Intermittent Positive Pressure Breathing and the Treatment of Acute Asthma

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Whether or not intermittent positive pressure breathing (IPPB) is beneficial in the treatment of asthma has been controversial for 30 years. IPPB is expensive and has been associated with pulmonary infection, pneumomediastinum, pneumothorax, and death. The exact factors involved in the observed effectiveness of IPPB remain undetermined. With evidence from a literature review, it is concluded that in cases of severe asthma failing to respond to other methods of β-agonist inhalation, there is sufficient evidence for the use of IPPB.

Asthma is a common problem facing primary care physicians. A controversy surrounds the use of intermittent positive pressure breathing (IPPB) in the treatment of asthma patients. When, if ever, should IPPB be used? What is the evidence concerning its risks and benefits? The literature has been reviewed in an attempt to find answers to these questions for the physician treating patients with severe asthma.

Case History

A 13-year-old steroid-dependent asthmatic girl maintained on oral theophylline, oral terbutaline, inhaled metaproterenol, and oral prednisone presented to a small hospital emergency room with severe bronchospasm. Emergency room treatment included humidified oxygen, subcutaneous epinephrine, initiation of an aminophylline infusion, and nebulized isoetharine (without intermittent positive pressure breathing). The patient continued to deteriorate, with blood gases showing retention of carbon dioxide. IPPB was not used because of recent emphatic admonitions from a tertiary care hospital physician that it never be used in asthma because of its ineffectiveness and dangers.

The patient was transferred to a facility with expertise and resources for mechanical ventilation with the expectation that she would require these resources. IPPB with isoetharine was used, and the patient improved markedly. Blood gases returned to normal. Intubation and mechanical ventilation (other than IPPB) were not necessary.

This case clearly does not prove that IPPB is effective, but it does bring out important questions. Is IPPB effective in the treatment of acute bronchospasm? Do possible benefits outweigh risks?

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The Controversy

In 1939 Barach and Swenson[1] presented a paper on the dilating effect of positive pressure on the lumens of small and medium-sized bronchi. In 1944 Barach[2] described beneficial effects of continuous positive pressure in the treatment of asthma. In 1947 Motley et al[3] published clinical observations on the use of IPPB for the treatment of asthma and other conditions. The use of IPPB for various diseases was rapidly accepted. In 1953, however, Fowler et al[4] reported a study in which IPPB did not provide additional benefit to oxygen-generated isoproterenol aerosol for 41 patients with emphysema. He stated the controversy that continues today: "This simultaneous use of several measures causes difficulty in assessing the relative importance of the various agents in producing clinical improvement." He felt that except for one report on the treatment of severe asthmatic attacks,[5] evidence for benefit from IPPB had not been presented. In fact, the value of IPPB in chronic obstructive pulmonary disease was not substantiated by many additional studies,[6-11] and its routine use in prevention of postoperative pulmonary complications also has proven to be unjustified.[12] Evidence against the routine use of IPPB in asthma has accumulated as well.

Delivery of β-agonists with IPPB is effective in treating acute bronchospasm.[13-18] The controversy centers on whether this means of treatment offers any advantage over delivery of β-agonists via a simple nebulizer or inhaler. IPPB does involve extra expense[11] and extra risks,[19-21] and if it offers no advantage in the treatment of asthma, it obviously should not be used. The effectiveness of IPPB has been called a myth.[22] IPPB has not been shown (when compared with quiet breathing) to improve the distribution of delivery of bronchodilators,[23] as had been proposed as a mechanism of effectiveness.[24] Should, then, the use of IPPB for the treatment of asthma be abandoned?

