

Chapter 6

The Heart-Lung Resuscitator (HLR)

Heart-Lung Resuscitators (cardiopulmonary resuscitators) provide for both artificial ventilation via a mechanical respirator and sternal compression via a pneumatically powered piston. Two models are currently in use by Alcor, the Brunswick *HLR 50-90* and the Michigan Instruments *Thumper* (and related units). This chapter will cover operating instructions in detail for the Brunswick unit. Please see the following chapter (*Chapter 6A*) for operating instructions for the Michigan Instruments machines.

Heart-lung resuscitators are utilized in the transport of cryonic suspension patients because manual cardiac compression and bag-valve ventilation lead to rapid exhaustion of personnel. Manual CPR, which is not optimum to begin with, will rapidly deteriorate as operator fatigue sets in. The very long periods (4 to 8 hrs.; perhaps less than 4 hours with use of the Portable Ice Bath (PIB)--see *Chapter 8*) of HLR support required to reduce patient core temperature to a safe level (10°C) necessitate the use of a mechanical device.

Once a stable, patent airway has been achieved, the patient may be positioned on the Brunswick HLR backboard and mechanical CPR may be begun using the HLR. Once the HLR has been installed and is administering chest compressions, the mask, endotracheal tube, or esophageal airway mask may be connected to the ventilator on the HLR and bag-valve ventilation may be discontinued.

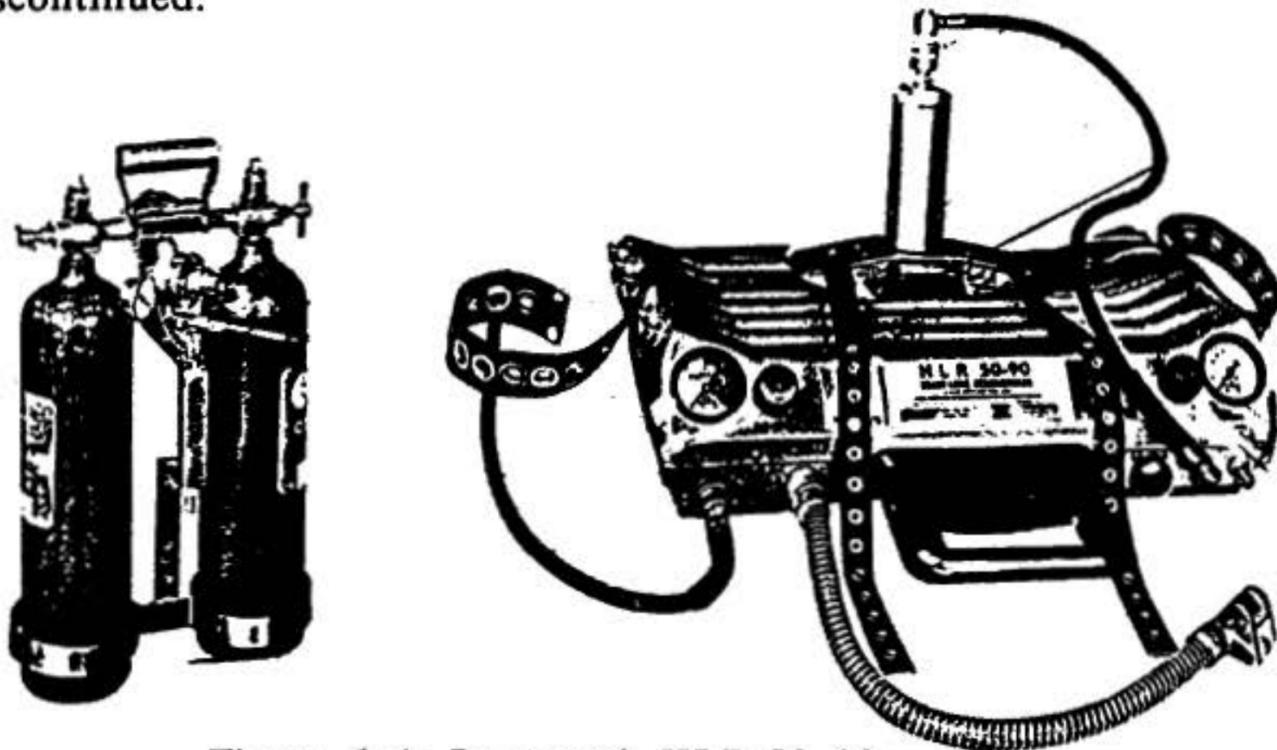


Figure 6-1: Brunswick HLR 50-90.

The Brunswick HLR

The Brunswick HLR automatically administers 60 compressions per minute and employs a strap-on plunger assembly which sandwiches the patient between the plunger and the backboard (the latter of which contains the valving, gauges, controls, and hardware of the timing system). The patient is placed face up on the backboard and the head tilts back over the edge of the backboard into the device handle, hyperextending the neck and opening

the airway.

The Brunswick HLR operates on compressed oxygen. In other words, it derives the energy required to compress the chest and ventilate the lungs from a high pressure oxygen supply. While this system frees the operator from dependence on electric power, it has the drawback of requiring large quantities of oxygen. The two standard "E" cylinders which come with the HLR in the Alcor rescue kit will provide approximately 30 minutes of operation under normal circumstances. For this reason, the E-cylinders should be used only for vehicular transport of the patient. Where possible, it is desirable to use the hospital oxygen supply, either in the form of an H-cylinder (220 cubic feet) or the wall oxygen outlet.

Switchover from E-cylinders to an H-cylinder or hospital wall oxygen supply may be done without interruption of CPR, since the backboard of the HLR has two oxygen inlet ports allowing for two gas supplies *simultaneously* to be connected to the device. When one gas supply is exhausted or removed, the unit automatically begins to draw on the other.

Regardless of whether hospital wall oxygen or a hospital H-cylinder is to be used, contact the respiratory therapy department of the hospital. Arrange for the presence of an H-cylinder or the availability of an adapter or coupler, which will allow the HLR to tap into the wall oxygen outlet. In the event a wall outlet is used, a regulator will be unnecessary, since standard hospital delivery pressure for medical devices is 50 to 90 psi, the operating pressure required by the HLR.

Wall adapters are manufactured in a variety of styles using a wide range of operating principles. It will be necessary to obtain an adapter for the system in use in whatever hospital the patient is in, and to make certain that the adapter does not have any flow restrictions or other devices attached to it (such as an oxygen flowmeter).

