Nasal continuous positive airway pressure (CPAP) has been widely and safely used in the treatment of sleep disorders but has not been previously utilized for therapy of pulmonary atelectasis in adults. We observed three patients with significant atelectasis which was refractory to conventional chest physiotherapy. Bronchoscopy was not a viable therapeutic option in any patient. Therapy with continuous nasal CPAP was initiated at 10 to 15 cm H₂O. The patients tolerated the therapy well and had prompt resolution of atelectasis. Nasal CPAP may be an effective modality for therapy of pulmonary atelectasis in spontaneously breathing patients, particularly when conventional therapies are not tolerated or are ineffectual.

Naosal continuous positive airway pressure (CPAP) was introduced in 1981 for the treatment of sleep apnea. Since then, it has accumulated an impressive record of safety in unsupervised outpatients with sleep disturbances. The equipment required is exceedingly simple: a small, specially fabricated nasal mask with interchangeable CPAP valves, a pliant bag reservoir, and a compact portable air compressor (Fig 1). Oxygen can easily be blended into the system for patients with requirements for enriched inspired oxygen concentrations.

Though limited to therapy of sleep disorders in adults, nasal CPAP has been widely used in pediatric disorders. A prospective study has demonstrated a favorable effect on prevention of postextubation atelectasis in neonates recovering from respiratory distress syndrome.

In this report, three adults with refractory pulmonary atelectasis were successfully treated with nasal CPAP.

**Case Reports**

**Case 1**

A 23-year-old man with a history of neurofibromatosis was admitted because of respiratory distress. He had severe kyphoscoliosis and had undergone left shoulder disarticulation in the distant past. He was known to have severe pulmonary restriction as a result of his chest wall abnormalities and was chronically hypercarbic. Evaluation included a chest roentgenogram showing left bilobar atelectasis without air bronchograms. Room air arterial blood gas values were as follow: pH, 7.25; PCO₂, 72; PO₂, 63. He was intubated and mechanically ventilated for three days with resolution of the atelectasis. Two days after extubation, he complained of dyspnea; chest roent-

---

*From the Departments of Medicine, Psychiatry, and Anesthesiology, Stanford University School of Medicine, Stanford, CA. Manuscript received October 13; revision accepted February 13. Reprint requests: Dr. Raffin, Division of Respiratory Medicine, Stanford University Medical Center, Stanford 94305

**Figure 1. Nasal CPAP apparatus.**
constitutional symptoms. Room air blood gas values were as follow: pH, 7.49; PCO₂, 28; and PO₂, 82. A pulmonary consultant recommended postural drainage and chest percussion at two-to-four hour intervals, nebulized metaproterenol, and voluntary cough, deep breathing and incentive spirometry every hour while awake. After more than 24 hours of therapy, there was no improvement by examination or roentgenogram. The patient refused bronchoscopy. After informed consent was obtained, nasal CPAP at 15 cm H₂O was started with instructions to nose breathe with the mouth closed. A roentgenogram taken less than 24 hours later showed marked improvement of the atelectasis. He was discharged with an incentive spirometer and a family member was taught to perform frequent chest physiotherapy. When seen in clinic three weeks later, his atelectasis had recurred.

CASE 3

A 55-year-old woman with lifelong severe mental retardation was admitted because of subacute progressive obtundation, emesis, and urinary incontinence. One year previously, a large posterior fossa meningioma had been diagnosed. At that time, the patient’s family decided not to subject her to a potentially hazardous neurosurgical procedure with little chance of cure. Admission examination showed her to be awake, uncommunicative, and incapable of following simple commands. On pulmonary examination, a dull left base with locally diminished breath sounds was noted. Arterial blood gas levels while receiving supplemental oxygen (2 L/min via nasal cannula) showed a pH value of 7.33, PCO₂ level of 22, and PO₂ value of 61. Chest roentgenogram revealed marked left lower lobe collapse which had been present on serial studies for three months. Head CT scan demonstrated progression of the tumor and hydrocephalus. The family elected not to permit placement of a ventricular shunt or other “invasive procedure.” However, the family did not want support withdrawn, and hoped the patient would be able to return home. Frequent treatment with inhaled metaproterenol, IPPB, and chest percussion produced some initial improvement of atelectasis. However, despite two days of additional therapy, the roentgenograms showed persistent stable atelectasis (Fig 4). Informed consent was obtained from the family and nasal CPAP was started at 15 cm H₂O.
with 5 L/min oxygen bled into the mask. She could not comply with instructions, and mouth breathing was frequently observed. Nevertheless, complete roentgenographic resolution occurred within 36 hours of therapy with nasal CPAP (Fig 5).

**DISCUSSION**

Pulmonary atelectasis is a commonly encountered problem following upper abdominal or thoracic surgery, in patients with neuromuscular disorders or obtundation, and in the critically ill. If not successfully treated, atelectasis can cause disturbances of gas exchange, increased work of breathing, and fever. Persistent atelectasis predisposes to pulmonary infection, and can lead to fibrosis with irreversible loss of functioning lung parenchyma.