Studies Comparing IPPB with Other Means of β-Agonist Inhalation

Studies evaluating the effectiveness of IPPB have given conflicting results. Ten published studies are outlined in Table 1. Six of these do not show IPPB to be effective. Chang and Levison[25] found IPPB to be no better than a Medihaler-Iso or simple nebulizer in improving forced expiratory volume in 1 second (FEV_1) for 15 outpatient asthmatics. Webber et al[26] noted no extra benefit for IPPB in 10 asthmatic patients. Shenfield et al[27] did not demonstrate improvement from IPPB in nine patients recovering from an acute attack, but he conceded that IPPB might have an advantage in patients in status asthmaticus. Loren et al[28] found no benefit from IPPB in 23 inpatients who went to the nurses' station for treatments when they experienced exacerbations in their asthma. Robbins[29] was critical of this study because all the children were given IPPB at 10 cm water, and the study does not refer to inspiratory volumes delivered by either method. Unless volumes are measured and treatment is individualized, he felt that IPPB could not be adequately studied and compared with other treatments. (Loren et al[28] are not alone in this deficiency.) Campbell et al[30] measured peak expiratory flow rate (PEFR) and also found no advantage for 10 inpatient asthmatics. Gupta et al[31] evaluated IPPB in 15 patients during symptom-free periods and noted no benefit. Weber et al[32] studied 16 patients with "moderately severe" asthma and found no difference in response with IPPB when compared with simple nebulization.

Three studies indicate that IPPB is effective. Choo-Kang and Grant[33] evaluated 78 patients with "chronic asthma." They found that IPPB was significantly more effective than a pressurized canister, with the superiority of IPPB greater for those with the lowest pretreatment FEV_1 values. Cayton et al[34] evaluated 10 patients with asthma within 12 hours of admission and found that slightly greater improvement was achieved by IPPB. He noted that the extra increase in FEV_1 with IPPB was slight compared with the overall bronchodilator effect produced by each method. He further felt that in practice clinicians can consider IPPB if a pressure-packed aerosol is ineffective. Webber et al[35] evaluated a total of 65 patients given albuterol by means of Rotahaler and by means of IPPB. IPPB resulted in a significant improvement in peak expiratory flow rate, regardless of whether it was given before or after albuterol was given by a different technique. It was concluded that although the benefit is small, ". . . the delivery of

Table 1. Studies Comparing IPPB With Other Methods of β-Agonist Delivery in Asthmatics

Study	Number of Patients	Description of Patients	β-Agonists	Method Compared With IPPB	Measure of Lung Function	IPPB Beneficial?
Chang & Levison[25] 1972	15	Outpatient asthmatics (8-16 years)	Isoproterenol	1. Bennett twin-jet nebulizer 2. Medihalor-Iso	FEV_1 & others	No
Webber et al[26] 1974	10	"Inpatients being treated for acute attacks of asthma"	Albuterol	1. Bird nebulizer 2. Wright's nebulizer	FEV_1	No
Shenfield et al[27] 1974	9	Patients recovering from an acute attack	Albuterol	1. Bird nebulizer 2. Wright's nebulizer	FEV_1	No
Choo-Kang & Grant[33] 1975	78	Patients with chronic asthma	Albuterol	1. Ventolin inhaler	FEV_1	Yes
Loren et al[28] 1977	23	Inpatient asthmatic children requiring treatment for exacerbations in their bronchospasm (6-16 years)	Isoproterenol	1. Freon-propelled metered-dose inhaler 2. Continuous nebulization	Peak expiratory flow rate (PEFR)	No
Campbell et al[30] 1978	10	Patients admitted in "status asthmaticus" (mean age 37 years)	Albuterol	1. Wright's nebulizer	Peak expiratory flow rate (PEFR)	No
Gupta et al[31] 1978	15	Symptom-free asthmatics (16-39 years)	Isoproterenol Albuterol	1. Bird nebulizer	FEV_1 & others	No
Cayton et al[34] 1978	10	Patients within 12 hours of admission to the hospital with "acute asthma" (mean age 43 years)	Albuterol	1. "Pressure-packed aerosol"	FEV_1	Yes
Weber et al[32] 1979	16	Patients with "moderately severe" asthma (age 19-63 years)	Terbutaline	1. Freon-propelled metered-dose aerosol 2. Compressor-powered nebulizer	FEV_1	No
Webber et al[35] 1982	65	Patients with "severe acute" asthma (16 years & older)	Albuterol	1. Rotahaler (dry powder) 2. Nebulization without IPPB	Peak expiratory flow rate (PEFR)	Yes

nebulized salbutamol via IPPB for the treatment of severe acute asthma does have advantages over the inhalation by other means."

