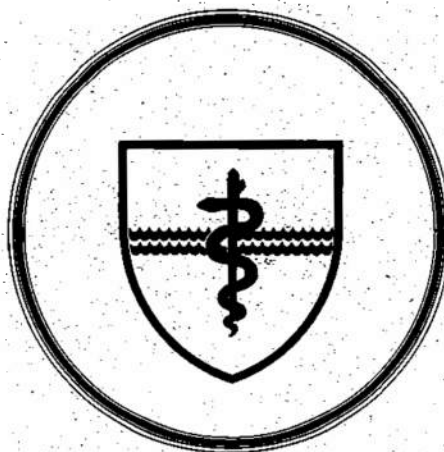


**NAVAL SUBMARINE MEDICAL
RESEARCH LABORATORY
SUBMARINE BASE, GROTON, CONN.**



REPORT NUMBER 1025

COMPUTER ASSISTED DIAGNOSIS OF CHEST PAIN

ADJUNCTIVE TREATMENT PROTOCOLS

by

LT Steven F. OSBORNE, MC, USNR

Naval Medical Research and Development Command
Work Unit #M0095PN.001-1045

Released by:

William C. Milroy, CAPT, MC, USN
Commanding Officer
Naval Submarine Medical Research Laboratory
30 July 1984

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SUMMARY PAGE

THE PROBLEM

To provide a manual of treatment protocols for use with the computer assisted diagnosis of chest pain system.

FINDINGS

Practical and helpful treatment protocols for use in chest pain disorders presenting at sea have been developed. There is a minimal need to procure medications that are not on the Authorized Medical Allowance List.

APPLICATION

Use of the treatment protocols will enable submarine Hospital Corpsmen to practically and efficiently manage the gamut of chest pain disorders that may present at sea.

ADMINISTRATIVE INFORMATION

This report was developed under work unit #63706N - M0095PN.001-1045 and was submitted for review in May 1984. It was approved for publication in July 1984 and has been designated as NAVSUBMEDRSCHLAB Report Number 1025.

Abstract

In support of the computer-assisted diagnosis of chest pain project, a chest pain treatment manual has been formulated. It is anticipated that this manual will be used by the Independent Duty (8402) Corpsmen stationed aboard patrolling nuclear submarines.

Treatment protocols are written for five diagnostic categories; namely, myocardial infarction (M.I.), angina (ANGINA), non-specific chest pain (NONSCP), pneumonia (PNEUMA), and pneumothorax (PNTHOR). Together, these categories account for nearly all causes of chest pain. Each protocol is divided into a discussion, differential diagnosis, treatment regimen, usual course with treatment, and complications and their management. Few medications are required that are not on the Authorized Medical Allowance List (AMAL). The protocols have been reviewed by a hospital-based internist and a Submarine Qualified Medical Officer, in addition to the normal review process.

I. INTRODUCTION

Medical evacuation from a patrolling nuclear submarine is costly in terms of risk to the patient, the expense of evacuation, and the compromise to the submarine's mission. The medical responsibilities are borne by the Independent Duty (8402) Corpsman who must independently diagnose and manage any serious illness which presents during patrol. This includes making recommendations regarding evacuation to a shore-based facility. His diagnostic task is complicated by mission constraints which often prevent communication with shore-based medical facilities and by the limited medical diagnostic facilities aboard nuclear submarines; lacking, for example, X-ray facilities and an electrocardiograph as well as many laboratory tests normally relied upon in the hospital or dispensary setting.

Chest pain is the second or third most common presentation of serious illness aboard ship, being clearly outnumbered only by abdominal pain cases. In the course of developing a system to assist in the diagnosis of chest pain syndromes, it became clear that ECG data was necessary. An attempt to pattern a system after the at-sea abdominal pain diagnostic system demonstrated inadequate efficacy. The chest pain diagnostic system is being re-evaluated using ECG data as an integral component. A breakthrough in technology has led to the development of a compact, three-channel ECG recorder which interacts by computer with the strip. Therefore, in anticipation of the upcoming availability of a revised system, an accompanying set of treatment protocols have been developed. They cover the diagnostic system's four specific categories of chest pain, namely myocardial infarction (M.I.), angina (ANGINA), pneumonia (PNEUMO), and pneumothorax (PNTHOR). In addition, a fifth category of non-specific chest pain (NONSCP) includes those entities which are vague and general and which are amenable to symptomatic treatment. Together, these five categories encompass almost all of the chest pain causes.

