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apparatus and techniques

Pocket mask for emergency artificial ventilation and oxygen inhalation

PETER SAFAR, MD

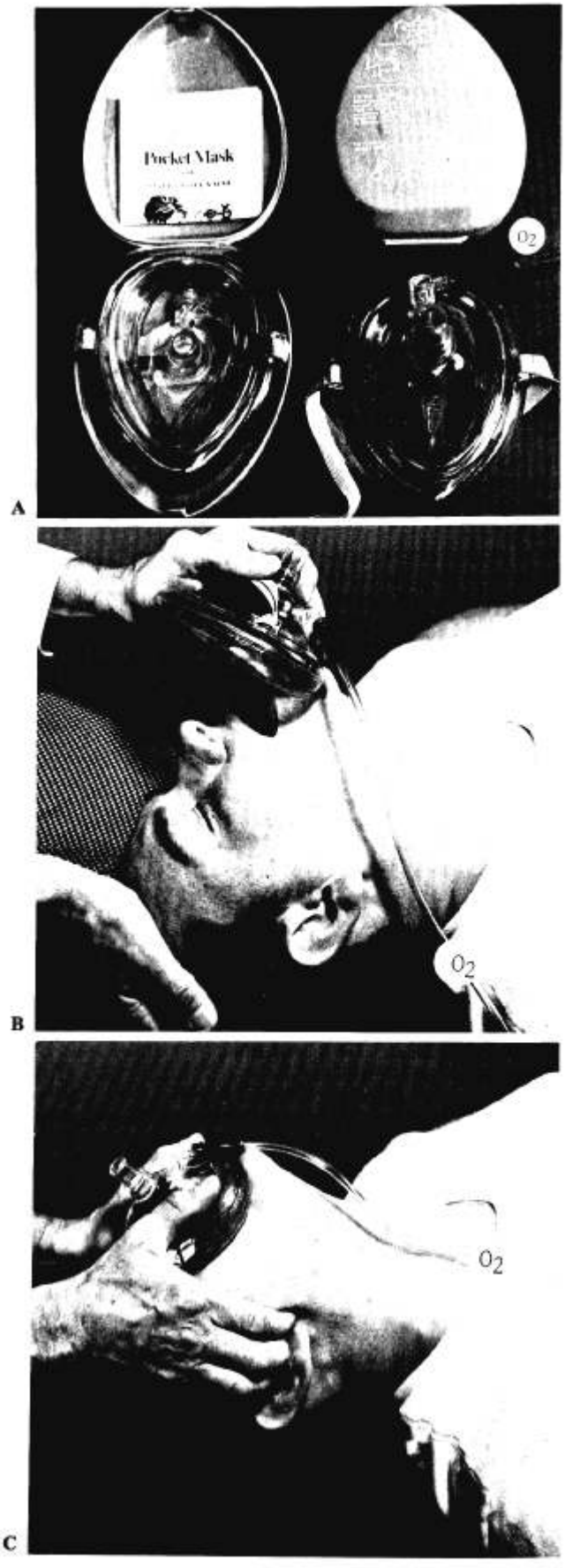
Adjuncts to mouth-to-mouth ventilation were introduced in the 1950s to overcome public objection to oral contact with strangers.[1,2] One of the better adjuncts available today is the Laerdal Pocket Mask.* It is transparent to allow observation of cyanosis, vomiting, and clouding with exhalations. It is designed with a cushioned rim to provide a fairly firm and comfortable mask fit for patients of all ages. For infants it is applied upside down, covering the entire face, with the nose part over the chin.

