

Chest Injuries

Physiologic Principles
and Emergency Management

Emil A. Naclerio, M.D.



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Dedication

To Brian Blades, Lyman A. Brewer III, Thomas H. Burford, Michael E. DeBakey, Dwight E. Harken, Paul C. Samson, and Robert H. Wylie, thoracic surgeons of preeminence, for their brilliant achievements in World War II.

During this time, these surgeons were instrumental in formulating pathophysiologic concepts and standardizing techniques in the management of combat-incurred thoracic wounds. These contributions constituted the foundations for present-day management of chest injuries.

In civilian life, these surgeons have continued to make notable contributions to the field of chest trauma and, in addition, have played a particularly important role in the development of the specialty of thoracic and cardiovascular surgery.

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Foreword *by C. Walton Lillehei, M.D., Ph.D.*

The sharp rise in the frequency of stabbings, gunshot wounds, severe blunt trauma, and other major traumatic insults incident to the changing character of our lives and cities, along with man's inherent desire to conquer space by resorting to increasingly high speed vehicles, has made the problem of trauma particularly important in recent years. Moreover, accidental injuries, like heart disease, respect no geographic boundaries. They occur in every nation of the world, strike all persons, all age groups, all races, and every stratum of society.

The magnitude of the problem of trauma in these increasingly violent times can be better appreciated when it is realized that in the United States accidents are now the leading cause of death up to the age of 37 years, and overall rank third (115,000 deaths and 10.8 million disabling injuries in 1969) exceeded only by cardiovascular disease and cancer. Moreover, approximately 25 percent of all accidental deaths, particularly those occurring within minute or several hours after injury, are due to chest trauma. In another 50 percent of these deaths, chest trauma plays a major role. Of no lesser importance are the staggering economic losses from the human disabilities resulting from accidents.

The chest contains the two most vital of the life sustaining organs, the heart and lungs. Therefore, any trauma to the chest that seriously compromises the function of these organs is an immediate threat to survival. Unless these injuries are treated "on the spot" or within a short period of time, death often occurs rapidly. Yet, even in these critical situations the lives of over 80 percent of patients can be saved with the prompt application of quite simple measures.

These facts clearly emphasize the necessity

for and the importance of an up-to-date book which presents in a clear and concise manner the essentials of prompt and accurate diagnoses together with seasoned methods for treatment of chest injuries, particularly those complicated by emergent cardiopulmonary and hemodynamic problems. Dr. Naclerio has adhered admirably to this task. In the very first chapters he immediately gets down to particulars with a lucid presentation of his three basically sound approaches to the overall management of chest trauma—physiologic, etiologic, and anatomic. In the chapters that follow, he presents each subject in a similar one-two-three fashion, in the concise style which is characteristic of his writings and teachings.

This "to the point" method of presentation, with the use of excellent drawings, pertinent roentgenograms, some well thought out tables (such as Table 2, Arterial Gas Studies in Cardiorespiratory and Metabolic Failure), and photographs of injuries and necropsy specimens provide the reader with a book from which he can readily grasp the many essentials relative to the successful care of the chest-injured patient.

A perusal of the Contents will reveal the all encompassing coverage of the formidable and challenging problems of chest trauma. While the urgent measures necessary to save lives are stressed throughout, later definitive treatment is also thoroughly covered. Dr. Naclerio's long-standing friendship and previous collaborations with Dr. Frank Netter have resulted in the inclusion in this book of the beautiful and comprehensive series of Netter color plates on chest injuries.

The sections dealing with emergency situations are of particular value, since present-day methods of communication and rapid trans-

portation often enable critically injured patients to survive to reach the hospital alive. An optimal salvage rate in such cases obviously requires immediate patient evaluation and prompt and effective resuscitative therapy. The basic steps of emergency resuscitation, according to their order of priority, are clearly outlined.

The discussion on penetrating wounds of the heart is excellent. It is based on an experience with a large volume of cardiac trauma personally managed over a period of 22 years. All other thoracic injuries, especially those involving the base of the neck, ribs, aorta, esophagus, and diaphragm are presented in a simple, direct, and categorical manner always

with the emphasis upon basic principles of management.

Dr. Naclerio is particularly well qualified to write an authoritative book on chest injuries. He uniquely combines a thorough knowledge of the world's scientific knowledge on this subject, frequent personal contacts with other surgeons who have devoted much time to the handling of these problems, together with the immense practical experience that has come from more than 20 years of close association with two of the most active emergency services in New York City.

He writes with the authority of an experienced surgeon together with the enthusiasm of an inspiring, energetic teacher.

Preface

During the past two decades, it has been my privilege to conduct daily ward rounds and weekly lectures and panel sessions relative to physiologic aspects, diagnosis, and treatment of chest trauma. This book is a presentation of the principles and methods discussed therein—the result of animal and laboratory research, but in large measure to a vast practical experience in the management of critically injured thoracic patients.

Pathologic physiology, the cornerstone of clinical medicine is particularly stressed. This knowledge provides the key to understanding both diagnosis and treatment.

This book is clinical in scope. It is not an exhaustive treatise. The intention is toward brevity, clarity, and practicality. Established facts have been emphasized, and controversial issues minimized. Thus, the treating physician seeking quick reference may find solutions with a minimum of difficulty.

The fundamental aim is to carry the reader through successive steps in diagnosis and treatment—from on-the-spot “first aid” to definitive hospital care. This book, therefore, should prove of inestimable value to the first-aider, the emergency room physician, and nursing personnel as well as to those physicians and surgeons who are involved in definitive therapy. Selected references and up-to-date reading sources are included at the end of the book.



The care of the critically injured patient is indeed a team effort. Hence, no book of this type could be written without the help in one way or another of many dedicated individuals. Admittedly, it would be impossible to enumerate all the surgeons, physicians, house residents and interns, X-ray technicians, laboratory personnel, chest physiotherapists, and the all-important astute and dedicated nurses of the modern intensive care unit who were directly or indirectly responsible for the author's formulation and presentation of many of the therapeutic modalities presented in this book. To these individuals, I am deeply indebted.

I am especially indebted to Milton Helpern, M.D., Chief Medical Examiner of the City of New York, John F. Devlin, M.D., Deputy Chief Medical Examiner, and Mr. John A. Foley, Administrative Assistant in Charge of Records and Statistics in the Office of the Medical Examiner, who over the period of years have cooperated most unselfishly and in addition have given much of their time in gathering and discussing pertinent necropsy material which appears in this book.