Application Of The HLR

Where possible, the HLR should be applied to the patient with only two interruptions in manual resuscitation of not more than five seconds each. This requires the presence of three people on the rescue team, or the availability of a bystander (hospital personnel) to provide some help. After the unit is in operation, only one person is required to monitor its performance and insure an adequate airway. *The HLR should never be allowed to operate without the patient being carefully monitored and attended by at least one knowledgeable individual.*

Note: Names and numbers of HLR controls refer to the diagrams on pages 6-11 and 6-12.

During the first five-second interruption in CPR, elevate the patient's head and shoulders and slip the **Backboard** of the device under the patient with the patient's head fitting into the **Handle-Head Rest** (if the backboard has not already been positioned under the patient prior to the start of manual CPR). This extends the head and facilitates opening of the airway and positioning of the patient for intubation, if it has not been carried out already. Then resume manual cardiac compression, with ventilation by the HLR respirator. Attach the **Chest Compressor (#9)** to the *feed line* and prepare it for placement.

During the second five-second interruption, move the **Chest Compressor (#9)** to its proper position over the lower 1/2 of the sternum and pull down tightly and secure the

Lateral Straps. Activate the chest compressor, fasten the **Shoulder Straps** on their **Hooks**, and the unit is in full operation.

The position of the patient on the HLR backboard is critical; the body should be centered on the backboard with the shoulders at the upper end of the shoulder lift and the head extended down into the cup of the handle. The lateral chest straps should include both arms in small or average sized patients. However, obese or very large frame patients may require positioning of both arms outside of the straps. *Do not include one arm and exclude the other*, since this prevents centering of the patient on the shoulder lift.

After the unit is installed and operating, move the patient into the Portable Ice Bath (PIB) or onto a gurney, without interrupting operation. One person must always remain at the head of the patient to monitor position of the compressor, patency of the airway, the adequacy of the oxygen supply, and the reliability of the unit.

Input Oxygen Pressure

When used with the **Portable Oxygen Pack (#1)** containing two E-cylinders, preset the oxygen pressure delivered to the unit at 90 psi. When using an alternate oxygen source, such as hospital wall oxygen or a larger oxygen cylinder and regulator, set the input pressure in the 50 to 90 psi range. This pressure assures delivery of up to 1500 cc of oxygen per ventilation, and at least 125 pounds of compressor thrust. If the pressure in the tanks falls below 50 psi, the maximum compressor thrust may decrease to below 100 pounds per compression, with inadequate sternal excursion in larger individuals a possible result. If the pressure drops further, the compression rate will decrease and the unit will eventually fail to cycle. Thus, it is imperative that a minimum input pressure of 50 psi be maintained at the oxygen source for effective, uninterrupted resuscitation.

NOTE: Do not connect the HLR to any oxygen source with a pressure greater than 110 psi, or the unit may be seriously damaged and promptly rendered inoperative.

Below and adjacent to each of the pressure gauges on the instrument are two male **Oxygen Input Sites (#2)** for connection of the unit to the **Oxygen Coupling (#3)**. Either site may be used. One site is provided on each side for convenience and to facilitate switching of the instrument from one oxygen supply source to another without interruption of function.

On-Off

Activated the unit by pulling the red **On-Off Control (#4)** out. Push it in to stop the unit.

Ventilation Volume

The mechanisms for regulating the ventilation volumes and pressures have been standardized at sea level at normal room temperature. Higher altitudes result in somewhat increased output volumes, allowing selection of lower volumes as indicated on the **Volume Dial (#5)**.

The volume of oxygen delivered can be adjusted by rotation of the **Ventilation Control Knob (#6)** through a range of 500 cc to 1500 cc per ventilation. The usual ranges for volumes required for children above 60 pounds, adult females, and adult males are

indicated by color-shaded areas on the **Volume Dial (#5)**. The operator may select an approximation of volume based on the appraisal of the patient's probable lung capacity when the device is started, and then adjust the volume delivered until the thoracic expansion with each ventilation is sufficient to insure adequate ventilation.

If the volume indicated on the dial is near the upper limit or outside the range indicated for the patient, or if satisfactory chest expansion does not occur, it is likely that there is an airway obstruction or some decrease in lung compliance, and a higher airway pressure is indicated. This can be achieved by rotation of the **Collar (#7)** on the **Relief Valve (#8)**, decreasing the aperture for blow-off.

Thus, reaching the optimum ventilation for an individual patient may require the regulation of both the **Ventilation Control Knob (#6)** and the **Relief Valve Collar (#7)**. It should be emphasized that, for the majority of patients who do not have underlying pulmonary disease--such as chronic obstructive pulmonary disease (COPD)--which would affect lung compliance, adequate ventilation may be achieved by delivering a reasonable volume of oxygen (as indicated the ranges on the **Volume Dial (#5)** with the **Relief Valve Collar (#7)** in the "normal" (open) position).

*Under no circumstances should the **Relief Valve (#8)** be adjusted to the closed position when the selected ventilation volume is greatly in excess of the normal for the size of the patient.* This is particularly important in children or small adults. Airway obstructions should be relieved whenever possible. Severe obstruction may prolong the ventilation time, resulting in a pause in chest compressions, since more time is required to deliver the same amount of oxygen past the obstruction to the lungs. It is still desirable to deliver adequate ventilation volumes at the expense of compression rate, since cardiac compression alone is ineffective.

Air leaks around the mask or endotracheal tube must be avoided, since the escaping air (which has been metered through the ventilator) is not being delivered to the lungs.

The **Ventilation Control Knob (#6)** should always be in the closed position (rotated counterclockwise to the stop) when the mechanism is started, to prevent inadvertent excessive lung inflation. Once the control has been set to the desired volume, it will deliver approximately that volume of oxygen each cycle as long as the oxygen pressure is held constant.

Chest Compression

The "travel" or length of stroke of the **Chest Compressor (#9)** is dependent on the condition of the patient's chest and the pounds of thrust selected by regulation of the **Compression Control Knob (#10)**. The pounds of thrust delivered by the piston is indicated on the **Thrust Dial (#11)**. The resultant sternal excursion can be approximated by noting the calibration marks on the shaft of the **Compressor Piston (#12)** at its maximum travel or compression. These marks are placed $\frac{1}{2}$ in. apart, so that two marks being visible indicate 1 in. of excursion, four marks indicate 2 in., and so on....

Return of the piston to the retracted position is accomplished by an internal spring rather than a reliance on thoracic pressure to counteract the piston. This complete release of pressure permits diastolic filling of the heart.

