A COMPARISON OF VENTURI AND SIDE-ARM VENTILATION IN ANAESTHESIA FOR BRONCHOSCOPY

EDWARD CARDEN, M.A., M.B., B.CHIR., F.R.C.P.(C), WALTER W. BURNS, M.D.,
NOEL B. McDEVITT, M.D., AND TED CARSON, M.D.*

EVER SINCE 1967, when Sanders published a paper¹ showing the Venturi principle for ventilating patients undergoing bronchoscopy, this technique has become increasingly popular. Many papers²⁻⁵ have been published promoting the use of the Venturi principle which in most cases entails a 16-gauge needle aimed distally down the proximal end of a bronchoscope through which a jet of oxygen is intermittently injected to produce positive pressure ventilation in the lungs (Figure 1). In 1970, a paper was published⁶ which described the use of the sidearm of the older type of Chevalier Jackson bronchoscope as a means of getting oxygen into the bronchoscope. This system was claimed to deliver higher pressures to the patient's lungs, resulting in lower CO₂ levels; and it was also claimed that it would deliver 100 per cent oxygen to the distal end of the bronchoscope (Figure 2). There has been certain skepticism in the minds of many people that this technique is superior to the use of a Venturi principle. We differentiate the two because it is claimed that the second technique described does not utilize a Venturi principle and that there is no air entrainment.

Because of this controversy a short clinical trial was undertaken to determine the relative merits of these two techniques.

METHOD

Sixteen adult patients presenting for bronchoscopy were ventilated with either the Sidearm system or the Venturi system on a random basis. For the Venturi system, the patients were bronchoscoped with a Chevalier Jackson-Hollinger type bronchoscope fitted with a Venturi oxygen injector, to which oxygen was supplied through a flow interrupter (Blowgun) from an adjustable pressure reducing valve connected to pipeline oxygen at 50 psi (this system is marketed by the Pilling Corporation) (Figure 3). The pressure reducing valve was adjusted to give the highest possible pressure (50 psi), which is the accepted technique with this system. For the Sidearm system of ventilation, old type Chevalier Jackson tapered bronchoscopes with small sidearms were used. Oxygen was supplied from the pipeline through an adjustable pressure reducing valve and a system for intermittent oxygen flow as described in the original paper⁶ (Figure 4). The pressure reducing valve was adjusted to give a pressure at the tip of the bronchoscope of

*From the Department of Anesthesiology and the Department of Surgery, University of North Carolina School of Medicine and North Carolina Memorial Hospital, Chapel Hill, North Carolina 27514, U.S.A.

FIGURE 1. Showing schematically the Venturi system for ventilation through a bronchoscope.

FIGURE 2. Showing schematically the Sidearm system for ventilation through a bronchoscope.

45 cm H₂O with all side holes closed, to conform to the accepted practice with this technique.

Age of the patients varied from 35 years to 75 years and they were bronchoscoped because some pulmonary disease was suspected. Premedication was diazepam 10 mg intramuscularly and, just prior to anaesthesia, 0.6 mg of Atropine intravenously. Following four minutes of pre-oxygenation, anaesthesia was induced with methohexital (Brevital®) intravenously in a sleep dose. The patients were then paralyzed with succinylcholine and the trachea and cords were sprayed with 4 per cent lidocaine. The bronchoscope was then passed, connected to the ventilating system and the patients were ventilated by an intermittent jet of oxygen into the bronchoscope. The patients were kept asleep with intermittent intravenous doses of methohexital and were kept paralyzed by succinylcholine in an intravenous drip consisting of one gram of succinylcholine in a 500 cc bottle of 5 per cent dextrose in 0.2 sodium chloride. During the anaesthetic the blood pressure, EKG (via telemetry),⁷ and pulse rate were constantly monitored. Our aim was to keep the arterial CO₂ level between 30 and 40 torr. Arterial blood samples were taken from the radial artery prior to pre-oxygenation and ten minutes after induction of anaesthesia and immediately analyzed on an IL Model 113 blood gas analyzer. Because much lower pressures are available from the Venturi system⁸ the method of ventilation differed in the two techniques. With the sidearm technique inspiration was long and deep, with an even longer

FIGURE 3. The Venturi ventilation system showing: A, Bronchoscope (Chevalier Jackson-Hollinger type); B, Attachment which has 16-gauge jet affixed; C, Blowgun; D, Pressure reducing valve; E, Schraeder connector.