I am grateful to Aubre deL. Maynard, M.D., formerly Director of Harlem Hospital Center, and to his successor, Jose M. Ferrer, M.D., Professor of Surgery, Columbia University, and Director of Surgery, Harlem Hospital Center, for their interest and cooperation in this book.

I am thankful to John E. Hutchinson III, M.D., Assistant Professor of Surgery, Columbia University, and Chief of Thoracic and Cardiovascular Surgery, Harlem

Hospital Center, for data relative to three patients with intracardiac defects secondary to penetrating wounds of the heart, all of whom have been successfully treated surgically.

I am grateful to those who contributed pertinent material for illustrations: Raymond LaRaja, M.D., formerly Major of the United States Army, for the findings and chest roentgenograms of two patients who died in Vietnam combat from the so-called "shock lung syndrome" (Fig. 54, Parts A and B); Plinio Rossi, M.D., Chief of Cardiovascular Roentgenology, St. Vincent's Hospital and Medical Center, and Consultant in Cardiovascular Roentgenology, Columbus Hospital, for the aortograms shown on page 286; and Daniel Salvioni, M.D., Director of Radiology, and Guido Padula, M.D., Associate in Roentgenology, Columbus Hospital for the roentgenograms presented on page 262.

I also express my sincere appreciation for the privilege of treating a number of trauma patients at the Physicians Hospital, Jackson Heights, New York. These patients, for the most part, were exercise boys and jockeys injured during their employ at various racetracks in and around the city of New York. The major presenting problem was that of severe respiratory insufficiency secondary to severe blunt trauma to the head, chest, or spine (Figs. 69 and 83).

I am especially grateful to J. Harold Walton, M.D., Editor of Clinical Symposia of the Ciba Pharmaceutical Company, whose warmth, keenness, and friendship I thoroughly enjoyed during the preparation of the presentation on Chest Trauma which appeared in the Fall 1970 issue of Clinical Symposia, and to Frank H. Netter, M.D., renowned medical artist, who made the excellent colored illustrations for this issue which now appear in the front matter of this book. To work with Frank Netter, M.D., was a pleasure indeed. Through the kindness of these men, and Frederick F. Yonkman, M.D., former Editor of the Ciba Collection of Medical Illustrations, and Robert K. Shapter, M.D., in charge of Medical Publications, it was possible to include in this book the vivid and dramatic pictorial presentations of Dr. Netter.

To Margaret Cosgrove, I am especially indebted, not only for her excellent artwork, but also for her untiring efforts expended in the overall planning of the book. To Florence Tracy, I express particular appreciation for her expert editorial assistance. I am thankful to Sylvia Gill for her painstaking secretarial help.

I am also indebted to Philip Varriale, M.D., Chief of Cardiology at Columbus Hospital and Associate Attending Physician in Medicine at St. Vincent's Hospital Center for his expert analysis of all electrocardiographic tracings on heart wounds.

A word of sincere gratitude is due Mr. Alvin Taylor, medical photographer, whose skill and painstaking efforts have resulted in the excellent reproductions of many X-ray films and a number of poor photographs taken under emergency circumstances, and to Mr. Michael Carlin, medical photographer, whose personal skill has resulted in bringing out the necessary details in many roentgenograms of poor quality.

I wish to thank the officers and personnel of Grune & Stratton, Incorporated, particularly Mr. Duncan Mackintosh, Mr. Frank Kurzer, Mrs. Pamela Landau, and Miss Virginia Wells for their continued direction and guidance.

Finally, to my wife, Gloria, and my sons, Emil Jr. and Ronald, I wish to express my sincerest gratitude for their most patient understanding and cooperation during the preparation of this book.

EMIL A. NACLERIO, M.D.

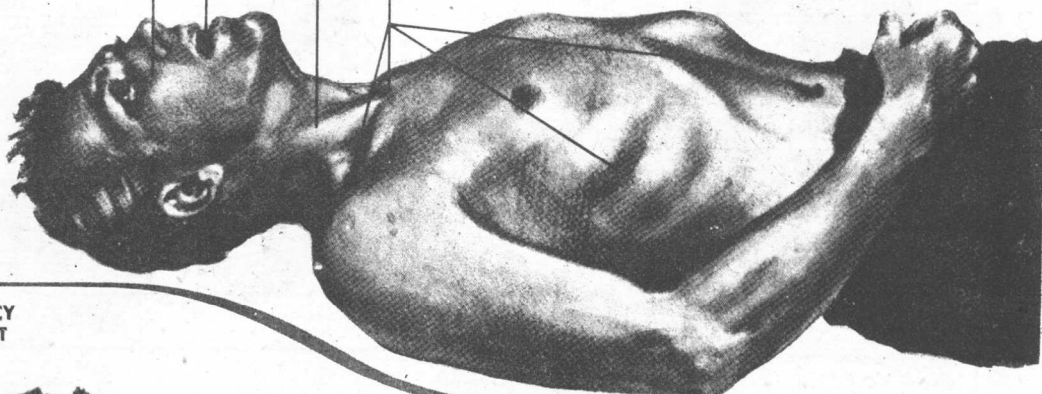
Pictorial Presentations in Color by Frank H. Netter, M.D.

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"Chest Trauma" by Emil A. Naclerio, M.D.
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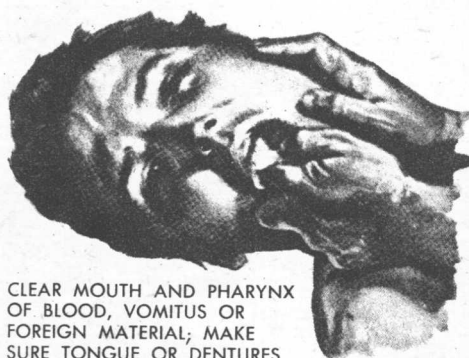
UPPER AIRWAY OBSTRUCTION

CLINICAL FEATURES

PATIENT CYANOTIC OR ASHEN GRAY
 STRONG INSPIRATORY EFFORTS; "CROWING" RESPIRATION
 CONTRACTION OF CERVICAL MUSCLES
 SUPRASTERNAL, SUPRACLAVICULAR,
 INTERCOSTAL AND EPIGASTRIC RETRACTION } WITH EACH INSPIRATION



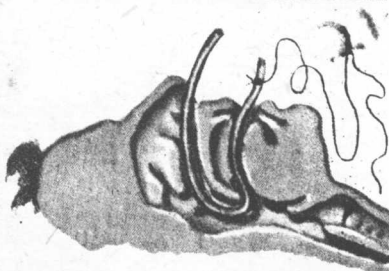
EMERGENCY TREATMENT



CLEAR MOUTH AND PHARYNX
 OF BLOOD, VOMITUS OR
 FOREIGN MATERIAL; MAKE
 SURE TONGUE OR DENTURES
 HAVE NOT SLIPPED BACK
 INTO THROAT