In general, the chest should be compressed $1\frac{1}{2}$ in. to 2 in. (3.8 cm to 5.1 cm) in the average adult and 1 in. to $1\frac{1}{2}$ in. (2.5 cm. to 3.8 cm.) in smaller individuals and children, in order to obtain adequate circulation. The pounds of thrust required to

produce this depth of sternal excursion ranges from 60 to 80 pounds in children to 80 to 120 pounds in adults. The femoral pulse should be evaluated after the unit is in place and the depth of sternal excursion should be increased, if no pulse is felt, by increasing the thrust.

Rotate the **Compression Control Knob (#10)** to the "off" position (counterclockwise to the stop) after use and check its position before activating the HLR. This precaution avoids inadvertent excessive chest compression.

Relief Valve

In its "normal" (open) position, the **Collar (#7)** of the **Relief Valve (#8)** allows unrestricted venting of the respiratory pathway at a preset pressure of about 30 cm of water. To achieve higher maximum airway pressures, rotate the **Collar** in either direction to progressively occlude the exhaust from the **Ventilation Hose (#14)**, thus restricting relief of pressure until, in the closed position, only the safety vent is operative. As the aperture is progressively occluded, the pressure developed in the upper airway increases, and may exceed 80 cm of water in cases of severe airway obstruction. Since this setting of the valve is never used except when airway obstruction or reduced lung compliance is encountered, it is evident that intrapulmonary (alveolar) pressure would be substantially lower. It is still possible to achieve alveolar pressures of 30 cm of water under these adverse conditions through proper regulation of the **Relief Valve (#8)** and the **Ventilation Control (#6)**.

The **Cap (#13)** of the **Valve (#8)** may be unscrewed and the spring and valve disc removed for cleaning.

Oxygen Source

The **Oxygen Coupling (#3)** on the **Oxygen Hose (#15)** from the **Oxygen Source (Oxygen Pack) (#1)** or **Wall Oxygen System** can be locked in place on either **Oxygen Input (#2)** by pressing the quick-connect coupling over the **Input** fitting. By rotating the coupling ring, you free the coupling from the fitting when disconnecting. A wrench is provided in one of the storage compartments of the HLR for opening the "E" oxygen cylinders and for making and breaking all screw connections to the oxygen supply (i.e., where the oxygen line to the HLR is attached to the regulator on the **Oxygen Pack (#1)**).

A *two gauge oxygen regulator* for use with an H-cylinder is provided in the rescue kit. When it becomes possible to switch from the **Oxygen Pack** to a larger cylinder or wall outlet, this may be done by shutting down the HLR and resuming manual chest compression temporarily while unscrewing the threaded fitting (DISS fitting) on the end of the oxygen line from the regulator on the **Oxygen Pack (#1)** and screwing it onto the regulator on the H-cylinder. If an extra oxygen line with the appropriate fittings is available, the extra line simply can be coupled between the larger cylinder (or wall outlet) and the other **Oxygen Input (#2)**. The valves of the E-cylinders can then be closed and operation will automatically switch over. When switching back to oxygen pack operation, be sure to open the valves on the E-cylinders *before* disconnecting from the other oxygen source.

Chest Compressor

Connect the **Compression Line (#16)** to the **Compression Fitting (#17)** by retracting the **Coupling Ring (#18)** while connecting the coupling. Disconnect it by again retracting the

Coupling Ring, freeing the coupling.

Ventilation Hose

The Ventilation Hose (#14) is ring-reinforced to prevent kinking and occlusion. Push the plain end Ventilator Coupling (#19) directly onto the Ventilator Output (#20), and connect the valve end directly to the mask or to a 15 mm Adapter (#21) provided, to an endotracheal tube. If particulate matter (i.e., vomitus) is introduced into the Ventilation Hose, it should not damage the HLR, since a valve prevents its entry into the unit.

Exhaled air is vented via the Ventilation Hose (#14) through the Exhalation Vent (#22). The hose and vent can be flushed out with water when the instrument is not in operation, and the vent screen removed for cleaning.

Steps For Application

The precise steps for application of the Brunswick HLR are presented on the four pages which end this Chapter (6-13 through 6-16).

Protection From Water

It is important that excessive amounts of water from melting ice do not enter the backboard of the unit or obstruct the exhaust port on the underside of the handle. If the (PIB) is available and direct skin contact with ice in the PIB is being used to cool the patient, a "dummy" HLR backboard will have to be substituted for the operational backboard containing the pneumatic computer, pneumatic driver and other working elements of the machine. The operational backboard may then be placed in the holster at the head or on the side of the PIB. When the Brunswick HLR is used with the PIB it will also be