FIGURE 4. The Sidearm system showing: A, Bronchoscope (Chevalier Jackson); B, Blowgun; C, Pressure reducing valve; D, Schraeder connector.

TABLE I
BLOOD GAS RESULTS OBTAINED FROM PATIENTS BEING VENTILATED WITH THE
VENTURI SYSTEM

Patient Age	1 JH 58	2 SB 31	3 AP 64	4 HE 48	5 DS 46	6 RP 64	7 HM 50	8 JB 26	Average
Sex	♂	♂	♂	♂	♀	♀	♀	♂	
Bronchoscope Size	8 × 40	8 × 40	8 × 40	8 × 40	7 × 40	7 × 40	7 × 40	7 × 40	
Pre Bronchoscopy									
PaO ₂ torr	47	68	70	56	94	60	65	87	68.4
PaCO ₂ torr	30	34	36	31	30	32	37	34	33
pH	7.48	7.43	7.66	7.48	7.51	7.48	7.51	7.50	
During Bronchoscopy									
PaO ₂ torr	108	80	138	62	235	140	115	86	120.5
PaCO ₂ torr	30	31	43	47	25	29	35	40	35
pH	7.45	7.39	7.38	7.21	7.54	7.45	7.49	7.48	

TABLE II
BLOOD GAS RESULTS OBTAINED FROM PATIENTS BEING VENTILATED WITH THE
SIDEARM SYSTEM

Patient Age	1 MC 15	2 RH 60	3 HI 59	4 RP 70	5 JC 43	6 CO 55	7 ES 70	8 EM 40	Average
Sex	♀	♂	♂	♂	♂	♂	♂	♂	
Bronchoscope Size	7 × 40	8 × 40	8 × 40	8 × 40	8 × 40	8 × 40	8 × 40	8 × 40	
Pre Bronchoscopy									
PaO ₂ torr	76	78	72	54	46	69	63	78	67
PaCO ₂ torr	43	36	39	30	36	36	35	47	37.75
pH	7.42	7.44	7.42	7.54	7.44	7.5	7.46	7.42	
During Bronchoscopy									
PaO ₂ torr	370	450	305	230	350	385	355	350	349
PaCO ₂ torr	35	29	37	40	33	48	37	29	36.25
pH	7.5	7.5	7.44	7.52	7.48	7.44	7.48	7.58	

expiratory pause (as with a patient undergoing endotracheal anaesthesia who is being artificially ventilated). With the Venturi system ventilation was more shallow at a much more rapid rate and usually the patient was being ventilated at the maximum allowed by this system.

RESULTS

The blood gas results from the 16 patients are displayed in Tables I and II. EKG monitoring did not demonstrate any arrhythmias during the course of bronchoscopy. There was no significant difference in blood pressure changes between the two groups.

DISCUSSION

As seen in Table I and Table II the average PaO₂ from the Sidearm technique is much higher than that from the Venturi technique, being 349 torr as compared

to 120.5 torr. The average PaCO_2 is slightly lower with the Venturi technique than with the sidearm technique. This was unexpected, since the sidearm technique delivers far more pressure to the end of the bronchoscope than the Venturi.⁸ The explanation of this interesting result is that more rapid and shallow ventilation was able to compensate for the pressure deficit in the Venturi system. One publication reporting the Venturi technique³ showed a slow rise in CO_2 levels, during operation and other authors have advocated using oxygen at pressures higher than 50 psi to make up for the lack in ventilation capacity.² We were running the Venturi system with a pressure of 50 psi distal to the reducing valve. Should we have had a patient who developed bronchospasm or one with chronic bronchitis with decreased compliance, for example, there would have been no pressure in reserve to keep alveolar ventilation normal. The Sidearm system, however, was not being used to capacity, since our aim was to keep the PaCO_2 between 30 and 40 torr. The patients were ventilated much more slowly and deeply. If the compliance had fallen, there would have been much more ventilation capacity immediately available, and even more by adjusting the pressure reducing valve, to ensure adequate ventilation of the patient.