Most patients in need of resuscitation have abnormal lungs, and thus require oxygen enrichment of inhaled air. The self-refilling bag-valve-mask unit[3] permits oxygen enrichment, but its use leaves only one hand of the operator free to hold the head tilted backward and provide a tight mask fit. Holding the mask with one hand tends to close the mouth of the patient. Since there is nasal obstruction in about one-third of unconscious patients[4] an oropharyngeal tube is often necessary, but its use may provoke laryngospasm and vomiting when there is no areflexia. Without the use of a pharyngeal tube, both hands are needed to provide the "ideal" non-cannulating "triple airway maneuver" (backward tilt of the head, plus forward displacement of the mandible, plus opening of the mouth[4-6]). This is possible during mouth-to-mask, but not with bag-to-mask artificial ventilation.[7]

We have therefore modified the Laerdal Pocket Mask as follows *(Fig. 1A)*: (a) a nipple with a one-way valve to prevent leakage during exhaled air ventilation was added for optional continuous insufflation of oxygen; (b) a head strap was attached to obviate the need to reapply the mask during cardiopulmonary resuscitation by one operator and to permit spontaneous inhalation of oxygen without the operator having to hold the

Department of Anesthesiology and Critical Care Medicine Program, University of Pittsburgh School of Medicine and Health Center Hospitals, Pittsburgh, Pennsylvania 15261

* Laerdal Medical Corp., Stavanger, Norway; and 1 Labriola Court, Armonk, New York 10504.



mask; and (c) a 15 mm male adaptor was attached to the breathing port, so that the mask can be used either for exhaled air ventilation or for attachment of resuscitation, respiratory care, and anesthesia equipment. Its use is illustrated in Figures 1B and 1C.

The fraction of oxygen in inspired gas (F_{IO_2}) obtained with various continuous flow rates of O_2 through the nipple can be predicted. One pilot test with *mouth-to-mask artificial ventilation (Table 1)* confirmed that F_{IO_2} may range from 18% when using exhaled air only, to 100% with an O_2 inflow rate of 30 L/min and intermittent occlusion of the mask port without blowing. Such a high flow is not practical with use of portable O_2 cylinders, but feasible in ambulances equipped with large O_2 cylinders. Only experienced personnel should use mask port occlusion because there is no pressure release valve. Between these extremes, F_{IO_2} depends upon the mixture of exhaled air and O_2. With an inflow rate of 10 L/min and mouth-to-mask inflations of one liter at a rate of 12 per minute, an F_{IO_2} of about 50% can be expected. During exhaled air ventilation, P_{ACO_2} values in the apneic "victim" can be maintained near normal over long periods, while the operator acquires moderate hypocarbia without dizziness.[1,8]

Emergency artificial ventilation should not be delayed by waiting for oxygen, but if oxygen is immediately available it speeds reoxygenation. For example, in a conscious volunteer holding his breath to a P_{AO_2} of 50 torr, arterial blood samplings revealed that five exhaled air ventilations of 1 liter each in 50 seconds increased P_{AO_2} to 75 torr and only three inflations with 100% oxygen in 30 seconds were required to increase P_{AO_2} to over 100 torr.

Fig. 1—Exhaled air emergency artificial ventilation via modified Laerdal Pocket Mask using the "triple airway maneuver" (backward tilt of head, plus forward displacement of mandible, plus opening of mouth) for emergency airway control. **(A)** Pocket mask, folded up (*left*) and ready for use (*right*). **(B)** Approach patient from vertex. Tilt his head backward. Open his mouth by retracting lower lip and apply rim of mask over chin. **(C)** apply mask to face by spreading and "clamping" with both thumbs (thenar eminences), while grasping ascending rami of the mandible in front of ear lobes with second, third and fourth fingers of both hands. Pull forcefully upward so that lower teeth are in front of upper teeth. Take care not to shut patient's mouth under the mask. Take a deep breath, blow into the mask until patient's chest rises, remove your mouth and allow patient to exhale passively. Repeat inflations every 3-5 seconds in an adult, every 2 seconds in a child. *In infants and small children, apply mask upside down covering entire face; use only puffs of air.* After about four deep lung inflations, feel for carotid pulse (not longer than 10 seconds). If there is no pulse, start external heart compressions. Alternate 15 heart compressions and two quick lung inflations. For heart-lung resuscitation, strap mask to face and work from one side of patient. When oxygen is available, deliver it via mask nipple at highest flow considered feasible and economical; ie, 10L/min.