AIRWAY MAY BE
 IMPROVED BY ELEVATING
 ANGLES OF JAW



INHALATION OF BLOOD FROM NOSE
 PREVENTED BY POSTNASAL PACKING:
 CATHETER PASSED THROUGH NOSE AND
 OUT MOUTH. PACKING TIED TO
 CATHETER, DRAWN INTO PLACE AND
 STRINGS TIED

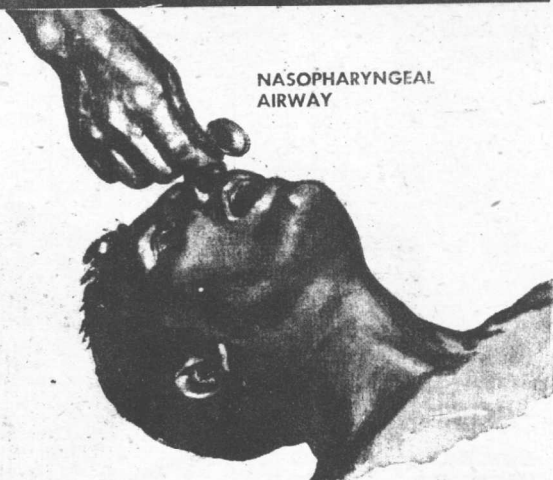


PATIENT MAY BE TURNED WITH MOUTH
 DEPENDENT TO PREVENT TONGUE
 FROM SLIPPING BACK AND TO
 FACILITATE DRAINAGE: PATIENT SHOULD
 BE ROLLED LIKE A LOG WITH ASSISTANCE
 TO AVOID TWISTING A POSSIBLY
 INJURED NECK OR SPINE

UPPER AIRWAY OBSTRUCTION; CONTINUED



OROPHARYNGEAL
AIRWAY



NASOPHARYNGEAL
AIRWAY

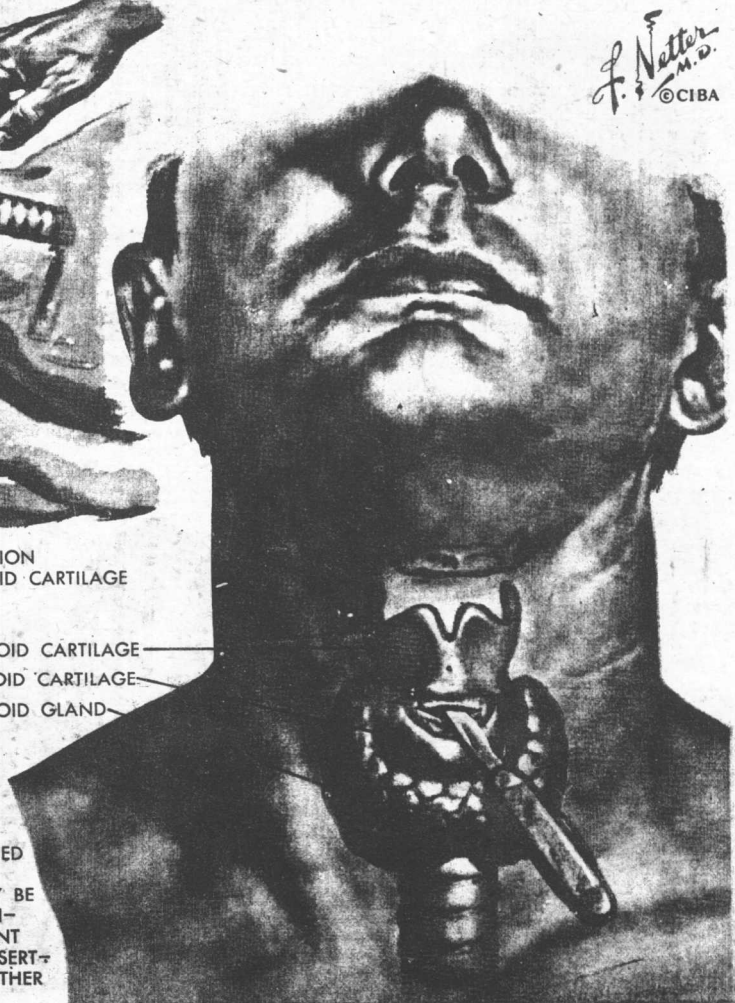
CRICOTHYROID STAB



CRICOTHYROID MEMBRANE IDENTIFIED
BY PALPATING FOR TRANSVERSE INDENTATION
BETWEEN THYROID CARTILAGE AND CRICOID CARTILAGE

THYROID CARTILAGE
CRICOID CARTILAGE
THYROID GLAND

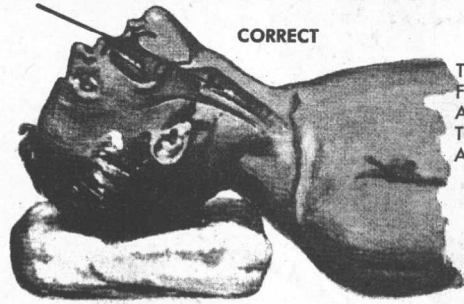
CRICOTHYROID MEMBRANE OPENED
WITH SCALPEL, KNIFE OR OTHER
SHARP INSTRUMENT WHICH MAY BE
AT HAND. OPENING MAY BE EN-
LARGED BY TWISTING INSTRUMENT
AND PATENCY PRESERVED BY INSERT-
ING RUBBER TUBING OR ANY OTHER
SUITABLE OBJECT AVAILABLE



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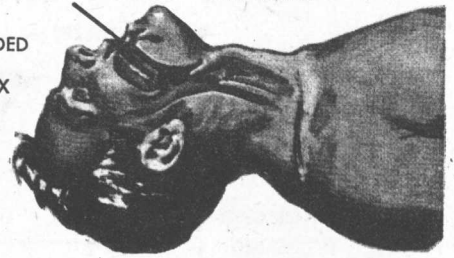
ENDOTRACHEAL INTUBATION

