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A New Disposable Spirometer

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The devices currently available for measur-
ing vital capacity (V_c) and minute ventilation
(V_E) usually suffer from one or more major
deficiencies. These include: 1) cost; 2) fra-
gility; 3) flow dependence; 4) lack of porta-
bility; 5) possibility for bacterial cross-con-
tamination between patients. Recently, a dis-
posable spirometer that appears to eliminate
all of these deficiencies has become available.[*]
This report assesses the accuracy and precision
of this new device for measuring vital capacity
and minute ventilation.

DESCRIPTION OF THE DISPOSABLE SPIROMETER

Figure 1 is a schematic diagram of the dis-
posable spirometer. The device consists of a
flexible 3-liter polyethylene bag calibrated in
25-ml increments. The bag is attached to a
rigid polyethylene T tube which can be either
used directly as a mouthpiece or attached to
standard 15-mm anesthesia fittings.

METHOD OF USE

Measuring Vital Capacity. The patient
breathes normally through the rigid tube while
the bag entrance port is occluded with the
operator's finger.[†] On command, a maximum
inhalation is taken. The operator removes his
finger from the bag entrance port and oc-
cludes the exhaust end of the T tube. The
patient then exhales maximally into the cali-
brated bag. When the exhalation is com-
pleted, the bag entrance port is again closed
with the operator's finger.

To measure the exhaled volume, the device
is placed on a flat surface. Using the heel of
the hand, the operator displaces the volume
of gas distally (away from the rigid tube)
until the bag lifts upward from the surface.
When this lift produces an angle of 30 degrees
between the flat surface and the bag, the vol-
ume is read directly from a scale printed on
the bag (fig. 2).

Measurement of Minute Ventilation. For a
patient on a ventilator, V_E is measured by at-
taching the device to the exhalation line of the
ventilator and measuring the volume of three
breaths. Respiratory frequency is recorded
simultaneously. V_E is then determined using

Bag Entrance Port   Rigid Tube

Room

Exhaust Port

15 mm I.D.

From Patient

— 3000
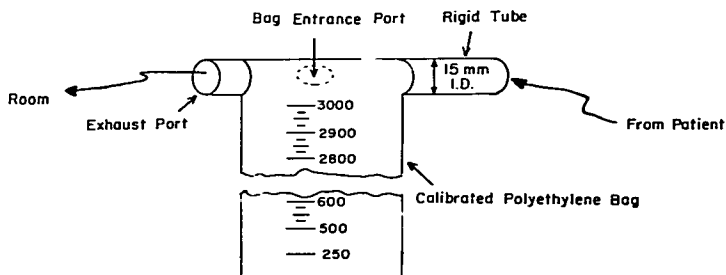— 2900
— 2800

Calibrated Polyethylene Bag

— 600
— 500
— 250

Fic. 1.   Schematic of the disposable spirometer.

these two values and the nomograph printed directly on the bag (fig. 3). For V_E determination in a patient breathing spontaneously, a nonrebreathing valve must be used between the patient and the spirometer to provide unidirectional gas flow into the spirometer.

METHODS

Vital Capacity Measurements. A disposable spirometer and a Wright respirometer were connected in series to a 2-liter giant syringe. Gas volumes were delivered by the giant syringe in four volume ranges (250, 500, 1,000,

and 1,500 ml). Within each range, volumes were varied randomly by ±20 per cent. Flow rates varied from 3.75 l/min to 60 l/min. A total of 70 measurements was made. Two independent observers determined the volume of gas in the disposable spirometer to the nearest 25 ml using the technique previously described. These observers were unaware of the actual volume of gas delivered from the giant syringe and were unaware of each other's readings.

Minute Ventilation Measurements. The disposable spirometer and the Wright respirome-

Fig. 2. Method of measurement using disposable spirometer.
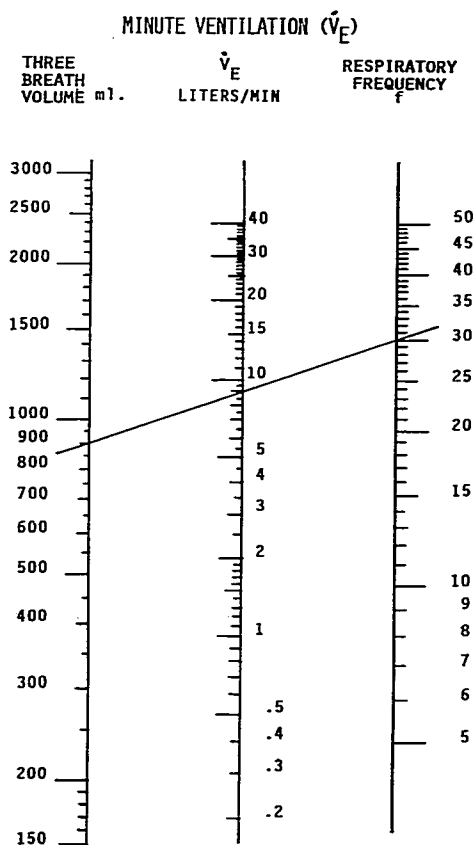
MINUTE VENTILATION ($\dot{V}_E$)
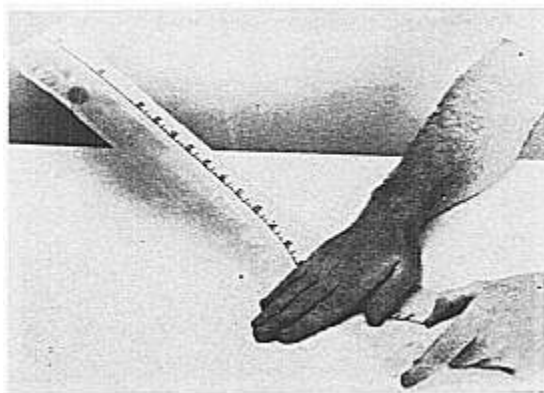
FIG. 3. Nomograph for converting three-breath volume and respiratory rate into $\dot{V}_E$. Example: A 900-ml three-breath volume with a respiratory frequency of 30 equals a $\dot{V}_E$ of 9 l/min.