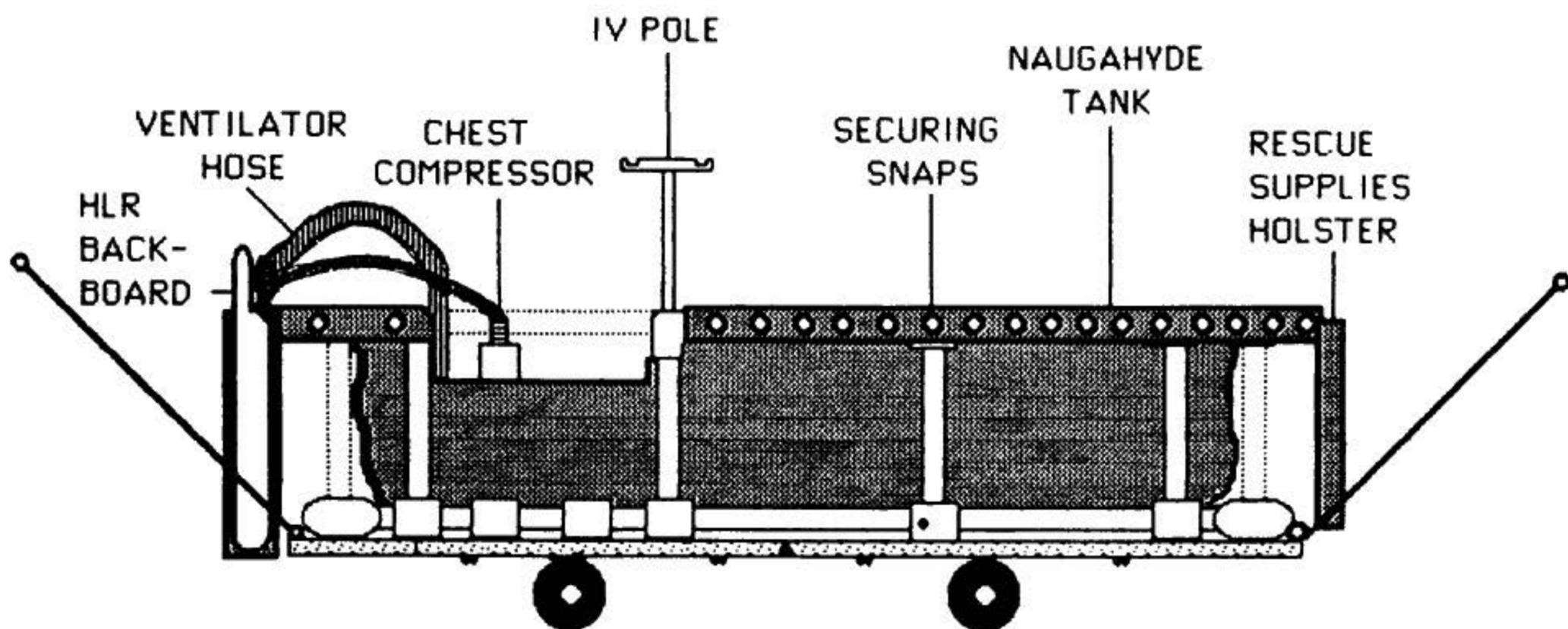


Figure 6-2: Configuration of the Brunswick HLR-50-90 when used with the Portable Ice Bath.

necessary to use the double length **Ventilation Hose** provided for this purpose.

If the PIB is unavailable and the patient is being cooled with ice packs (i.e., ice contained in plastic bags), vigilance will still have to be exercised to insure that water does not get into the unit. The device will tolerate some exposure to dripping water from sweating or leaking ice bags, but serious wetting, saturation, or immersion of the device in water can result in abnormal cycling, contamination of the respiratory pathways with water, inaccurate readings on monitoring gauges, or complete failure of the unit.

If the unit is being used without the PIB on an embalming table, it may be protected from excessive moisture by judicious application of ice bags in the chest area, and the use of towels or other absorbent material to sponge off or divert water from the table surface on which the backboard rests. Placing a small blanket, towels, or other thin flat items under the HLR backboard to elevate it slightly above the table surface is acceptable.

If the patient is being surface-cooled on an embalming table, operating table, or other tiltable table, *do not* tilt the table "head end up" (reverse Trendelenburg position) to facilitate drainage of accumulating water, as this will decrease cerebral pressure.

Terminating HLR Support

Interrupt or terminate HLR support only when the patient's core temperature (esophageal temperature) is 12°C or lower. Do not allow the patient's core temperature to fall below 10°C while administering CPR, since blood sludging and cold agglutination will prevent adequate tissue perfusion.

Troubleshooting The Brunswick HLR

Background and History

Alcor has used the Brunswick HLR since Alcor was founded in 1972. Most of the units which are in service were purchased second-hand from various ambulance companies and emergency rooms when the devices lost popularity in the mid 1970's. The units were actually manufactured in the early 1970's, around the time that Alcor was founded!

As a consequence, much of this equipment is in very poor condition, and some of these units are being used far beyond their rated service life. Static tests of HLRs have indicated that failure is not uncommon, and failure of an HLR during one cryonic suspension at Alcor has already occurred (a new "driver" unit was promptly substituted without interruption in CPR, and the patient's care was not compromised).

This equipment was purchased second-hand for one simple reason: the cost. The current purchase price for a new Brunswick HLR 50-90 is over \$3000. Purchase price for the Michigan Instruments HLR (Brunswick's competitor) is over \$6000. Clearly, given Alcor's past (and current) size and budget, it would not be possible to deploy new units with each Coordinator.

And yet, without HLR's, fast response to a local emergency would be problematic at best. It is virtually impossible to carry out manual CPR for an extended period of time during transport operations. A question which comes to mind is: if this is the case, *why* is old, unreliable equipment being used in an area as critical as cardiopulmonary support?

At this time, and for the foreseeable future, it simply is not economically possible to replace the unreliable HLRs now in use with new units. The rationale for deploying them in the first place is simple: as long as the Transport Technician can reliably determine the status of the unit before and *during* its use, it is better to have a unit which may fail at some point (and thus have get the benefit out of it for however long it lasts) than to have *no unit at all*. Thus, if a transport technician gets two hours of CPR time out of the unit before it fails, he is in a much better position than if he was able to deliver only 20 minutes of manual CPR before giving up from exhaustion.

Additionally, if there is advance notice, a newer and more reliable unit can be shipped from Alcor Southern California (ASC) to serve as the primary unit. In most cases, a Coordinator will know some days or weeks in advance that he or she is likely to be dealing with a suspension in his or her area, and can thus request a new (and presumably more reliable) unit from ASC. Thus, the primary function of the old, second string units is to serve in the event of an unanticipated emergency.

Diagnosing Failure Modes

A variety of failure modes have been observed with the HLR 50-90. Most are immediately obvious and can be easily detected. However, several are *not* obvious and require careful observation of the unit and/or the patient to detect.

Obvious Failure Modes

The obvious failure modes are those which involve the pneumatic computer inside the device, and these can be readily discerned by virtue of the fact that the unit will fail to cycle properly in some fashion. The ratio of compressions to ventilations may become improper, the unit may fail to stop compressions during ventilation, or it may simply omit ventilating the patient and continue chest compressions without the normal 5:1 ratio. These types of malfunctions are immediately apparent to even the casual observer, since they disrupt the cadence of the machine. Alternatively, the machine may start to "miss" a compression, or give an incomplete one at various points in the cycle.

If the unit simply stops ventilating the patient, it is easy enough to take over ventilation manually with the bag-valve respirator in the kit, imposing an inflation every 5th compression, whether or not the unit pauses in administering chest compressions. In such a situation, it is important to check the chest compressor for proper excursion (1½" to 2") and make sure that it continues to work properly.

If the unit begins to miss or incompletely deliver compressions, the Transport Technician will have to exercise a judgement call. Is it far enough into the cooling process that the failure is not likely to be significant? Is the malfunction significant enough that switching to manual CPR would be better?

In our experience, the HLR 50-90 has never failed completely. We have yet to see a failure mode in which the patient's transport would have been improved by simply abandoning machine CPR altogether.

Subtle Failure Modes

Subtle failure modes can occur in two ways: failure of the plunger to compress the chest to the proper depth, and failure of the respirator to adequately ventilate the

patient's lungs. Both of these failure modes can be detected by continuous observation of the patient during use of the device.