THE MOST RAPID AND EFFECTIVE WAY OF ESTABLISHING AND MAINTAINING A CLEAR AIRWAY

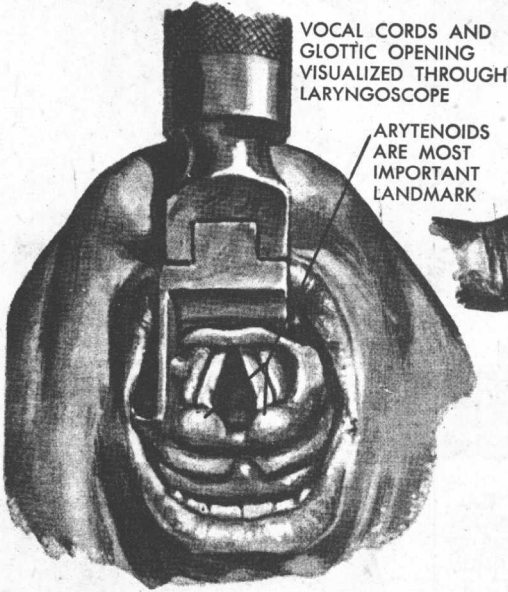


CORRECT

THE NECK SHOULD BE FLEXED AND HEAD EXTENDED AND SUPPORTED ON PAD TO BRING MOUTH, LARYNX AND TRACHEA IN LINE

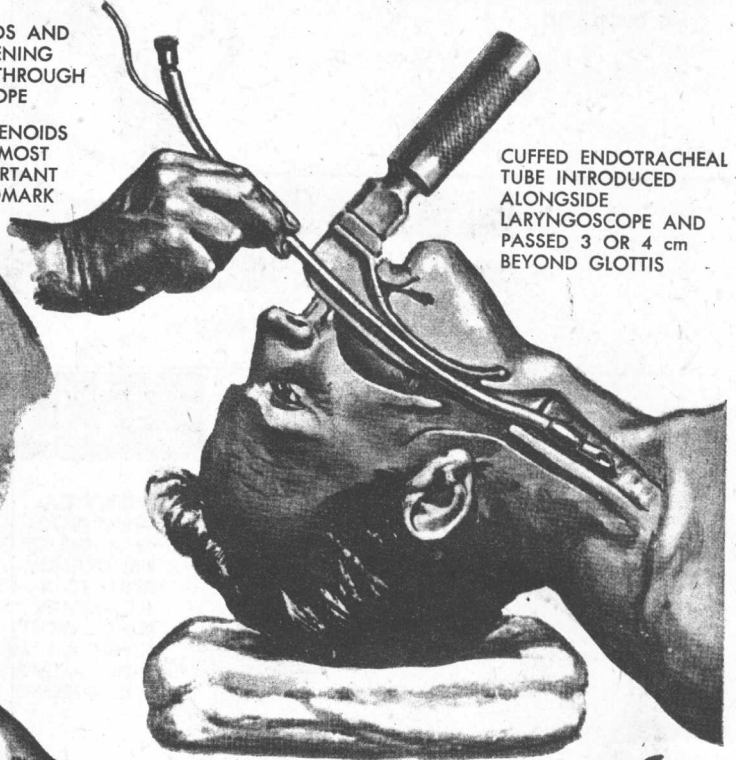


INCORRECT



VOCAL CORDS AND GLOTTIC OPENING VISUALIZED THROUGH LARYNGOSCOPE

ARYTENOIDS ARE MOST IMPORTANT LANDMARK



CUFFED ENDOTRACHEAL TUBE INTRODUCED ALONGSIDE LARYNGOSCOPE AND PASSED 3 OR 4 cm BEYOND GLOTTIS



LARYNGOSCOPE REMOVED LEAVING TUBE IN PLACE: CUFF INFLATED, SEALING TRACHEA, THUS PREVENTING ASPIRATION AND PERMITTING VENTILATION BY MOUTH-TO-AIRWAY, AMBU BAG OR MECHANICAL RESPIRATOR

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LOWER AIRWAY OBSTRUCTION

CYANOSIS
DYSPNEA
INEFFECTIVE COUGH
RALES, WHEEZES,
RHONCHI
X-RAY SIGNS OF
ATELECTASIS AND/OR
PNEUMONIA

P_aCO_2 INCREASED
 P_aO_2 DECREASED
pH DECREASED

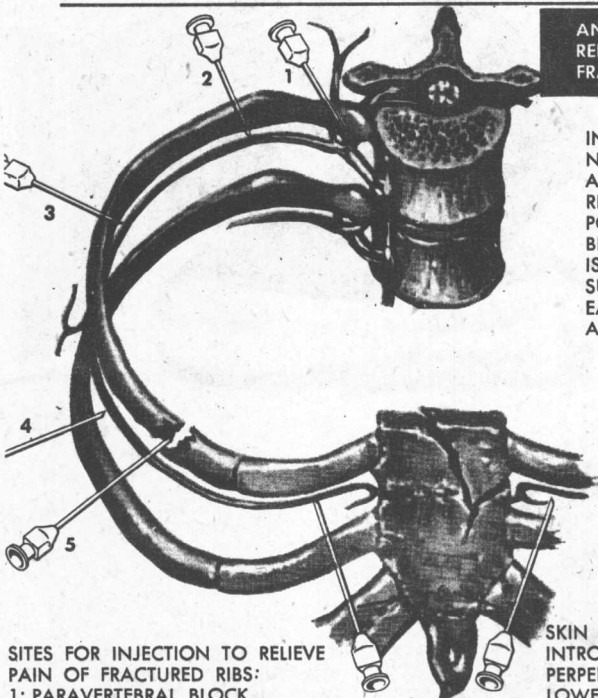
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EVACUATION OF SECRETIONS

MANUAL SUPPORT OF CHEST
TO FACILITATE COUGH AND RID
TRACHEOBRONCHIAL TREE
OF SECRETIONS (SEE ALSO PLATE V)

ANESTHESIA TO
RELIEVE PAIN OF
FRACTURED RIBS

INTERCOSTAL
NERVE BLOCK
AT ANGLE OF
RIB; OPTIMUM
POINT TO INJECT
BECAUSE RIB
IS HERE MOST
SUPERFICIAL, MOST
EASILY PALPABLE
AND ACCESSIBLE



SITES FOR INJECTION TO RELIEVE

PAIN OF FRACTURED RIBS:

- 1: PARAVERTEBRAL BLOCK
- 2: INTERCOSTAL BLOCK AT ANGLE OF RIB
- 3: INTERCOSTAL BLOCK AT POST. AXILLARY LINE
- 4: INTERCOSTAL BLOCK AT ANT. AXILLARY LINE
- 5: LOCAL INFILTRATION AT FRACTURE SITE
- 6: PARASTERNAL BLOCK