The treatment protocols are to be considered as suggestions; to be tempered and adapted by the corpsman with knowledge of the patient. They are brief and practical, having been reviewed by a hospital-based internist and a Submarine Qualified medical officer who instructs corpsmen in submarine medicine. Other approved references may be used to supplement these protocols when indicated.

II. DIAGNOSTIC CATEGORIES:

The diagnostic program is intended to specifically diagnose four of the most common and the most serious causes of chest pain in the submarine population. These categories are: acute myocardial infarction (M.I.), angina (ANGINA), pneumonia (PNEUMO), and pneumothorax (THORAX).

In addition, a fifth category termed nonspecific chest pain (NONSCP) is intended to include those conditions which are vague and general in nature and which are amenable to symptomatic treatment. Occasionally, the practitioner will pinpoint a "specific" diagnosis (i.e., esophagitis) in this category, but in all cases NONSCP is intended to encompass those conditions which are non-life-threatening and not a reason for medical evacuation.

There are several causes of acute chest pain (pulmonary embolism, pericarditis, aortic dissection) which are not included in the above categories, yet are of a serious nature. The program will yield the diagnosis of the category which most closely reflects the sign/symptom complex of a serious illness for which there is no specific category. Thus, the practitioner must utilize his clinical judgment both when gathering and entering the data and when interpreting the results of his computer interaction.

III. TREATMENT SUGGESTIONS:

The computer-assisted diagnosis program is designed to increase the standard of medical care for crewmembers who present with acute chest pain. Although designed primarily to function as a diagnostic aid, the program has been augmented with suggestions for treatment and some recommendations about MEDEVAC for each of the diagnostic categories. Since the causes and presentations of chest pain are so varied, treatment must be tailored to the individual patient and tempered with the clinical judgment of the practitioner. The practitioner must be confident in his diagnosis, prescribe a treatment regimen accordingly, and monitor the patient closely for indications that the treatment should be modified. Thus, these treatment protocols are SUGGESTIONS - to be viewed as advice and tempered with the practitioner's knowledge of his patient. You are urged to consult your textbooks and other approved references. The advantages of the suggestions below are their brevity, conformance with the AMAL, and practicality in isolated situations.

1. MYOCARDIAL INFARCTION:

DISCUSSION: Myocardial Infarction (M.I.) is a leading cause of mortality and morbidity in the population of the western, affluent civilization. In the United States, the annual incidence is approximately 1,000,000 cases weighted towards a middle age or older age group. Pre-hospital mortality approaches 50%. M.I. is acute necrosis of myocardium secondary to a sudden interruption or decrease of blood supply. Major risk factors are hypertension, hyperlipidemia, and smoking. Diabetes and angina are related risk factors unlikely to be presented in the submarine population.

A history of acute onset of crushing substernal chest discomfort radiating to the left arm and accompanied by diaphoresis, nausea, and a sense of impending doom is classic. The pain lasts longer than 20 minutes and is unrelieved by rest and nitroglycerin. Physical exam ranges from near-normal to obvious shock. An electrocardiogram (ECG) taken early in the course is abnormal less than 50% of the time, but may show ST elevation, T wave inversion, or evidence of left ventricular hypertrophy. Q waves appear later. Cardiac enzyme determination may be helpful but is unavailable at sea. Variations in the presentation are legion and well-documented. Diagnosis must be made on clinical grounds incorporating risk factors, the history and physical exam, the ECG (if available), and the practitioner's impression of the patient's overall conditions. Early mortality is most feared and is due to a lethal dysrhythmia. After 24 hours, the death rate declines steadily.

