This case illustrates the need to determine preoperatively the cause of severe hypertension that is untreated or inadequately treated. In a recent study[1] of cardiac arrest in the operating area, 50 per cent of the arrests were in patients who were hypertensive, and 10 of the 12 having an arrest had not received treatment for their hypertension. Certainly, in the case of a hypertensive patient who has had cardiac arrest or a hypertensive crisis during a previous induction of anesthesia, the cause of the hypertension must be sought. In these cases, pheochromocytoma should be considered a possibility and should be specifically ruled out. Although the yield of pheochromocytoma screening procedures applied to all hypertensive patients is less than 1 per cent,[4] preoperative preparation including α- and β-adrenergic receptor blockade in patients with pheochromocytoma decreases the intraoperative incidence of acute increases in blood pressure, arrhythmia, and cardiac arrest.[5]

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A Device to Measure Closing Capacity with Positive Pressure

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Measurement of closing capacity (CC) and its relationship to functional residual capacity (FRC) have important implications with regard to pulmonary gas exchange.[1] Closing capacity can be determined only in subjects capable of consciously cooperating with the ventilatory maneuvers involved.[2] Since airway closure may frequently occur in anesthetized or comatose subjects, the measurement of closing capacity may be of value in their evaluation.

In this paper we describe the construction and use of a 5-liter syringe to allow controlled ventilation duplicating the spontaneous ventilatory maneuvers required to measure closing capacity. Results are compared with values obtained during voluntary performance of the standard nitrogen method for measurement of closing capacity.[3]

Procedure

We constructed a 5-liter syringe (fig. 1) using a ⅛-inch brass cylinder 4 inches in internal diameter and a hand-driven reciprocating Teflon-sealed piston. The position of the piston and thus volume within the syringe was determined by a rack mounted on a connecting rod which drove a pinion gear attached to a potentiometer. Volume per unit of piston movement was calibrated with a 9-liter Collins spirometer.

We studied seven unmedicated healthy subjects with no evidence of pulmonary disease by history, physical examination, or chest roentgenogram. Vital capacities and forced expiratory volumes in one second were

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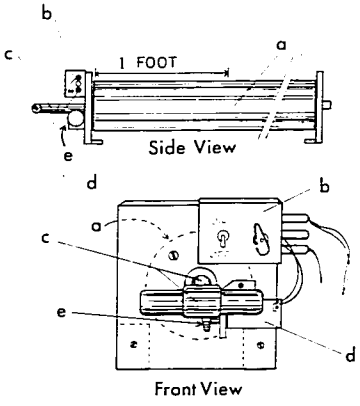

FIG. 1. *a*, five-liter syringe; *b*, voltage regulator; *c*, rack; *d*, potentiometer; *e*, pinion gear. Movement of the piston causes the rack to turn the pinion gear, varying the voltage output of the potentiometer. The voltage regulator allows adjustment of the electrical signal to the desired output.

normal. Ages of the subjects ranged from 26 to 65 years (mean 40.3 ± 9.0 SD years). All subjects were supine when studied.

We measured closing capacity using the standard nitrogen technique[3] except that inhalation of the test gas started from FRC instead of residual volume. We determined closing capacity in each subject in triplicate under three different conditions. In the first, the subject breathed room air, test gas oxygen. In the second, the subject breathed oxygen (expired nitrogen < 2 per cent), test gas air. Then, using each subject's previously determined inspiratory capacity and expiratory reserve volume, we used the 5-liter syringe to perform the ventilatory maneuvers necessary to measure closing capacity. The test gas was air as the subjects breathed oxygen (expired nitrogen < 2 per cent). To perform this test we used the syringe to inflate the subject's lungs from FRC to total lung capacity and then withdrew gas until near residual volume. FRC was determined in triplicate by helium dilution and used to calculate closing capacity by the following formula:

TABLE 1. Closing Capacity and Functional Residual Capacity for Each Subject*

	Closing Capacity (ml)					Functional Residual Capacity (ml)
	Spontaneous Ventilation			Five-liter Syringe		
		Air		Air		
	Oxygen Test 1 (Control)	Test 2	Per Cent of Control	Test 3	Per Cent of Control	
Subject 1	2,883 ± 66	2,964 ± 135	102.8	2,893 ± 176	100.3	2,470 ± 24
Subject 2	2,230 ± 166	2,300 ± 113	103.1	2,277 ± 75	102.1	1,889 ± 30
Subject 3	3,533 ± 167	3,488 ± 110	98.7	3,512 ± 122	99.4	3,400 ± 19
Subject 4	2,332 ± 64	2,110 ± 136	90.5	1,770 ± 122	75.9	2,530 ± 34
Subject 5	3,015 ± 145	3,052 ± 158	101.2	2,784 ± 46	92.3	2,332 ± 22
Subject 6	2,483 ± 101	2,546 ± 115	102.6	2,586 ± 64	104.2	2,520 ± 44
Subject 7	2,876 ± 68	3,150 ± 152	109.5	2,870 ± 112	99.8	2,002 ± 10
MEAN	2,765 ± 171	2,801 ± 188	101.2 ± 5.7	2,670 ± 206	96.3 ± 9.7	2,449 ± 185

* Each value is the mean of three measurements ± SD.

CC = FRC − (volume from FRC to III–IV inflection expired nitrogen curve)

Results and Discussion

It proved easy to perform the ventilatory maneuvers with the 5-liter syringe, and the awake subjects tolerated the inflation and deflation maneuvers without complaint. Inspiratory and expiratory flow rates could be controlled at desired levels, and crisp III–IV nitrogen inflections were consistently observed. There was no significant difference in closing capacities determined by the three tests (table 1). This does not mean, however, that positive-pressure inflation might not affect the measurement of closing capacity. Our subjects were awake and tended to assist inspiration, which minimized pressure applied to their airways.

In the standard protocol for measurement of closing capacity subjects breathe room air and then inspire oxygen (test gas) from residual volume to total lung capacity.[3] We elected to have our subjects inhale the test gas, or have their lungs inflated, from FRC, considering that in patients whose ventilation is controlled FRC is an easily obtained and identified lung volume. Modification of the standard protocol, *i.e.*, starting at FRC not residual volume, was suggested by Mansell *et al.*,[4] who found that addition of an air-filled deadspace, expiratory reserve volume sharpened the III–IV point of nitrogen inflection.

In addition, we studied the results of using room air as the test gas, after the subject was denitrogenated by oxygen breathing. We considered that in comatose or anesthetized patients breathing high concentrations of oxygen, the use of room air as the test gas might be advantageous. The two test gases produced similar results (table 1).

We suggest that in using this method for measuring closing capacity in man suitable pressure valves be installed to prevent any unwanted pressure from being applied to the airway.

We have described a method for measuring closing capacity in unconscious subjects and in those unable to control their ventilatory patterns. There was no significant difference between closing capacities measured during conscious spontaneous breathing and during controlled positive–negative-pressure ventilation using this method.

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Defective Disposable Oxygen Face Masks

David H. Sprague, M.D.*

This communication reports three incidents in which manufacturing defects or poor design of disposable oxygen face masks led to potentially lethal problems when humidified, oxygen-enriched gases were being administered to patients in the recovery room and intensive care unit.

Report of Three Cases

Patient 1. A 69-year-old, edentulous man in good health underwent an inguinal herniorrhaphy. Anesthesia with thiopental, meperidine, and nitrous oxide was supplemented with pancuronium for muscle relaxation. At the conclusion of the operation, the patient was taken to the recovery room in a conscious but sedated state. A disposable,

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