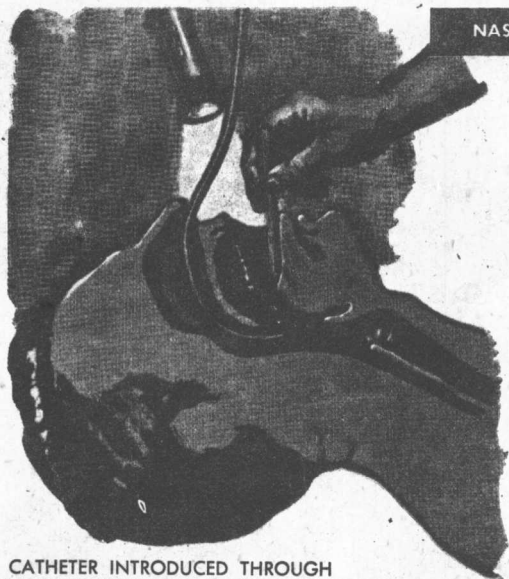
SKIN IMMOBILIZED BY INDEX FINGER; NEEDLE
INTRODUCED THROUGH CUTANEOUS WHEEL
PERPENDICULAR TO SKIN TO CONTACT
LOWER BORDER OF RIB (1), WITHDRAWN
SLIGHTLY, DIRECTED CAUDAL AND AD-
VANCED 1/8 INCH TO SLIP UNDER RIB
AND ENTER INTERCOSTAL SPACE (2):
ASPIRATION ATTEMPTED PRIOR
TO INJECTION OF 5 ml ANESTHETIC



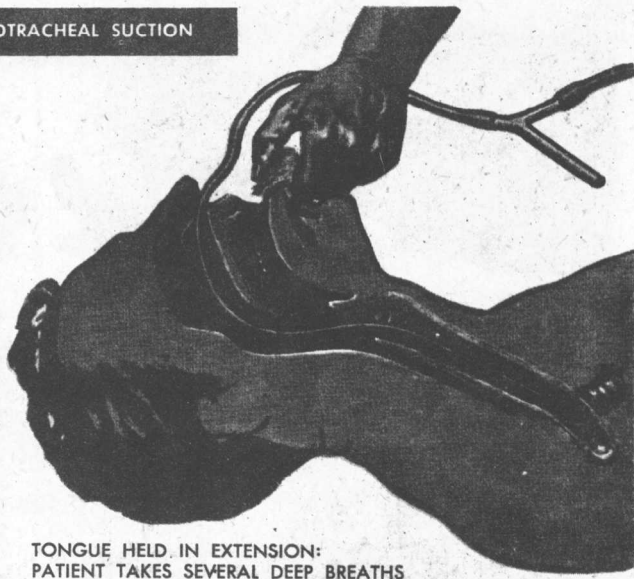
PLATE IV

LOWER AIRWAY OBSTRUCTION
INTERCOSTAL NERVE BLOCK

NASOTRACHEAL SUCTION

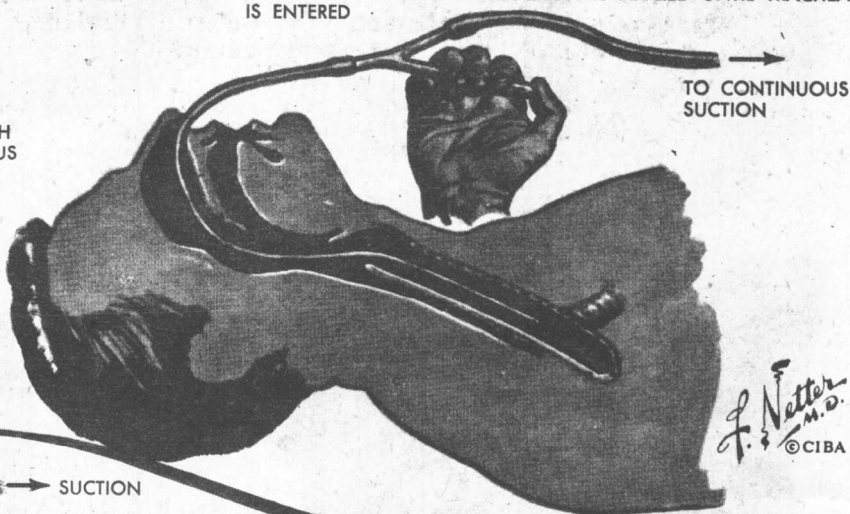


CATHETER INTRODUCED THROUGH NOSTRIL: POSITION IN PHARYNX CHECKED BY EXAMINATION WITH TONGUE BLADE AND LIGHT

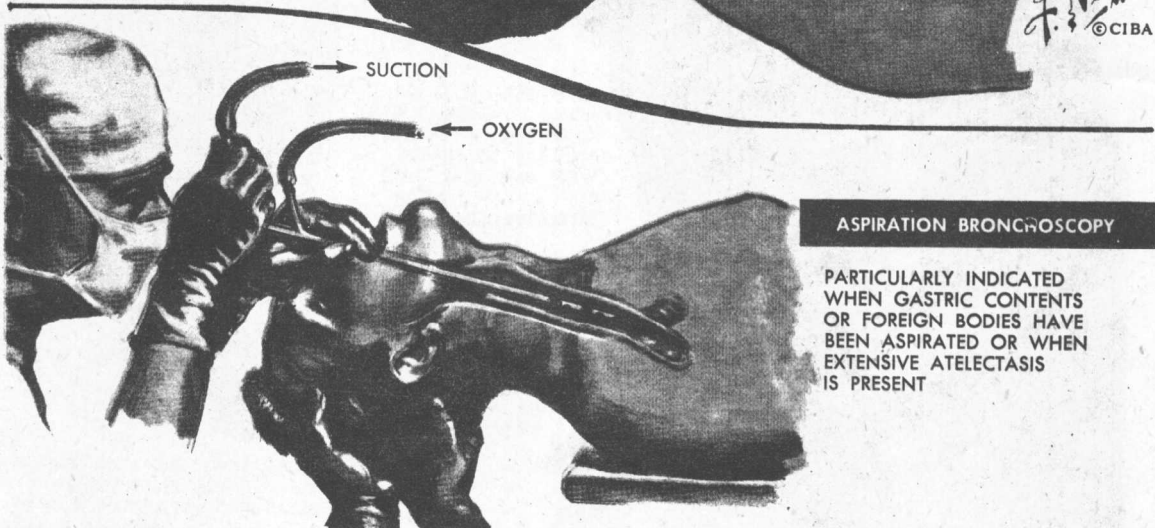


TONGUE HELD IN EXTENSION: PATIENT TAKES SEVERAL DEEP BREATHS AND CATHETER IS QUICKLY ADVANCED INTO TRACHEA TO MAXIMAL DEPTH: NO SUCTION IS APPLIED UNTIL TRACHEA IS ENTERED