Table 1: Mouth-to-mask/oxygen emergency artificial ventilation. Results in one conscious, nonbreathing, adult volunteer.

VT ≈ 1 liter** *Type of Ventilation 5 Minutes Each*	f = 12/min FIO_2*	PaO_2	$PaCO_2$
Spontaneous respiratory control	21	85	27
Mouth-Mask O_2 zero	18	90	32
Mouth-Mask O_2 5 L/min	40	149	30
Mouth-Mask O_2 10 L/min	50	220	29
Mouth-Mask O_2 15 L/min	54	225	27
Intermittent mask occulsion O_2 30 L/min	98	475	21

* Paramagnetic O_2 analyzer. Gas samples manually drawn during inhalations from under mask, between mouth and nose.
** Ventilation meter at mask port.

Personnel not trained in anesthesia can ventilate manikins and anesthetized patients more easily with the mouth-to-mask technique than with the bag-valve-mask technique, since the former provides larger inflation volumes to overcome leakage and leaves both hands free for airway support and mask fit.[7,9,10] In teaching tests, over 300 medical students easily performed mouth-to-mask artificial ventilation on anesthetized patients and manikins, but they required special coaching of how to grasp the ascending rami of the mandible above its angles *(Fig. 1C)* in order to accomplish the triple airway maneuver.

During *spontaneous breathing* through the mask port, FIO_2 depends on mixing the flows of the air inhaled by the patient and the oxygen flow delivered. The FIO_2 values with the use of a conventional semi-open plastic, disposable, valveless bag mask-O_2 unit compare favorably with those with the pocket mask *(Table 2)*. However, the conventional bag mask-O_2 unit cannot be used for artificial ventilation. The principle of the modified pocket mask is that of the Ayre's T or Y piece.[11]

For spontaneous inhalation of 100% oxygen we are using a non-rebreathing valve-reservoir bag assembly** attached to the breathing port of the pocket mask, with the O_2 nipple plugged. A positive end-expiratory pressure valve (PEEP valve)*** attached to the expiratory port of the nonrebreathing valve permits spontaneous breathing of oxygen with expiratory positive airway pressure (EPAP). The same valve is used for spontaneous breathing with continuous positive airway pressure (CPAP), but the oxygen inflow must exceed peak inspiratory flow rate; ie, 25 L/min.[12] For EPAP or CPAP, both indicated in hypoxemia from alveolar disease (eg, pulmonary edema), an airway pressure gauge is also attached near the mask port. The cushion rim and head strap provide a sufficient seal for airway pressures of up to 5 cm H_2O without holding the mask.

** Instrumentation Industries, Inc., 215 Thomas Drive, Pittsburgh, PA 15236.
*** Boehringer Lab, Box 18, Wynnewood, PA 19096; or the Emerson Company, 22 Cottage Park Avenue, Cambridge, MA 02140.

Table 2: Spontaneous inhalation of oxygen. Results in one conscious adult volunteer

	FIO_2 *values** *Laerdal Pocket Mask Port Open To Air*		FIO_2 *values** *Conventional Valveless Oronasal O_2 Mask With Leaks and Bag*	
O_2 Flow Into Mask Nipple	*Quiet Breathing*	*Hyper-ventilation*	*Quiet Breathing*	*Hyper-ventilation*
Zero (air)	21	21	21	21
5 L/min	50	30	62	38
10 L/min	68	48	72	42
15 L/min	80	48	80	50
30 L/min	90	60	—	—
Non-rebreathing valve-bag on mask port	100	100	—	—

* Paramagnetic O_2 analyzer. Gas samples manually drawn during inhalation from under mask, between mouth and nose.

CONCLUSIONS

The modified Laerdal pocket mask is a simple, versatile device for artificial ventilation with exhaled air and oxygen and for spontaneous oxygen inhalation without need for a pharyngeal tube. It allows for the freedom of the operator's hands for the "triple airway maneuver." Moreover, it permits attachment of respiratory care apparatus. This pocket mask seems particularly valuable for utilization by pre-hospital emergency care personnel such as police, fire, lifeguards and emergency medical technicians.

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