Optimal therapy for atelectasis is controversial, and conventional techniques have several drawbacks. Chest physiotherapy and/or bronchoscopy have been demonstrated to be only 60 to 90 percent effective in resolving lobar atelectasis. Chest physical therapy can worsen hypoxemia in the acutely ill, is not tolerated by many patients, and is contraindicated in several disorders. Bronchoscopy has the additional disadvantage of being an invasive procedure with associated finite morbidity and mortality. Further, IPPB does not produce beneficial roentgenographic changes in randomized studies and may cause a number of complications. Incentive spirometry, coughing, and deep breathing require an alert, cooperative, and motivated patient to perform often painful tasks. The effectiveness of both incentive spirometry and deep breathing exercises has been questioned in the prevention of postoperative atelectasis. All of these therapies require time-consuming and costly supervision by trained personnel.

Positive airway pressure for therapy of atelectasis has gained widespread use. In spontaneously breathing, nonintubated patients, intermittent face mask CPAP has been advocated as an efficacious modality for prevention and treatment of atelectasis. Face mask CPAP is currently in use by 25 percent of the hospitals in the United States for the treatment of atelectasis despite a lack of studies showing it to be unequivocally superior to conventional techniques.

Face mask CPAP has several potential drawbacks. The masks cover a large area of the patient's face, are by necessity tight fitting, and consequently, are often poorly tolerated for extended periods. Face mask CPAP therapy must therefore be interrupted frequently. Patients should be continuously supervised and undergo nasogastric suctioning during use of face mask CPAP due to the potential for catastrophic aspiration of gastric contents.

Our case reports demonstrate the possible effectiveness of nasal CPAP in patients with atelectasis refractory to conventional techniques. In two cases, resolution occurred within 24 hours of instituting nasal CPAP. Complete resolution of atelectasis in the third case required approximately 36 hours of nasal CPAP. The delayed response of the third patient may have been related to the chronicity of her atelectasis, which had been roentgenographically documented for three months. To our knowledge, there are no previously reported cases of treatment of atelectasis in adults with nasal CPAP.

Since these data are anecdotal, it may be argued that the benefit we attribute to nasal CPAP in these three cases may have occurred spontaneously or as a result of initial therapies. However, the prompt resolution of atelectasis with nasal CPAP, and the eventual recurrence of atelectasis after discontinuation of therapy in two patients is strongly supportive of direct causal action of nasal CPAP.

As well as being surprisingly effective in all patients so far treated with this modality, the technique was simple to use, required very little supervision or maintenance, and was well tolerated by these patients. There were no adverse effects of nasal CPAP. We arbitrarily chose 10 to 15 cm H₂O of CPAP based on our favorable experience with therapy of sleep disorders. It is possible that lower levels of nasal CPAP may be equally efficacious, but this determination awaits further study.

Nasal CPAP may have advantages when compared to other techniques for the treatment of atelectasis. The nasal mask covers only the nose and is easily tolerated for extended periods. The potential for aspiration of oral secretions or stomach contents confined in an occluding face mask is obviously avoided with nasal CPAP. In the unlikely event of equipment failure, patients can mouth breathe. Oral feeding is not impeded. Nasal CPAP requires much less skilled personnel time than other treatments because this therapy does not require frequent interruption. Nasal CPAP may prove to be safe and effective treatment in outpatients with recurrent atelectasis.

Aside from potential economic and patient compliance advantages, this anecdotal pilot study of three patients suggests nasal CPAP may be more efficacious than current conventional therapy in the treatment of pulmonary atelectasis. Before widespread implementation of nasal CPAP for this indication, it needs to be systematically studied in comparison to other techniques. Until such studies are completed, nasal CPAP may be appropriate as a therapeutic alternative when other measures have failed or are not tolerated.

**ADDENDUM**

Since submission of this report we have used nasal CPAP in another patient with refractory atelectasis.

A 70-year old man was admitted with the complaint of sudden onset of dyspnea and nonproductive cough.
He had previously been in excellent health but had a long history of cigarette smoking. Examination showed him to be in mild distress with a respiratory rate of 22. Temperature at admission was 38.6°C. Initial chest x-ray film showed marked atelectasis of the right middle lobe. Arterial blood gas on 5% oxygen per nasal cannula showed pH 7.47; PCO_2, 23; and PO_2, 95. Fiberoptic bronchoscopy performed within a few hours of admission showed widely patent airways without mucosal lesion or abnormality, and cytologic examination of brush and lavage specimens was negative. Chest roentgenogram and symptoms were not improved by bronchoscopy nor by 48 hours of intense physiotherapy as described in the aforementioned cases. Nasal CPAP at 15 cm H_2O was used for approximately 12 hours with very near total resolution of the right middle lobe collapse. The patient was discharged shortly thereafter with a normal respiratory rate, afebrile, and with resolution of dyspnea. He has continued to do well on follow-up without recurrence of pulmonary problems.

REFERENCES
1 Sullivan CE, Issa FG, Berthon-Jones M. Reversal of obstructive sleep apnea by continuous positive airway pressure applied through the nares. Lancet 1981; 1:562-65
4 Theilade D. Nasal continuous positive pressure in the treatment of whooping cough. Anaesthesia 1979; 34:1028-31
5 Beasley JM, Jones SE. Continuous positive pressure in bronchiolitis. Br Med J 1981; 283:1506-08
7 O’Donohue WJ. Prevention and treatment of postoperative atelectasis: Can it and will it be adequately studied? Chest 1985; 87:1-2
9 Connors AF, Hammon WE, Martin RJ, Rogers RM. Chest physical therapy: the immediate effect on oxygenation in acutely ill patients. Chest 1980; 78:559-64
22 Smith RA, Kirby RB, Gooding JM, Civetta JM. Continuous positive airway pressure (CPAP) by mask. Crit Care Med 1980; 8:483-84