CATHETER ATTACHED TO "Y" TUBE, ONE END OF WHICH IS CONNECTED TO CONTINUOUS SUCTION: SUCTION APPLIED FOR ONLY A FEW SECONDS BETWEEN INSPIRATIONS, BY FINGER OCCLUSION OF OPEN END OF "Y" TUBE: CATHETER GRADUALLY WITHDRAWN DURING SUCTION



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ASPIRATION BRONCHOSCOPY

PARTICULARLY INDICATED WHEN GASTRIC CONTENTS OR FOREIGN BODIES HAVE BEEN ASPIRATED OR WHEN EXTENSIVE ATELECTASIS IS PRESENT

TRACHEOSTOMY

POSITION OF PATIENT: SHOULDERS
ELEVATED, NECK EXTENDED.
INFILTRATION OF
LOCAL ANESTHETIC

INCISION: VERTICAL MID-
LINE IF TIME OF THE
ESSENCE; HORIZONTAL
 $\frac{3}{4}$ " BELOW THYROID
CARILAGE IF TIME
PERMITS

STRAP MUSCLES SEPARATED
BY HEMOSTAT

THYROID ISTHMUS
ELEVATED; PRE-
TRACHEAL VEINS
SEPARATED; WINDOW
EXCISED IN TRACHEA

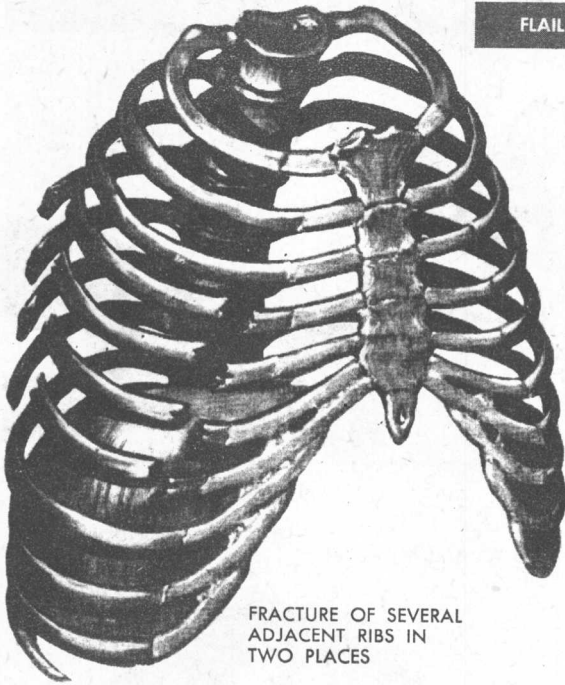
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FOREGGER NO. 7 OR
NO. 8 TRACHEAL TUBE
(CUFF TYPE) INSERTED
AND TIED IN PLACE
WITH UMBILICAL TAPE;
CUFF INFLATED AFTER
INTRODUCTION