DIFFERENTIAL DIAGNOSIS: Other diagnoses which can mimic symptoms of myocardial infarction are:

- a) Pulmonary embolus
- b) Pericarditis
- c) Aortic dissection
- d) Acute pancreatitis
- e) Spontaneous mediastinal emphysema
- f) Angina - see ANGINA

a) Pulmonary embolus is heralded by an acute onset of dyspnea, pleuritic chest pain, apprehension, cough, and occasionally hemotysis. Substernal chest pain is present in less than 5% of the cases. Upon exam, tachypnea, tachycardia, diaphoresis, and rales may be noted. Differentiation from M.I. may be difficult but the dyspnea and tachypnea are prominent, whereas in M.I. pain is the chief complaint. If thrombophlebitis (calves, thighs) is noted, pulmonary embolism is most likely. The ECG will be normal or show tachycardia with or without T wave changes. Bedrest, O₂, leg elevation, pain medication, and anticoagulation are necessary, although the latter cannot be accomplished safely aboard ship.

b) Pericarditis is characterized by mild to severe precordial chest pain with fever, leukocytosis, and a pericardial rub. The pain is relieved somewhat by sitting up and leaning forward. High dose aspirin and bed rest are therapeutic. Occasionally, fever and/or leukocytosis are absent or minimal.

c) Aortic dissection is a medical/surgical emergency characterized by the acute onset of severe substernal chest pain radiating to the back. The patient may present in extremis. A diastolic heart murmur and significantly different upper extremity blood pressure readings may be noted. Treatment consists of bed rest with IV fluids, pain medication and immediate MEDEVAC. Blood pressure should be maintained with saline or Ringer's lactate through two large bore IV catheters.

d) Acute pancreatitis is characterized by moderate to severe epigastric pain radiating to the back. It is often associated with ulcer disease, cholecystitis, trauma, or alcoholism and may occasionally be confused with M.I. The abdominal exam will reveal epigastric tenderness not found with M.I. The ECG may be normal or show sinus tachycardia. Treatment consists of bowel rest, IV fluids, pain medication, and, perhaps, antibiotics.

e) Spontaneous mediastinal emphysema, while common in divers, is otherwise uncommon. The presentation involves precordial chest pain with, perhaps, a pleuritic component in an otherwise healthy-appearing individual. Subcutaneous emphysema may be palpable and a mediastinal crunch is noted upon auscultation. The ECG is normal. Treatment with an analgesic and reassurance is adequate.

f) Angina - see ANGINA.

TREATMENT: The goals of treatment of M.I. are to: 1) relieve the pain; 2) control dysrhythmias; 3) minimize infarct extension; and 4) compensate for compromised cardiac function. The patient should be placed in bed and an IV of D5W at KVO rate started.

Relief of pain is accomplished with bed rest and IV morphine sulfate 1-4 mg every 2-5 minutes as needed for pain relief up to a maximum of 10-15 mg in every 3 hour period. Dosages above this amount are rarely necessary and may be associated with CNS depression and hypotension. Morphine should probably be withheld if the systolic blood pressure is below

mm Hg. While there is no harm in trying sublingual nitroglycerin (NTG) initially, the pain of M.I. is classically unrelieved by NTG. If full relief is obtained with NTG, angina is a more likely diagnosis. Other narcotics (i.e. Demerol) also relieve the pain but are not discussed here.

CAUTION: Whenever IV narcotics are used, the opioid antagonist, naloxone (Narcon), should be immediately available. If the patient becomes unconscious while injecting morphine, 1-2 ampules (0.4-0.8 mg) of naloxone should be given IV and the ABC's of resuscitation employed as necessary. If the episode is due to narcotic overdose, consciousness will return within a minute or two. The pain will likely return and can be treated with morphine. The 10-15 mg maximum morphine every 3 hr may then have to be judiciously overstepped. **NOTE:** the duration of action of naloxone is less than of morphine. Such patients must be carefully monitored for 3 or more hours.

Control of ventricular dysrhythmias is accomplished through adequate dosage of lidocaine HCl. While in the past lidocaine was used only at the onset of an arrhythmia, the current weight of evidence points toward its use in the prophylaxis of dysrhythmia as well. The protocol is outlined below:

1) For documented PVC's or

V-tach : a) 75 mg IV - over 2 min at time zero
b) Start 2 mg/min drip
c) Re-bolus with 50 mg over 2 min at time 6 min, time 11 min, time 16 min (thus the boluses equal 75+50+50+50=225 mg)

2) For prophylaxis: a) 75 mg IV over 2 min at time zero
b) start 2 mg/min drip
c) May administer another 75 mg IV over 2 min at time 6 min.

