a lung model. Ventilator circuit (inspiratory) resistance was constant. We used the Bird model 3001 humidifier since it offers minimal resistance to flow. We apologize for failing to include the manufacturer in the article. All CPAP delivery systems were tested under these constraints.

Messrs. Iturralde and Hogman suggest the additional work of breathing imposed by CPAP systems were different when comparing the studies of Viale et al (using patients) and Katz et al (using a lung model). The calculation of work was identical (integration of the volume-pressure curve), although we reported our data in kg-m L-1 and they reported in mJ L-1. In fact, comparing the two studies, the additional work for the continuous flow and the Engström Erica models were similar (Table 1). The additional work of breathing differed only for the Siemens Servo 900B and 900C ventilators (Table 1). We do not know why the results are different, but suggest that the use of different humidifiers may be responsible (Viale et al also did not report the type of humidifier used.) For example, the Bennett Cascade humidifier (one commonly used), when appropriately filled with water, offers an increased flow resistance as compared to the Bird humidifier. Siemens 900B and 900C ventilators regulate demand flow based on the airway pressure relative to end-expiratory pressure at the ventilator, not at the airway. Therefore, a pressure difference across a humidifier will not be appropriately compensated by an increased flow in the Servo system. Continuous flow systems should not be affected by such a pressure drop provided that the continuous flow exceeds patient demand flow and/or the reservoir bag is on the humidifier outlet.

We evaluated this hypothesis and compared the additional work (in our lung model) using Bird and Bennett Cascade humidifiers. For the continuous flow device, there was no difference in additional work between the two humidifiers. In contrast, the Servo ventilators were dramatically affected (Fig 1). With the Cascade humidifier, the additional work was 306 mJ L-1 for the 900B and 298 mJ L-1 for the 900C, values similar to those reported by Viale et al (Table 1).

In our study, we showed that CPAP systems vary widely in the amount of additional work they impose, and that some demand flow systems impose less additional work than a continuous flow device. In addition, ventilator circuits/humidifiers may decrease a demand flow systems performance. Therefore, when using demand flow CPAP systems, humidifiers which offer a minimal resistance to flow should be utilized.

An ideal CPAP system would impose no additional work of breathing. Iturralde and Hogman suggest that 9 cm H2O of inspiratory assist (pressure support) in the Engström Erica ventilator will result in equal amounts of additional and reduced work, yielding a mathematic net (superimposed) inspiratory work of zero. It is unclear whether the QO2 consumption of the respiratory muscles re-

![Figure 1](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21545/)
Table 1—Mean Results for Four CPAP Systems

<table>
<thead>
<tr>
<th></th>
<th>Continuous Flow</th>
<th>Engström Erica</th>
<th>Siemens Servo 900B</th>
<th>Siemens Servo 900C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viale et al*</td>
<td>190</td>
<td>289</td>
<td>405</td>
<td>277</td>
</tr>
<tr>
<td>Additional work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mL·L⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak inspiratory</td>
<td>33</td>
<td>36</td>
<td>33</td>
<td>37</td>
</tr>
<tr>
<td>flow (L·min⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katz et al†</td>
<td>177</td>
<td>328</td>
<td>43</td>
<td>44</td>
</tr>
<tr>
<td>Additional work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mL·L⁻¹)</td>
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<tr>
<td>Reduced work</td>
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<td>0</td>
<td>235</td>
<td>68</td>
</tr>
<tr>
<td>(mL·L⁻¹)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Peak inspiratory</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
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<tr>
<td>flow (L·min⁻¹)</td>
<td></td>
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</tr>
</tbody>
</table>

*at 6.5 cm H₂O end expiratory pressure
†at 10 cm H₂O end expiratory pressure

required to perform the additional work will be offset by a reduced O₂ consumption when the device performs work for the patient. At present, there are no published studies which clearly define the role of inspiratory assist in the ventilatory management of patients.

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REFERENCES


Socioeconomic Factors in Tuberculosis

To the Editor:

We write with interest the article of Davis et al on the causes of death in patients with active tuberculosis, since we performed a similar retrospective analysis of 1,079 patients with active tuberculosis hospitalized during the period from 1972 to 1984. In general, our findings were similar to those expressed by Davis et al, except that we found a higher mortality rate (56 of 1,079 or 5.2 percent vs 41 of 2,937 or 1.4 percent, p<0.001 by Chi-square test), a difference that can not be explained by differences in age, prevalence of drug-resistant mycobacteria, or compliance to therapy.

Of our 1,079 patients, 436 (40 percent) were young North African immigrants of fair socioeconomic status who, for religious reasons, did not consume alcohol. None of them died. All 56 deaths occurred in the remaining 643 patients, who were mostly elderly or homeless people with very low socioeconomic status, and of whom 456 acknowledged chronic alcohol consumption. Severe alcoholic liver disease was documented in 39 patients and was significantly more prevalent in nonsurvivors than in survivors (10 of 56 or 18 percent vs 29 of 587 or 4.9 percent, p<0.001 by Chi-square test). In our and others' view, alcoholism, the socio-economic effects related to alcoholism and in particular alcoholic liver disease seem important determinants of mortality in tuberculosis, presumably by limiting the choice and dosage of antituberculous drug therapy. Unfortunately, Davis et al give no comments on alcohol consumption in their nonsurvivors. We nevertheless presume that the high prevalence of alcohol consumption in our patients may explain our higher mortality rate.

Davis et al noted hypoalbuminemia in all their nonsurvivors in whom serum albumin levels had been determined. Severe hypoalbuminemia (<2.5 g/dl) was also prevalent in our nonsurvivors (24 of 56 or 43 percent), while significantly less prevalent in our survivors (41 of 1,023 or 4 percent, p<0.001 by Chi-square test). Hypoalbuminemia not related to severe alcoholic liver disease was present in only three of the 24 hypoalbuminemic nonsurvivors. Hypoalbuminemia seems a separate risk factor for mortality, presumably reflecting poor nutritional status, severity of infection and catabolic condition.

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To the Editor:

The letter of Dr. Cauchie et al is of interest to us. We suspect that the differences in mortality reflect the differences in the populations studied. Most of our patients were on the poorer end of the socioeconomic scale, and had accompanying stigmata of crowded living conditions and poor nutrition. Eighteen of the 41 patients (44 percent) who died were characterized by the attending physician as alcoholic. Nevertheless, none of the deaths could be directly related to alcoholism. None of the patients had the choice of drug therapy nor the drug dosage limited by alcohol-related liver disease. Eight of the 21 patients (38 percent) who died from common medical problems were characterized as alcoholic, but none of them had documented complications of alcoholism. Ten of the 20 patients (50 percent) who died as a direct result of tuberculosis were alcoholic. Again, in none of these patients was the alcoholism or alcohol-related medical problems a major contributing factor in the death.

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Bruce A. Bush, M.D.; and Andre J. Ognibene, M.D.,
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Flexible Fiberoptic Pericardioscopy

To the Editor:

We read with interest the recent article by Little et al (Chest 1985; 89:53-55). They reported their results with pericardiocscopic examination as an adjunct to pericardial window in 17 patients.

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