Before the unit is used, it should be given a short test run to see if the plunger is activated and the cadence of the machine is proper. The ventilator coupling should be firmly occluded with a thumb--with the respirator on the adult setting--causing a failure of the machine to cycle. If there is an air leak within the unit on the respirator circuit, the device will continue to cycle normally. *In such a situation, the ventilator on the machine cannot be used, and a bag-valve device must be substituted.*

Evaluating The Unit

Once the HLR is being used on the patient, the device and the patient *should be continuously observed*. Is the patient's chest expanding adequately? Is the plunger depressing the sternum by the correct amount?

As long as the cadence of the device is proper (i.e., 5:1 compression to ventilation ratio) and chest expansion during ventilation is adequate, the HLR can be presumed to be functioning properly.

The Cause of Malfunctions

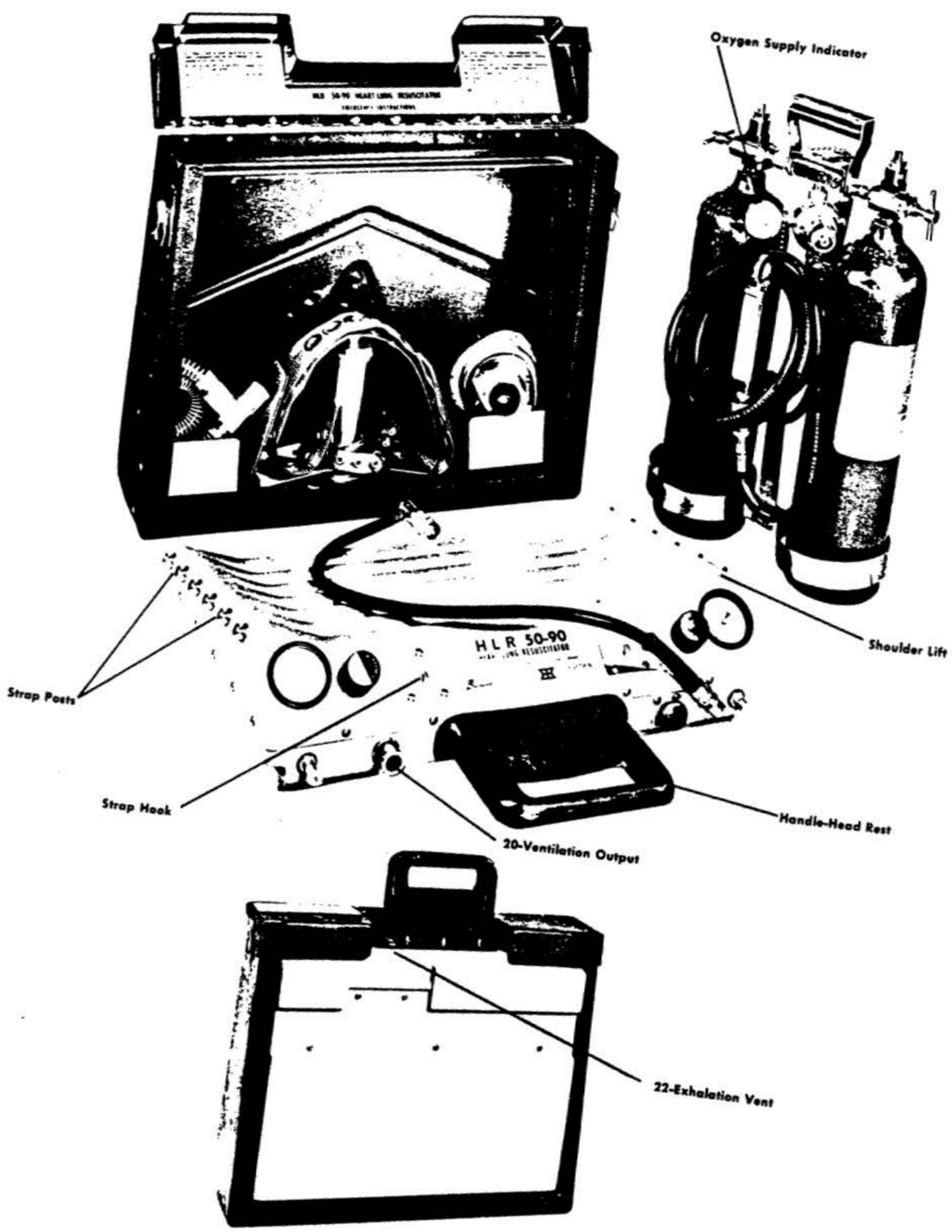
There are a number of possible causes of malfunctions of the unit. Most relate to the construction (inside and out) being almost completely of plastic. With the passage of time, oxidation of the plastic renders it brittle and prone to cracking and crazing. Additionally, O-rings inside the pneumatic computer or drivers may wear and fail.

An Alcor technician or a factory representative (in those cases where the machines are still new enough to be considered reconditionable by the manufacturer) has opened each machine that Alcor has deployed, and replaced or repaired obviously damaged or oxidized plastic parts. *No machine has been issued without an overhaul followed by bench testing.*

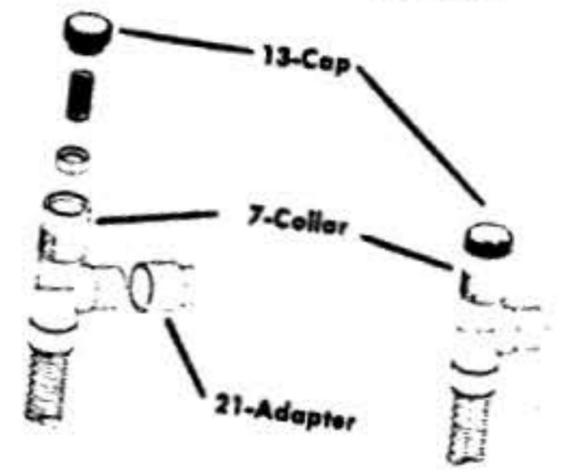
In the event of a malfunction as described above, it should be obvious that repair by the Transport Technician in the field is virtually impossible. The only alternatives available are the substitution of a bag-valve ventilator (if the respirator has failed), toleration of an improper compression ratio or occasional inadequate plunger excursion, a switch over to manual CPR, or complete discontinuation of CPR.