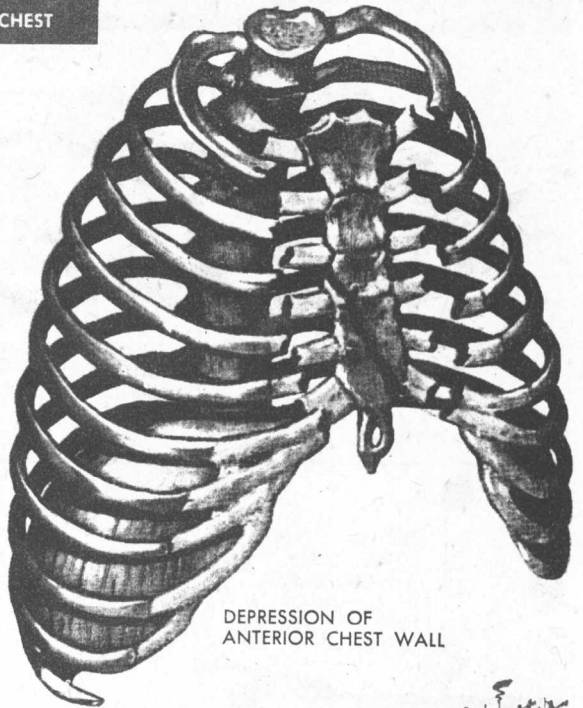
OBTURATOR
REMOVED
AND INNER
CANNULA
REPLACED

RESPIRATORY BAG OR INTER-
MITTENT POSITIVE PRESSURE
BREATHING APPARATUS MAY BE
ATTACHED TO CANNULA IF NEEDED

FLAIL CHEST



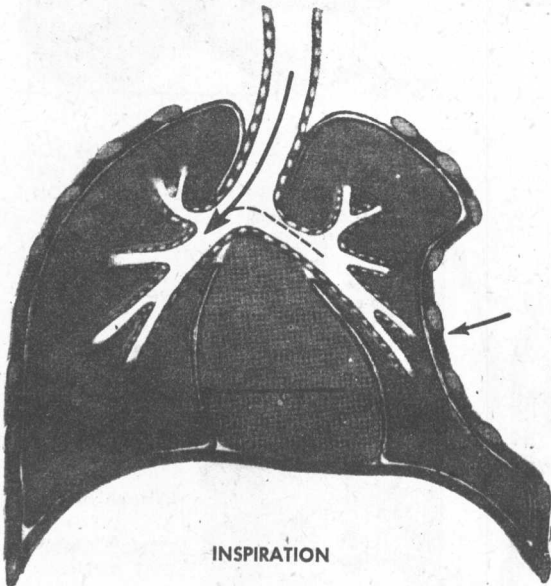
FRACTURE OF SEVERAL
ADJACENT RIBS IN
TWO PLACES



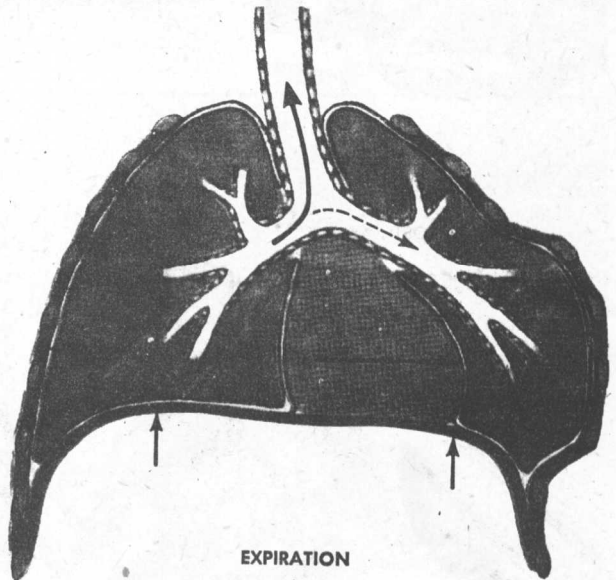
DEPRESSION OF
ANTERIOR CHEST WALL

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PATHOLOGIC PHYSIOLOGY OF LATERAL FLAIL CHEST



INSPIRATION



EXPIRATION

ON INSPIRATION: AS CHEST EXPANDS, FLAIL SECTION SINKS IN, THUS IMPAIRING ABILITY TO PRODUCE NEGATIVE INTRAPLEURAL PRESSURE TO DRAW IN AIR. MEDIASTINUM SHIFTS TO THE UNINJURED SIDE. ON EXPIRATION: THE FLAIL SEGMENT BULGES OUTWARD, THUS IMPAIRING ABILITY TO EXHALE. MEDIASTINUM SHIFTS TO INJURED SIDE. IN SEVERE FLAIL CHEST, AIR MAY SHIFT USELESSLY FROM SIDE TO SIDE (PENDELLUFT) INDICATED BY BROKEN LINES

MANAGEMENT OF FLAIL CHEST

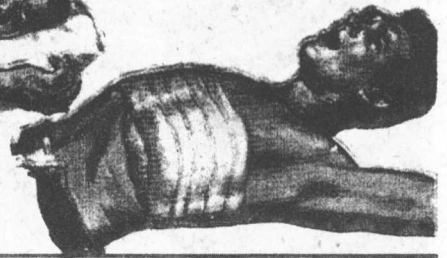
COMPRESSION METHODS (FIRST AID)



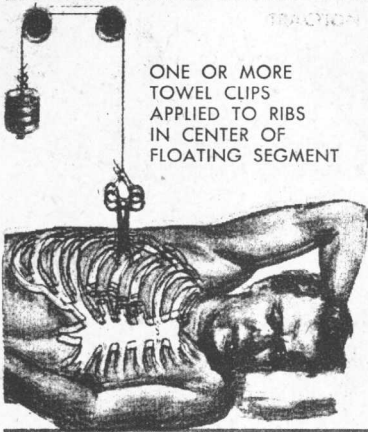
HAND PRESSURE



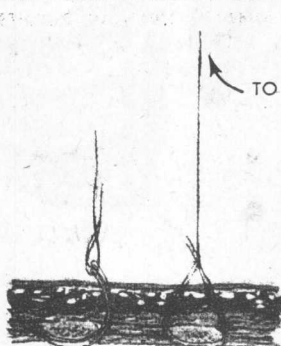
PLACING PATIENT ON AFFECTED SIDE WITH COMPRESSION BY PADDING (FOLDED COAT, BLANKET, SANDBAG, ETC.)



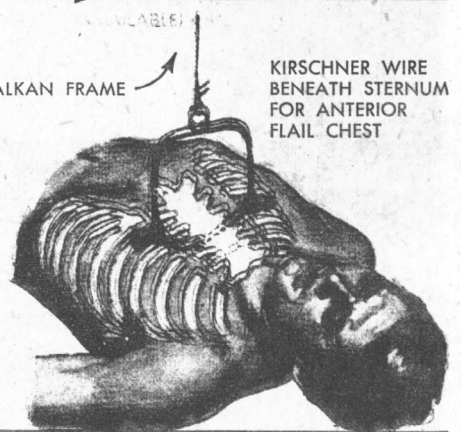
CIRCUMFERENTIAL STRAPPING OVER THICK, FIRM PAD



ONE OR MORE TOWEL CLIPS APPLIED TO RIBS IN CENTER OF FLOATING SEGMENT

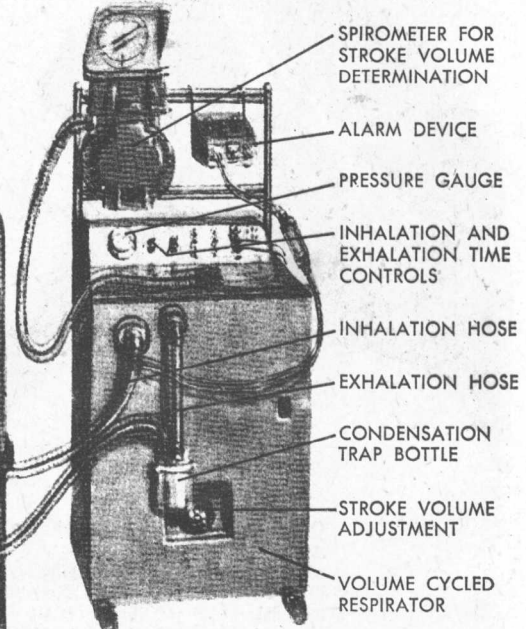
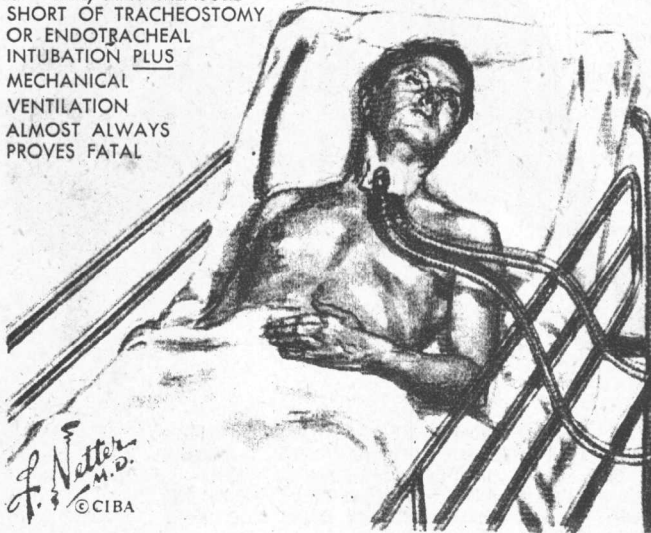


STAINLESS STEEL WIRE PASSED AROUND RIBS BY LARGE CURVED NEEDLE



KIRSCHNER WIRE BENEATH STERNUM FOR ANTERIOR FLAIL CHEST

FOR CRUSHED CHEST WITH MAJOR DEGREE OF FLAIL, ANY MEASURE SHORT OF TRACHEOSTOMY OR ENDOTRACHEAL INTUBATION PLUS MECHANICAL VENTILATION ALMOST ALWAYS PROVES FATAL