The extent of the infarct is limited by bed rest, control of pain and (perhaps) by the use of supplemental O₂. The latter can be supplied at 2 liters/min by nasal cannula. Straining to have a bowel movement should be avoided. A Surfak® capsule po bid is used. Valium 5 mg po bid-qid may be used for control of anxiety in the awake, alert patient.

Loss of myocardial tissue leads to varying degrees of impairment of myocardial function. If rales are not heard upon chest exam and peripheral edema is absent, the impairment is (at least temporarily) adequately compensated.

USUAL COURSE WITH TREATMENT - Response to the therapeutic regimen will generally be good. Recurrence of pain with declining morphine blood

level is common and treated by readministration of morphine IV. Transient ventricular dysrhythmia may occur but is less common when lidocaine prophylaxis is given. Resolution of pain over the first 12-48 hours is accompanied by an increasing appetite, desire to ambulate, and (often) denial of the seriousness of the condition. The initial "ice-chip" diet can be advanced from clear liquids to a regular diet over 1-2 days as seems appropriate. Ambulation may begin on day 2 (minimal) and gradually advance to out-of-bed at lib by Day 7. Ladders should probably not be climbed until Day 7, and then sparingly. Lidocaine, morphine, and the IV may be discontinued at 48 hours. Three weeks of no duty is reasonable, with a gradual return to light duty. NTG should be available for post-infarction angina. Consultation with a medical officer ashore should be accomplished upon return from sea.

NOTE: a) The use of subcutaneous heparin until fully ambulatory is controversial. Heparin 5000 units subcutaneously q12h is generally safe and minimizes the chance of deep venous thrombosis.

b) It is advisable to draw a blood sample (10cc) daily, for 5 days, spin it down, and freeze the serum for possible enzyme analysis upon return. The analysis is possible even months after the event.

c) An ECG should be taken daily for 5 days. A previously non-diagnostic strip may later show an infarction or become normal, clarifying the initial impressions.

COMPLICATIONS AND THEIR MANAGEMENT - Uncontrolled dysrhythmias and cardiogenic shock are the complications of concern. Bursts of PVC's (or more than 5 per minute) and V-tach (3 successive beats) denote ventricular irritability which must be treated to minimize the chance of ventricular fibrillation or degenerating cardiac output. A 50 mg bolus of lidocaine over 2 min and an increase in the drip rate to a maximum of 4 mg/min is indicated. An additional 50 mg bolus in 5 min is safe if:

- a) the dysrhythmia continues and
- b) less than 300 mg of lidocaine have been given by bolus in the past 20 min.

Administration of amounts greater than 300 mg over 20 minutes is potentially toxic with seizures the most worrisome problem.

The cardiac compromise due to M.I. may be manifested by minimal rales and dyspnea or massive pulmonary edema with shock. Lasix[®] is the diuretic most used ashore for pulmonary congestion but it is not on the AMAL. It is recommended that it be obtained from the Squadron Medical Officer and used as outlined below. Fluid administration should be minimized.

First, sit patient up and administer O₂ by face mask at 5 liter/min

- a) minimal rales - Lasix 20 mg IV push
- b) moderate rales (halfway up the back) - Lasix 40 mg IV push
- c) pulmonary edema (pinkish froth from mouth and rales throughout lung fields) - Lasix 40 mg IV push, consider rotating extremity tourniquets.

The input and outputs should be monitored with a urinary catheter (indwelling type preferable). If Lasix® is unavailable, morphine works well, with or without rotating tourniquets. For example:

- a) minimal rales - morphine 5mg IV over 1-5 min
- b) moderate rales - morphine 5-10 mg over 1-5 min
- c) pulmonary edema - morphine 10 mg IV over 1-5 min, consider rotating tourniquets.

There may be a fine balance between unacceptable levels of hypotension caused by morphine or Lasix (sys BP < 100 mmHg) and pulmonary edema from cardiac failure.

Patients presenting with pulmonary edema and hypotension should be treated with O₂, rotating tourniquets, and Lasix 40 mg IV push. The upright posture is contraindicated if the patient is unconscious, otherwise a 30° sitting angle is reasonable. Morphine will exacerbate the hypotension but may be tried if Lasix is unavailable. Fluids to correct the hypotension may worsen the pulmonary edema, but they have been tried (100-300 cc Saline over 15-30 minutes). Needless to say, these individuals are gravely ill and have an in-hospital mortality of 80%. Aminophylline 5mg/kg (i.e. about 350 mg) in minimal diluent (D₅W) given over 15 min may help. Aminophylline is not on the AMAL.