The sidearm technique delivers much higher oxygen concentrations at higher pressures. Various objections have been leveled against the sidearm technique because these higher pressures might damage the lungs when the bronchoscope is down one bronchus, and also because the use of 100 per cent dry oxygen might cause pulmonary damage. In one institution, over 1000 bronchoscopies⁹ have been carried out with the sidearm technique over the last two years with no record of pulmonary damage resulting from this technique. It may therefore be considered that the technique is safe.

A problem associated with both of these techniques is the use of intravenous barbiturates as the anaesthetic agent. Should the bronchoscopy continue for any length of time, then the post-anaesthetic recovery period will be prolonged. It should be possible to inject nitrous oxide and oxygen mixtures down the bronchoscope, so reducing the dose of barbiturates. The whole procedure could then be carried out with less likelihood of awareness on the part of the patient. This could be done only with the sidearm technique, where there is little or no air entrainment.^{6,8} Further research along these lines is under way.¹⁰

CONCLUSION

A comparative study has been carried out on the use of the Sidearm system and Venturi system for ventilation during bronchoscopy. It has been demonstrated that the Sidearm system delivered much higher oxygen concentrations and, therefore, gave significantly higher PaO_2 levels. It also seemed that by more rapid and shallower ventilation, the lack of pressure developed by the Venturi system when connected to pipeline oxygen at 50 psi can be compensated for and arterial CO_2 levels can be kept at physiological levels, provided that patients do not have much decrease in compliance.

RÉSUMÉ

Nous avons fait une étude comparative de l'usage d'un système à embouchure de côté et d'un système de Venturi pour faire la ventilation au cours de la bronchoscopie. L'étude a montré que le système à embouchure de côté permet des taux d'oxygène beaucoup plus élevés et, en conséquence, donne des PaCO_2 élevées. Il nous semble également que, avec une ventilation plus rapide et plus superficielle, le manque de pression produit par le système Venturi branché sur la canalisation d'oxygène à 50 lb par P2 peut compenser pour des taux de CO_2 artériels voisins des taux physiologiques, à la condition que les malades ne présentent pas une compliance trop réduite.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Benson Wilcox, Professor of Cardiovascular and Thoracic Surgery, the University of North Carolina School of Medicine, for his kind assistance in allowing us to carry out these investigations on patients under his care and Mrs. Lane Harrington for her invaluable secretarial help.

REFERENCES

1. SANDERS, R.D. Two ventilating attachments for bronchoscopes. *Delaware M.J.* 39: 170 (1967).
2. SPOEREL, W.E. Ventilation through an open bronchoscope. *Canadian Anaesthetists' Society Journal* 16: 61 (1969).
3. MORALES, G.A., *et al.* Ventilation during general anesthesia for bronchoscopy. *Journal of Thoracic and Cardiovascular Surgery* 57: 873 (1969).
4. FULLER, W.R., DAVIES, D.M., & STRADLING, P. Anaesthesia for bronchoscopy prolonged by teaching and photography. *Anaesthesia* 27: 292 (1972).
5. BETHUNE, D.W., COLLIS, J.M., BURBRIDGE, N.J., & FORSTER, D.M. Bronchoscope injectors. A design for use with pipeline oxygen supplies. *Anaesthesia* 27: 81 (1972).
6. CARDEN, E., *et al.* A ventilation system for patients undergoing bronchoscopy. *Anesthesiology* 33: 454 (1970).
7. DAVIS, D.A. & THORNTON, W.E. Radiotelemetry in anesthesia and surgery. *Int. Anesthesia Clinics* 3: 535-545 (May 1965).
8. CARDEN, E. Positive pressure ventilation during anesthesia for bronchoscopy. *Anesthesia and Analgesia*. In Press.
9. OULTON, J. Personal communication (1972).
10. CARDEN, E. & SCHWESINGER, W. "Further Advances in Bronchoscopic Anesthesia." *Anesthesiology*. In Press.