Unit 15
Manual Resuscitators

GOAL

On completion of this unit, the student should comprehend the proper operation of self-inflating resuscitation bags, flow-inflating resuscitation bags and gas-powered demand valves.

COMPETENCIES

1. Identify parts of manual resuscitators:
2. Disassemble and reassemble the bags for use.
3. Assess which bags allow for spontaneous breathing.
4. Measure the attainable volumes with both the one- and two-hand compression technique.
5. Analyze the oxygen concentrations delivered when changing the following parameters:
   a. refill time
   b. respiratory frequency
   c. stroke volume
   d. oxygen reservoir size
6. Perform artificial ventilation with self-inflating resuscitation bags, flow-inflating resuscitation bags and gas-powered demand valves, attached to an endotracheal tube on a mannequin.
7. Perform artificial ventilation with self-inflating resuscitation bags, flow-inflating resuscitation bags and gas-powered demand valves on a non-intubated mannequin.

EQUIPMENT

1. manual resuscitator bags with masks (adult, pediatric and infant)
2. test lung
3. oxygen analyzer with adaptors
4. airway pressure manometer
5. 50 psi oxygen source
6. respirometer
7. flowmeter
8. chronometer
9. ventilation manikin
10. flow-inflating resuscitator
11. gas-powered resuscitator

EXERCISE A - RESUSCITATOR COMPONENTS

1. Connect each bag to a test lung.
2. Deliver several ventilations to the test lung and observe the bag parts for movement either during the compression (patient-inspiration) phase or re-inflation (patient-expiration) phase. Identify the following parts of a self-inflating manual resuscitator:
   a. patient connection
d. exhalation port
   b. patient valve
e. oxygen reservoir (if applicable)
c. bag inlet valve
f. oxygen demand valve (if applicable)
   1) air entrainment ports
g. PEEP device (if applicable)
   2) oxygen-inlet connection
3. Be sure you can name the type of patient valve in each bag (see diagram). Compare the route of airflow through each type of valve.

**MANUAL RESUSCITATOR VALVES**

**DIAPHRAGM (LEAF) VALVE**

**SPRING AND DISK VALVE**

**DUCK BILL VALVE**
Thought questions:
  a. Compare the self-inflating bags to the flow-inflating bags. What similarities and differences do you note?

EXERCISE B - VOLUME MEASUREMENT

1. Obtain a respirometer.

WARNING: These volume measuring devices are delicate and VERY expensive. High flow rates can damage the internal mechanisms. Under NO circumstance should you forcefully exhale through one of these devices.

2. Connect the respirometer to the patient connector of an adult manual resuscitator that has a pressure manometer in-line. There should be no leaks at the connection point.
3. Using both hands, compress the bag in one smooth easy motion. Zero the respirometer and repeat the measurement several times. Record the average volume delivered and the peak inspiratory pressure (PIP) attained with one compression.
4. Repeat step #3, using only one hand to compress the bag.
5. Repeat steps #2 to 4 with 2 other adult resuscitators.

<table>
<thead>
<tr>
<th>Bag</th>
<th>1-hand volume</th>
<th>1-hand PIP</th>
<th>2-hand volume</th>
<th>2-hand PIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
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<td>2.</td>
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<td>3.</td>
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Thought questions
  a. How much volume variation do you observe with the following:
    1) each different bag?  2) 1-hand vs. 2-hand technique?
b. Under what clinical conditions might one-hand compression be necessary?

c. What types of pressures are generated with the different bags? Are they safe pressures?

EXERCISE C - FIO2 DELIVERED vs. LITER FLOW

1. Obtain an oxygen analyzer with a continuous monitoring adaptor, a test lung, and an oxygen source.
2. Connect the oxygen source to an adult resuscitator bag using small-bore oxygen tubing.
3. Connect the oxygen analyzer to the patient connection port of the resuscitator using the continuous monitoring adaptor. Connect the test lung to the other end of the analyzer adaptor.
4. Measure the oxygen concentration delivered with 3 different adult resuscitator bags of the same size.
   a. Set the flowmeter at 5 L/min.
   b. Compress the bag at a rate of 12 breaths per minute (once every 5 seconds).
5. After compression, release the bag and allow it to refill by its own elastic recoil. It is important that you NOT restrict the expansion of the bag by maintaining pressure on it with your hands.
6. Repeat step #4, using liter flows of 10 and 15 L/min. Plot your data on the following graph. Connect the points on the graph and label the line with the name of the resuscitator.