These results are not consistent. The severity of disease varies from study to study. There is difficulty in controlling the delivered dosage precisely with IPPB, and different dosages must be given by IPPB compared with an inhaler for the same dose response.[9,36] One might conclude that IPPB offers no advantage to the asymptomatic patient[31] and those not acutely ill,[25] but that as bronchospasm becomes severe, IPPB becomes effective. This is supported by the two studies with the largest study populations.[33,35] Controversy remains, however, as not all of the data given above support this view.

Complications Associated with IPPB

Not only is IPPB expensive,[37] but there are also complications secondary to its use. Nosocomial

pulmonary infection can result from the use of inhalation therapy equipment.[38] IPPB may result in increased air "trapping"[39] and increased airway resistance.[40] Air "trapping," however, was not confirmed in other studies.[10,25] Pneumothorax and pneumomediastinum are potential problems in patients with severe asthma, but there is no proof that the incidence of barotrauma in asthmatic patients is influenced by IPPB.[41] Jorgensen et al[42] reported three cases of pneumothorax and four cases with subcutaneous and mediastinal emphysema in a review of 269 asthmatic children. Only one episode occurred in close temporal relationship to IPPB therapy. Bierman[43] reported on 16 children with pneumomediastinum and pneumothorax complicating asthma. Only four cases received IPPB; for only one case was it noted that symptoms increased markedly after IPPB, and in this case the increase occurred four hours after IPPB therapy. There were no deaths in this series. Karetzky[21,44] reported deaths in patients with acute asthma who developed pneumothorax in association with IPPB. Bierman and Pierson[20] do recommend avoidance of IPPB for fear of "inducing further bronchoconstriction and/or pneumomediastinum or pneumothorax." Asthma is associated with pneumothorax and pneumomediastinum, and there is a real possibility that IPPB may contribute to this; however, this has not been proven, and if there are risks, it appears they are small when IPPB is used properly.[35]

Factors Involved in the Effectiveness of IPPB

If IPPB is effective in severe bronchospasm, the mechanism of its effectiveness is unknown. One possibility was expressed by Choo-Kang et al,[13] who stated that patients with status asthmaticus "are often unable to inhale more than a small proportion of a single dose of aerosol from a pressurized dispenser, and this may partly account for the poor response" of these patients to bronchodilators. This idea is supported by the fact that responses in the study of Choo-Kang and Grant[33] were related to the severity of asthma, with the greatest benefit derived by those with the lowest pretreatment levels of FEV_1. Similarly Welch[41] stated "the only indication for the effective use of therapy with IPPB should be to produce a greater maximal inspiratory volume than can be spontaneously produced by the effort of the patient," and this indication may be present in severe asthma. That the aerosol deposition was better with quiet breathing than with IPPB (for patients with chronic bronchitis) in a study by Dolovich et al[23] does not necessarily pertain in severe bronchospasm.

Other factors have been proposed to account for the effectiveness of IPPB. The resting of fatigued respiratory muscles and an improvement in alveolar ventilation have been suggested.[22] In a study of patients with chronic obstructive pulmonary disease, Goldberg and Cherniack[10] remarked, "it is of interest that the airway resistance also fell, in 13 of 32 instances, following the inhalation of either saline or air." Gold[37] remarked that "many of the studies which seem to criticize IPPB therapy also demonstrate subjective improvement." Murray[45] stated that "insufficient attention has been directed toward assessment of possible psychosocial benefits of IPPB." Thus the exact factors contributing to IPPB effectiveness remain undetermined.

Conclusions

It remains to be determined what can be concluded from these conflicting data.

Studies were not found to test the efficacy of IPPB in asthma patients who are desperately ill and deteriorating in spite of other measures, but it has been stated that "the strongest case for the use of IPPB can be made in the treatment of patients with acute ventilatory failure."[46] From the data available it is clear that most acute asthma patients do not need IPPB and that its use has the drawbacks of unnecessary expense and possible complications. IPPB should then be reserved for those who are failing to respond to a management scheme that includes inhalation of a β-agonist without IPPB. For severe asthmatics failing to respond to other forms of therapy, there is enough supportive evidence to justify the use of IPPB.

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