The Future

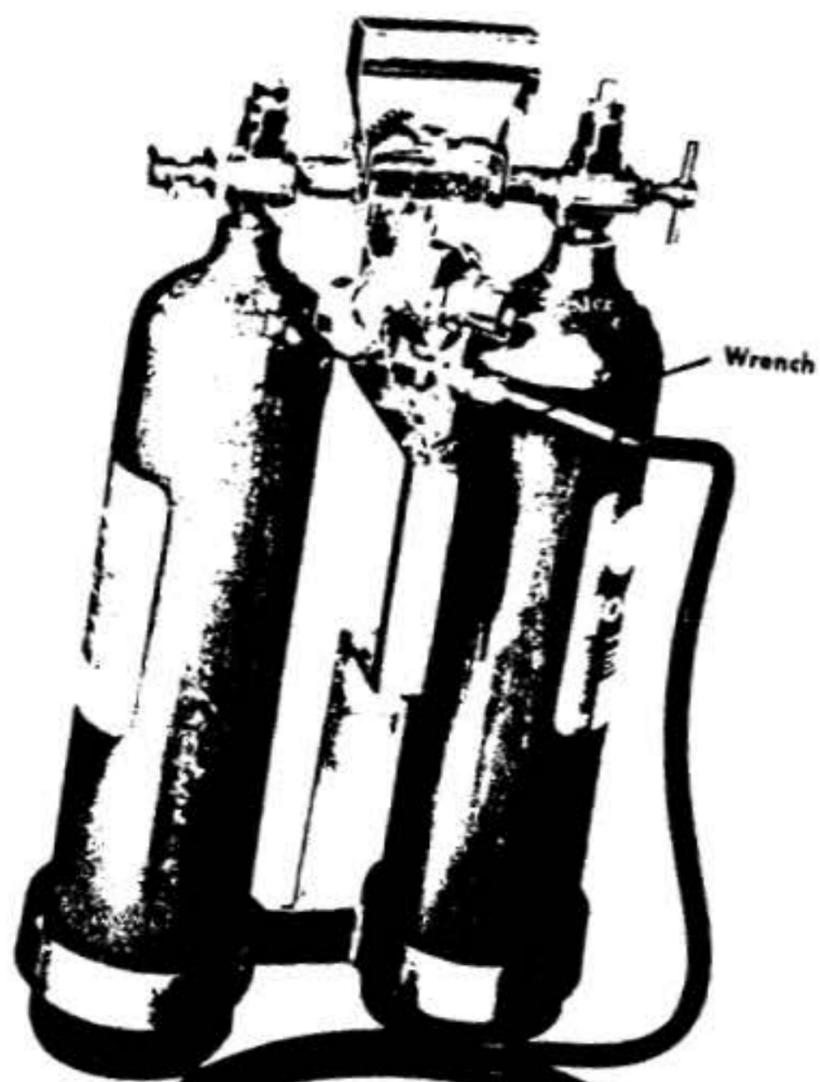
As soon as it becomes possible to do so, Alcor intends to replace aged, failure-prone units with new, high impulse CPR machines. In the meantime, *some* capability for mechanical CPR (even unreliable), *if used thoughtfully and vigilantly*, is better than none at all.



8-Relief Valve Detail



1-Oxygen Pack



Wrench

18-Coupling Ring

17-Compressor Fitting

16-Compression Line

9-Chest Compressor

12-Compressor Piston

Lateral Chest Strap

HLR 50-90
HEART LUNG RESUSCITATOR

11-Thrust Dial

10-Compression Control

2-Oxygen Input

4-On-Off

Shoulder Strap

13-Cap

7-Collar

8-Relief Valve
(See Insert
above)

Lateral Chest Strap

Volume Dial

Ventilation Control

Oxygen Input

Oxygen Coupling

Oxygen Hose

19-Ventilator Coupling

14-Ventilation Hose

Steps for Application

The primary consideration is avoiding interruption of manual external resuscitation procedures which should be employed prior to and during these steps for application of the HLR unit. The HLR unit is applied best when there are three people ("Rescuers") available, although it can also be applied without signifi-

cant interruption by only two rescuers. The person applying manual external chest compression will be designated "Rescuer #1", the person giving mouth-to-mouth (or bag and mask) ventilation is "Rescuer #2", and the person free to manipulate the HLR unit is "Rescuer #3".



Step 1 - Rescuers #1 and 2:

Continue manual chest compression and artificial respiration without interruption at all times during the procedure, except where noted.



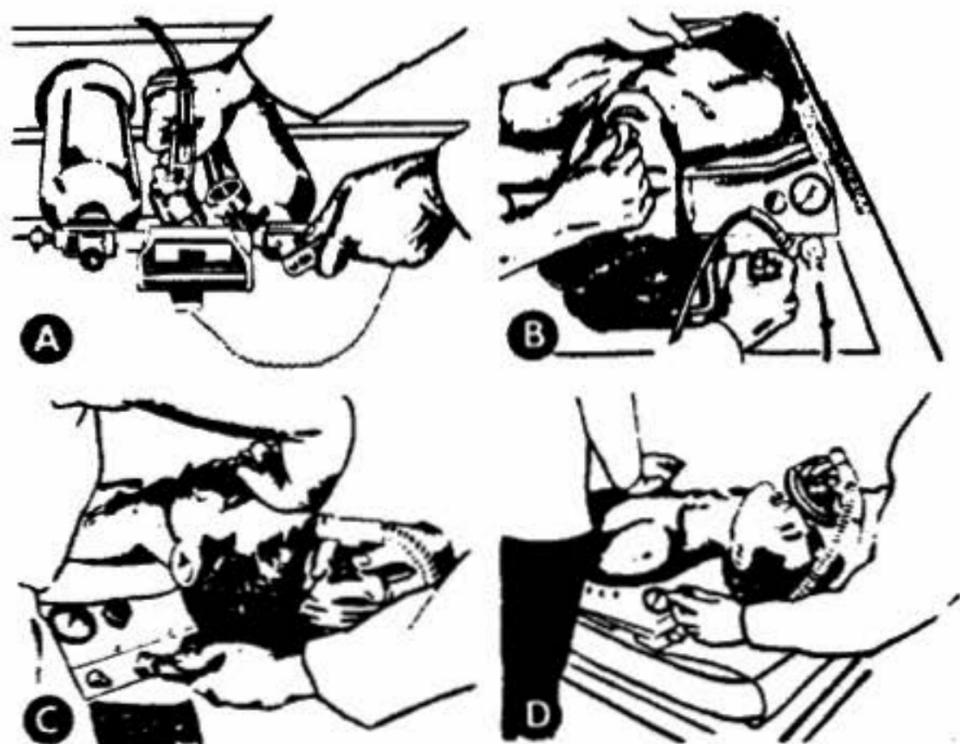
Step 2 - Rescuer #3:

Check HLR ON-OFF control, VENTILATION CONTROL and COMPRESSION CONTROL knobs to make sure that they are turned OFF (counterclockwise to the stop). Connect the HLR unit to the OXYGEN PACK or other oxygen source by pushing the OXYGEN COUPLING over one OXYGEN INPUT.