EXERCISE D - FIO2 DELIVERED vs. BAG REFILL TIME

1. Measure the oxygen concentration delivered with the same adult resuscitator bags and the same method as in the previous exercise. However, this time, make the following adjustments:
a. Set the flowmeter at 10 L/min.
b. Maintain a ventilation rate of 12 breaths per minute (1 breath every 5 sec.)
c. Restrict the re-expansion of the bags with your hands. The bags should expand slowly enough so that it refills just in time to give the next breath.

2. Record your results in the chart below:

<table>
<thead>
<tr>
<th>Bag: _____________________________</th>
<th>F_O2: __________</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
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<tr>
<td>2.</td>
<td></td>
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<td>3.</td>
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Thought questions

a. Compare the results of Exercise C (liter flow changed) with those at the same flow rate in Exercise D (restricted and unrestricted refill). Are there any differences? If so, why?

b. Were there any significant changes in the different resuscitator bags?

c. Which liter flow in Exercise C and which refill time in Exercise D is the optimal in a clinical resuscitation situation?

EXERCISE E - FIO2 DELIVERED vs. COMPRESSION RATE

1. Measure the oxygen concentration delivered with 3 different adult manual resuscitators as in the previous two exercises. However, in this exercise, make the following adjustments:
   a. Set the flowmeter at 10 L/min.
   b. Do not restrict the re-expansion of the bags.
   c. Compress the bags at a rate of once every 6 seconds (10 BPM), and record the results below.
   d. Compress the bags at a rate of once every 3 seconds (20 BPM), and record the results below.

<table>
<thead>
<tr>
<th>Bag: _____________________________</th>
<th>10 BPM</th>
<th>20 BPM</th>
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<tbody>
<tr>
<td>1.</td>
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Thought question
   a. Are there any differences in oxygen concentrations at varying rates? If so, why?

EXERCISE F - FIO2 DELIVERED vs. RESERVOIR SIZE

1. Repeat steps #1 to 3 of Exercise C using 2 different adult resuscitators.
2. Obtain several lengths of wide-bore tubing. Use lengths of 200, 600, and 800 ml.
3. Connect the 200 ml section to the large connector on the tail of the bag.
4. Compress the bag at a steady rate (once every 5 sec.) and analyze the delivered concentration of oxygen when the flow rate of oxygen is 10 and 15 L/min.
5. Repeat steps #3 and 4, using the 600 and 800 ml sections.
6. Record your observations in the space below.

   \[ F_O^2 \text{w/200 ml at 10 L/min: } \_ \_ \_ \_ \_ \text{ } 15 \text{ L/min: } \_ \_ \_ \_ \_ \]

   \[ F_O^2 \text{w/600 ml at 10 L/min: } \_ \_ \_ \_ \_ \text{ } 15 \text{ L/min: } \_ \_ \_ \_ \_ \]

   \[ F_O^2 \text{w/800 ml at 10 L/min: } \_ \_ \_ \_ \_ \text{ } 15 \text{ L/min: } \_ \_ \_ \_ \_ \]

Thought question
   a. What is the function of the wide-bore tubing?

EXERCISE G - ARTIFICIAL VENTILATION TECHNIQUE

1. Select a laboratory partner on whom you will perform artificial ventilation with a bag and mask.
2. Ask your partner to lie on a flat surface in a supine position.
3. Position yourself at your partner’s head and perform the “head tilt” maneuver to open the upper airway.
4. Place the mask of a resuscitator bag over the nose and mouth of your partner. To tightly seal the mask against the face with one hand, your fingertips should be along the lower edge of the jaw line and the thumb placed on the mask near the bridge of the nose.
5. Making sure that the mask is tightly sealed, ask your partner to inhale several times. Carefully observe the bag for any response to your partner’s inspiratory efforts. Note particularly whether the valve opens in response to your partner’s effort.
6. Now perform steps #3 and 4 using a manikin. Manually ventilate the manikin for several breaths being careful to maintain a proper seal between the mask and face.
7. Change places with your partner and repeat steps #2 through 6.
Thought questions
  a. From which of the bags was it easy to breathe spontaneously?

  a. Did you have any problems creating a seal with the mask? If so, why?
WORKSHEET

1. Which resuscitator delivered the largest volume with the one-handed compression technique?

   What was this volume? ________________________________

2. Which resuscitator delivered the largest volume with the two-handed compression technique?

   What volume was delivered? __________________________

3. What will be the effect on the delivered FIO₂ when:
   a. the oxygen liter flow is increased? Why?
   b. the refill time of the bag is restricted? Why?
   c. the compression rate is increased? Why?

4. Identify 4 ways to increase FIO₂ delivered by a manual resuscitator.
5. What additional technique could be used to improve the patient’s PaO₂ during manual ventilation?

6. What are the complications of manual ventilation?

7. How can you assess the adequacy of manual ventilation?