2. ANGINA -

DISCUSSION - Relative myocardial ischemia from an imbalance in myocardial oxygen supply versus demand is believed to be the basis for angina pectoris. Risk factors are the same as for M.I. Angina (ANGINA) is commonly described as substernal chest pain, pressure, tightness, or burning sensation that may radiate to the left arm (or elsewhere). The discomfort is relieved within 1-5 minutes of resting and/or by nitroglycerin.

The physical exam is usually normal. Cardiac examination, during an episode of pain, may reveal an S₃ or S₄, a mitral regurgitant murmur, or a systolic bulge that disappears as the pain subsides. The ECG is usually normal but may show ST depression which later resolves. Cardiac enzymes are normal, although such testing is unavailable at sea.

Diagnosis is made on the assessment of the risk factors, the history and physical exam, the ECG, and the response to rest and nitroglycerin.

Variant or "rest" angina, also known as Prinzmetal's angina, is due to coronary artery spasm. There is a good response to nitroglycerin but not to rest. The ECG may show transient ST elevation.

Recurrent and frequent episodes of angina may be a harbinger of impending M.I. These episodes may occur given less cardiopulmonary stress and be less responsive to rest and nitroglycerin than in typical stable angina.

DIFFERENTIAL DIAGNOSIS - Typical angina is occasionally simulated by these other categories of chest pain:

- a) Myocardial Infarction - see M.I.
- b) Esophageal spasm
- c) Other causes of chest pain - see NONSCP

b) Esophageal spasm - The pain of esophageal spasm is felt substernally in the midchest or epigastrium. The pain may follow a meal and is accompanied by dysphagia. The pain is often relieved by NTG, making differentiation from classic angina difficult. The concomitant dysphagia and lack of relationship to exercise may be helpful in diagnosis.

TREATMENT - Angina is readily treated with rest and sublingual (SL) NTG. With the patient sitting up, a 0.4mg ("1/150 grains") tablet is given SL. The resulting sublingual burning sensation and (occasionally) throbbing headache are accompanied by a gradual easing of pain over 1-5 minutes. If relief is incomplete, the dosage may be repeated at 5 min intervals to a total of 3 tablets.

USUAL COURSE WITH TREATMENT - The pain of angina often resolves within 5 minutes of rest and NTG administration. A residual nagging substernal discomfort of low grade intensity may persist and should be treated with continued rest and NTG administration. Headache from NTG can be treated with acetaminophen 650 mg po q4h.

One day of rest and observation is sufficient if there is no recurrence of pain and a follow-up ECG is normal. Light duty should be recommended for the remainder of the deployment. Smoking and heavy exertion are proscribed. Caffeine intake (coffee, colas) and meal amounts should be diminished if previously heavy. Blood pressure, if elevated, should be controlled with hydrochlorothiazide 50mg po qd and reduced salt intake with diet.

COMPLICATIONS AND THEIR MANAGEMENT - Hypotension from repeated administration of NTG is a possibility. It is easily treated by placing the patient in the Trendelenberg position (head down, legs up). If necessary, a 300 cc bolus of saline can be administered IV. The short duration of action of NTG leads to normalization of the BP within 5-10 minutes.

If, after days of relief from pain, there is a gradual return of chest pain, the patient should be re-examined. If the history and physical point to angina and there is relief with rest and NTG, there is no cause for alarm. The 24-hour bed rest and limitation of physical effort (with elimination of smoking, etc.) should be reinstituted. A follow-up ECG may be useful as in the initial evaluation, but needn't be repeated for each episode of angina.

Occasionally, there will be a rapid return of chest pain following an initial period of relief. If bed rest and three doses of NTG were utilized, then this a worrisome symptom. If but minutes to perhaps an hour has passed, then impending infarction or actual infarction may be occurring. The treatment suggestions for M.I. should now be employed -- bed rest, IV D W KVO, morphine for pain, dysrhythmia prophylaxis, etc.

3. NON-SPECIFIC CHEST PAIN:

DISCUSSION - Non-specific chest pain (NONSCP) is intended to encompass those disorders which are not serious and not a cause for medical evacuation. Pain in this category is often more annoying than worrisome to patients. This aspect is helpful in diagnosis.