SPIROMETER FOR STROKE VOLUME DETERMINATION

ALARM DEVICE

PRESSURE GAUGE

INHALATION AND EXHALATION TIME CONTROLS

INHALATION HOSE

EXHALATION HOSE

CONDENSATION TRAP BOTTLE

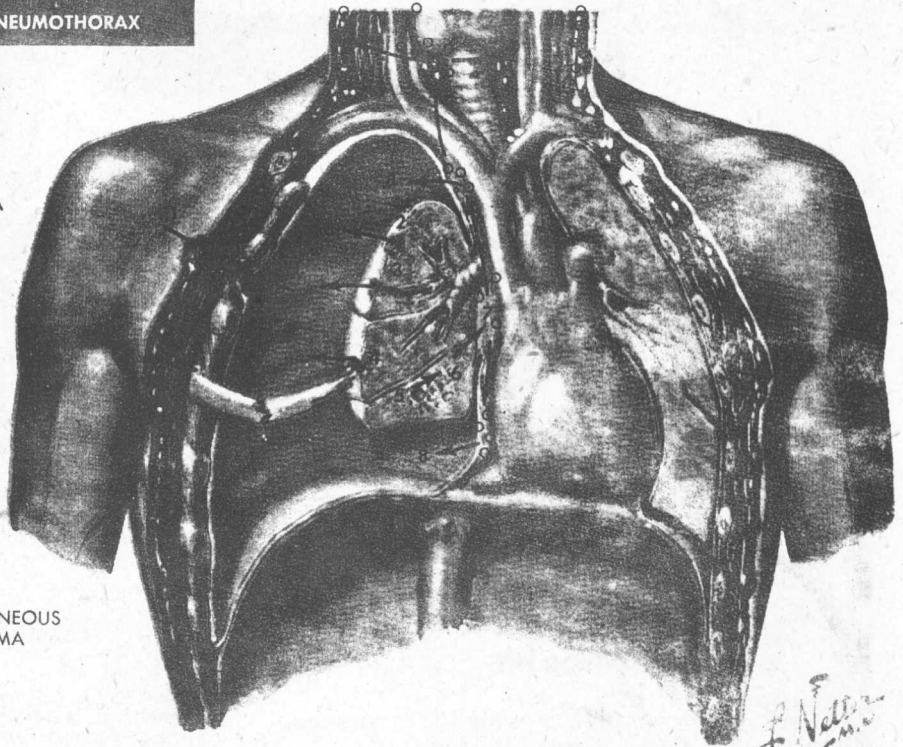
STROKE VOLUME ADJUSTMENT

VOLUME CYCLED RESPIRATOR

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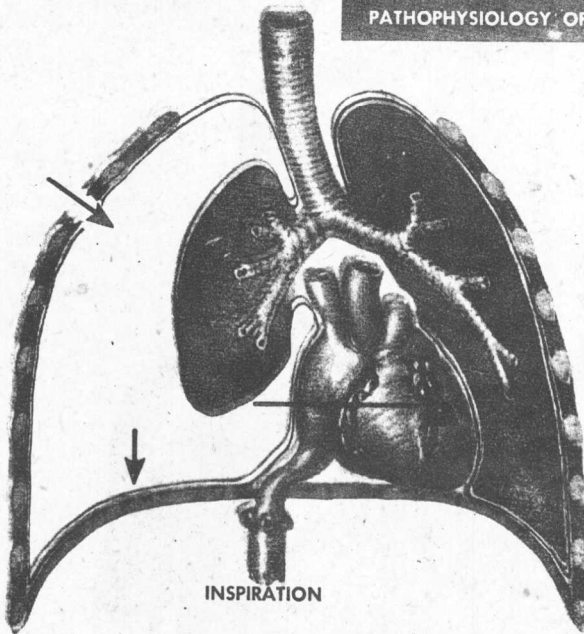
PATHOGENESIS OF PNEUMOTHORAX

- 1: PENETRATION OF CHEST WALL
- 2: LACERATION OF LUNG
- 3: PERFORATION OF BRONCHUS OR TRACHEA
- 4: TEAR OF LUNG BY INDRIVEN RIB FRAGMENT
- 5: RUPTURE OF ALVEOLI SECONDARY TO BLUNT TRAUMA OR STRAINING
- ↓
- 6: PULMONARY INTERSTITIAL EMPHYSEMA
- ↓
- 7: MEDIASTINAL EMPHYSEMA
- ↙ ↘
- 8: PNEUMO-THORAX 9: SUBCUTANEOUS EMPHYSEMA

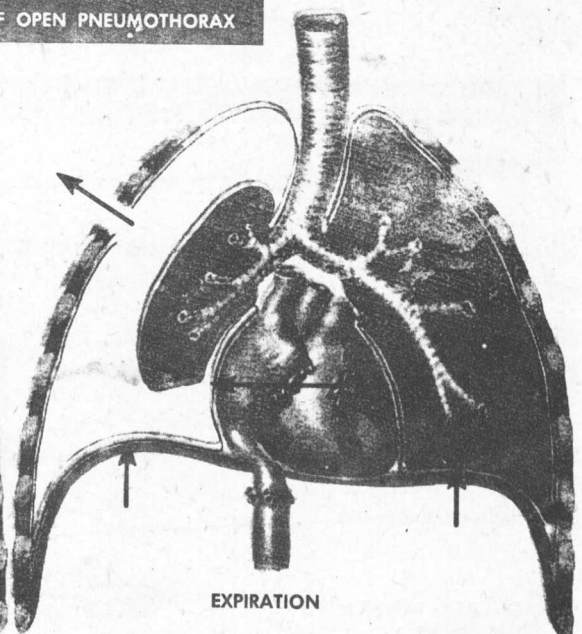


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PATHOPHYSIOLOGY OF OPEN PNEUMOTHORAX



AIR ENTERS PLEURAL CAVITY. NEGATIVE PRESSURE IS DIMINISHED OR LOST, COLLAPSING IPSILATERAL LUNG AND REDUCING VENOUS RETURN. SHIFT OF MEDIASTINUM COMPRESSES OPPOSITE LUNG AND IMPAIRS ITS VENTILATION



AIR IS EXPELLED FROM PLEURAL CAVITY. MEDIASTINUM SHIFTS TO AFFECTED SIDE. SIDE-TO-SIDE SHIFT (FLUTTER) OF MEDIASTINUM FURTHER REDUCES VENOUS RETURN BY DISTORTING VENAE CAVAE

PLATE IX

PNEUMOTHORAX