TABLE 1. Regression Equations and Correlation Coefficients for V_E Data vs. Giant-syringe Volumes

Instrument	Regression Equation	Correlation Coefficient
Disposable spirometer	y = 0.9870 X +4.6615	r = 0.9985
Wright respirometer	y = 1.079 X +17.888	r = 0.9901

TABLE 2. Regression Equations and Correlation Coefficients for V_E data vs. Collins Spirometer Measurements

Instrument	Regression Equation	Correlation Coefficient
Disposable spirometer	y = 0.9215 X +0.4767	r = 0.9968
Wright respirometer	y = 1.1243 X −0.4980	r = 0.9938

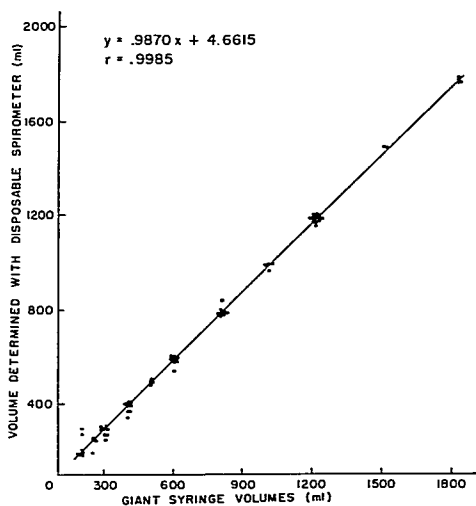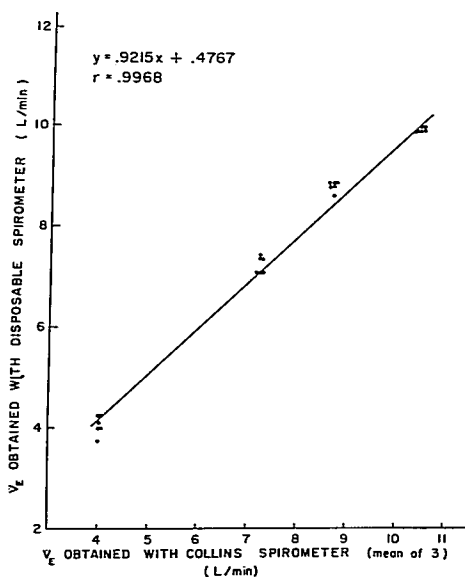FIG. 4. Regression of disposable spirometer V_e data vs. giant-syringe measurements.

$$y = .9870 x + 4.6615$$
$$r = .9985$$

FIG. 5. Regression of disposable spirometer V_E data vs. Collins spirometer measurements.

$$y = .9215x + .4767$$
$$r = .9968$$

ter were again connected in series and at-
tached to the exhaust tubing of a Bennett
MA-1 mechanical ventilator. Six measure-
ments of V_E were made with this system at
four different delivered volumes. The output
of the ventilator was calibrated before, dur-
ing, and after each series of measurements
using a Collins spirometer.

RESULTS

Vital Capacity Measurements. Regression
equations and correlation coefficients for the
disposable spirometer V_c data (one observer)
and Wright respirometer V_c data *vs.* the de-
livered giant-syringe volumes are presented in
table 1. Figure 4 is a plot of the disposable
spirometer data. There was good agreement
between the two independent observers who
measured the volumes of gas in the dis-
posable spirometer (correlation coefficient =
0.998). The accuracy of the disposable spi-
rometer compared quite favorably with that
of the Wright respirometer at all delivered
volumes and flow rates. Moreover, the Wright
respirometer was notably flow-dependent,
while the disposable spirometer was not.

Minute Ventilation Measurements. Regres-
sion equations and correlation coefficients for

the disposable spirometer V_E data and the
Wright respirometer V_E data *vs.* Collins spi-
rometer measurements are presented in table
2. Figure 5 is a plot of the disposable spi-
rometer data. Again, the results were at least
as accurate with the disposable device as with
the Wright respirometer.

DISCUSSION

On the basis of the above data, it is ap-
parent that accuracy of the disposable Boeh-
ringer spirometer is more than adequate for
clinical needs. The new device has the dura-
bility to be used over the entire hospital
course of any given patient. The only obvi-
ous disadvantages of the disposable spirome-
ter are: 1) a nonbreathing valve is needed
for V_E determinations in a patient who is
breathing spontaneously; 2) V_E is not read
directly but must be calculated via nomogram
from three tidal volumes plus the respiratory
rate. (A nomogram for calculating V_E from
ten tidal volumes is also available for pedi-
atric use.) However, the cost advantages of
the new device, its independence of flow rate,
and its elimination of cross-contamination haz-
ards make it an attractive clinical tool for pa-
tients who need intensive respiratory care.

Comparison of the Ventilating and Injection Bronchoscopes

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This study compares mechanical ventilation
with the ventilating bronchoscope and with
the injection bronchoscope during operative
bronchoscopy in anesthetized, fully-relaxed
patients with regard to: 1) adequacy of pul-
monary ventilation; 2) pulse and blood-pres-
sure changes; 3) time necessary for bronchos-
copy; 4) acceptance by the surgeon and anes-
thesiologist.

METHODS

Forty-two adult patients were selected for
the study after having given permission for