Step 3 - Rescuers #1, 2, and 3:

At a signal from Rescuer #3, the patient's head and shoulders are lifted by Rescuers #1 and 2, and the HLR shoulder lift is slid under the patient by Rescuer #3. It is placed so that the patient lies in the center of the shoulder lift with the shoulders at the upper edge and the head falling well back into the handle recess, facilitating opening the airway by extension of the head. *This step should require no more than five seconds to complete.* Rescuers #1 and 2 quickly resume manual chest compression and artificial respiration.



Step 4 - Rescuer #3:

- Turn on OXYGEN at source.
- Activate the HLR unit by pulling out the ON-OFF control knob.
- Connect the VENTILATION HOSE to the HLR shoulder lift and to the mask (or endotracheal tube adapter).
- Adjust the VENTILATION CONTROL to the proper setting — child, adult female, or adult male (proper setting should equal two times the normal resting tidal volume plus the dead space).
- If it is not already in place on the endotracheal tube, attach the end-tidal CO₂ detector.

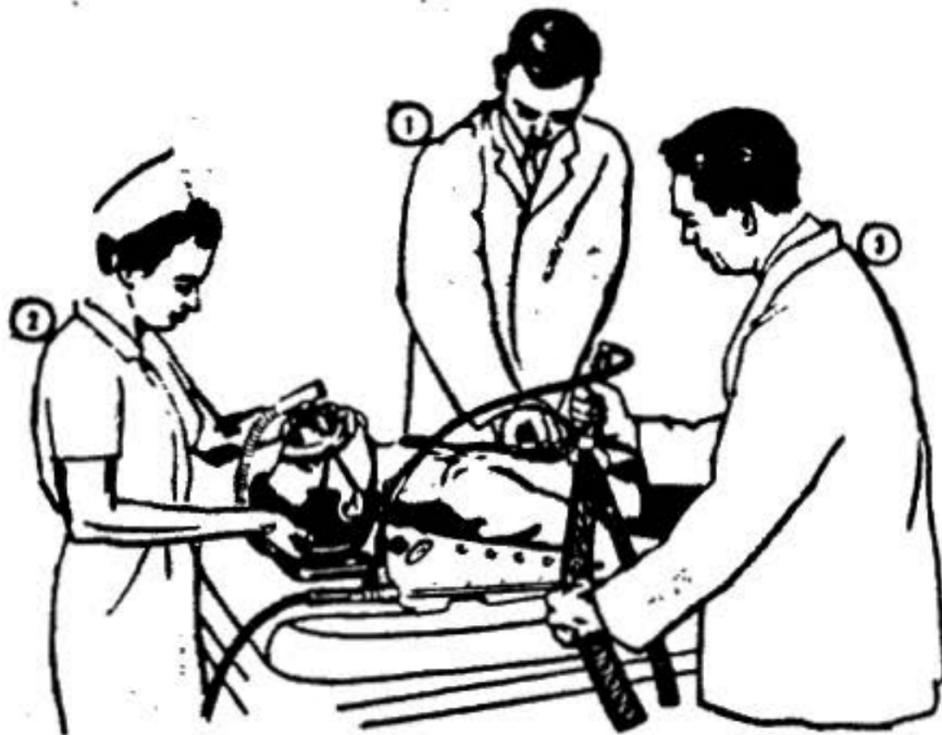


Step 5 - Rescuers #2 and 3:

During one of the natural pauses between breaths of artificial respiration, Rescuer #3 applies the mask to the patient's face, or connects the endotracheal tube to the VENTILATION HOSE ADAPTER. Rescuer #2 should secure the head straps of the mask as soon as possible, remaining at the head of the patient to monitor the controls and keep the head tilted back into maximum extension at all times. This step requires no interruption in manual external cardiac compression by Rescuer #1.

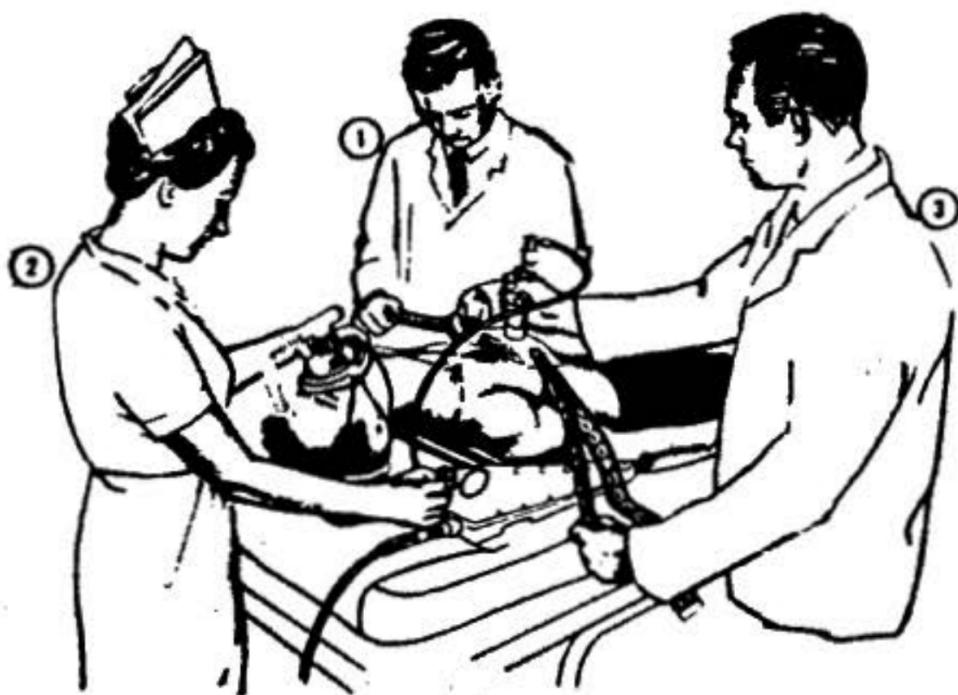
Step 6 - Rescuer #3:

Connect the COMPRESSOR LINE from the shoulder lift to the CHEST COMPRESSOR. Then fasten one LATERAL CHEST STRAP (A) to the appropriate STRAP POST on the side of the shoulder lift opposite to where Rescuer #1 is stationed, so that the COMPRESSOR PISTON will rest in the midline near the hands of Rescuer #1. The unfastened LATERAL CHEST STRAP (B) should be extended loosely across the body toward the other STRAP POST where it will subsequently be connected.



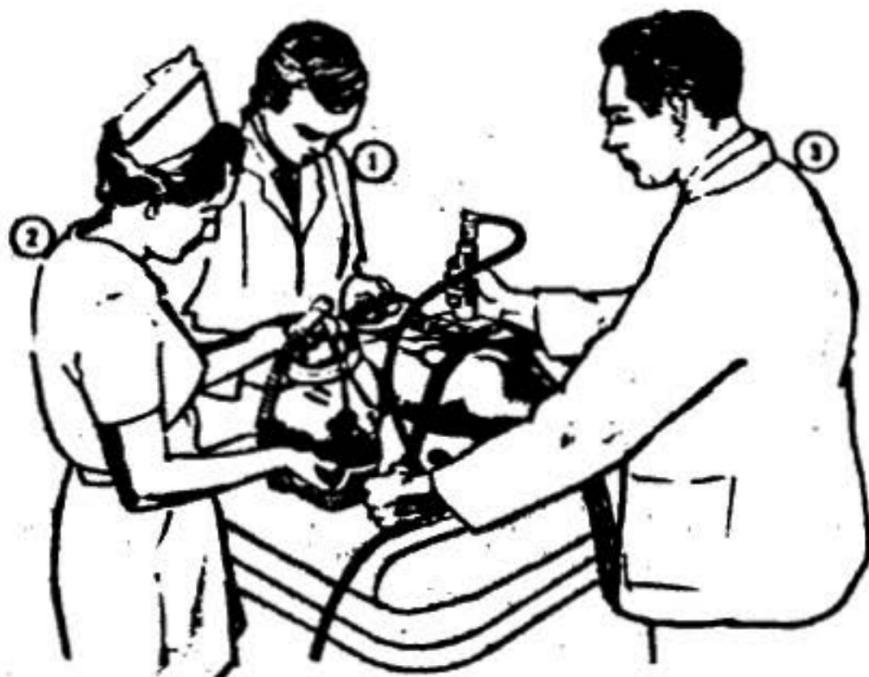
Step 7 - Rescuers #1, 2, and 3:

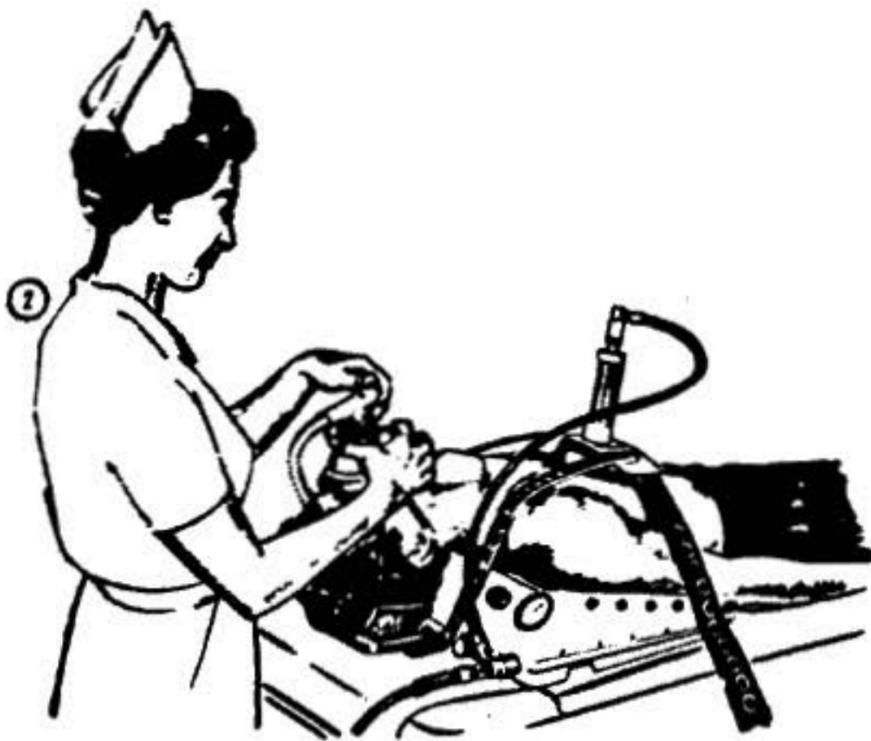
At a signal from Rescuer #3 (preferably immediately after the fifth chest compression in the 5:1 cycle), Rescuer #3 moves the CHEST COMPRESSOR to the correct position in the midline over the lower one-half of the sternum, excluding the xiphoid. Rescuer #1 pulls down and secures the LATERAL CHEST STRAP (B) on his side very tightly. (If necessary, Rescuers #1 and 3 correct the location of the LATERAL CHEST STRAPS to insure proper placement and correct tension.) Rescuer #2 then quickly adjusts the COMPRESSION CONTROL so that the sternum is being compressed 1½ to 2 inches (3.8 cm. to 5.1 cm.) per stroke. (1 to 1½ inches (2.5 cm. to 3.8 cm.) for smaller individuals.) *This step should require no more than five seconds to complete.*



Step 8 - Rescuers #1 and 3:

With the unit now in operation, fasten both shoulder straps over the STRAP HOOKS to stabilize the chest compressor.





Step 9 - Rescuer #2:

Make fine adjustment of **COMPRESSION CONTROL** to insure optimum movement of the sternum. Adjust **VENTILATION CONTROL** and **RELIEF VALVE** so that adequate chest and abdominal expansion occurs with each ventilation.



Step 10 -

One Rescuer should remain at the head of the patient at all times to insure an open airway, proper placement of the **CHEST COMPRESSOR**, adequate ventilation volume and compressor thrust; observe for vomiting, check the pulse (carotid) and pupils, and maintain constant oxygen supply. When the oxygen pressure begins to fall in the first tank, open the second tank with the wrench provided. The first tank can be removed and a fresh tank connected in its place while the second tank continues to operate the unit. If a large oxygen cylinder becomes available, it can be connected to the second **OXYGEN INPUT** without interrupting performance. If vomiting occurs, turn the patient's head to the side and remove the mask. Replace the cleaned mask as soon as possible. The patient and the HLR unit can now be lifted and moved together without interruption in artificial respiration and artificial circulation.