The likelihood of chest pain being due to non-specific causes varies with the age of the patient and clinical circumstances of the case. In a young adult without previous or recent medical illness, a serious cause for chest pain is unlikely.

Non-specific causes for chest pain include: a) musculoskeletal pain; b) costochondritis (Tietze's syndrome); c) esophagitis; d) esophageal spasm ("esophageal angina"); e) hyperventilation syndrome; f) psychoneurotic disorder; g) epigastric lesions (cholelithiasis, peptic ulcer, etc.).

Musculoskeletal pain and the pain of costochondritis denote muscle, rib, or cartilage pain due to inflammation or trauma. The pain is often sharp, of moderate intensity, localized to the chest wall, and reproduced by direct manipulation of the affected area. The lung exam is normal. Treatment includes mild analgesics, heat therapy, and, perhaps, rest.

The pain of esophagitis and esophageal spasm is felt substernally in the mid-chest and/or epigastrium. Esophagitis is caused by direct irritation from food or drink, by reflux of gastric contents, or by infection (the latter is uncommon in healthy people). There is a good response to liquid antacids, a fact which assists in diagnosis. Esophageal spasm may follow a meal and is accompanied by dysphagia. The pain is relieved by nitroglycerin, making differentiation from classic angina difficult. The concomitant dysphagia and lack of relationship to exercise may be helpful in diagnosis.

Hyperventilation syndrome is a relatively common cause of chest discomfort in an (already) anxious person. The accompanying breathlessness, palpitations, weakness, and response to re-breathing techniques are diagnostic. The lung exam is normal.

In psychoneurotic disorders, no physical etiology for chest pain is found. This diagnosis is best made by those skilled in psychiatric evaluation. It should be assumed that crewmembers with chest pain have a physical etiology for chest pain.

Disorders that present with epigastric pain such as gastritis, peptic ulcer, pancreatitis, and cholelithiasis may occasionally be confused with chest pain disorders. In most of these disorders, the abdominal exam is revealing -- any abdominal tenderness points to a non-chest source of the pain. The key issue is to avoid overlooking an atypical presentation of M.I. The assessment of risk factors, the history and physical exam (chest, and abdominal), and the ECG are helpful in this regard.

DIFFERENTIAL DIAGNOSIS - Non-specific chest pain is occasionally confused with:

- a) Myocardial Infarction - see M.I.
- b) Angina - see ANGINA

In general, vital signs are normal in non-specific chest pain disorders. A good appearance coupled with normal blood pressure, pulse, respiration, and temperature suggest a non-alarming etiology of the discomfort. A normal ECG or a finding of sinus tachycardia is typical.

TREATMENT - Most of these disorders respond well to symptomatic therapy. Musculoskeletal pain responds well to aspirin and heat. Costochondritis may require a more effective anti-inflammatory agent than aspirin for optimal treatment (i.e., indomethacin, not on the AMAL). It may, however, be managed with aspirin, . 3 tabs po q4h. Codeine 30-60mg po q4h may be added, if necessary.

Esophagitis is treated with (preferably) a liquid antacid regimen, 1 oz po q1-4h prn, with about a 7 oz maximum per day. Coffee intake and smoking should be eliminated.

Esophageal spasm responds to NTG and a liquid or soft diet. Food should be chewed well and taken with fluid, although this offers no guarantee of non-recurrence. The NTG should be used sparingly, and a medical consult obtained when ashore. Sometimes the spasm resolves without medication in minutes to hours of simply "waiting it out."

Hyperventilation responds to reassurance and bag re-breathing. A 15 minute effort of both will usually calm the individual. Rarely is medication indicated. If necessary, Valium 5 mg po may be given. Parental medication and oxygen therapy are unnecessary. The patient should be encouraged to treat recurrences with re-breathing on his own.

Treatment of epigastric disorders is covered in separate publications.

USUAL COURSE WITH TREATMENT - Most non-specific chest pain disorders stabilize and improve following diagnosis. The simple reassurance that the disorder is not serious will lead many individuals to improve with modest therapy.

COMPLICATIONS AND THEIR MANAGEMENT - Musculoskeletal pain, costochondritis, and esophagitis are uncomplicated. Epigastric disorders can be complicated (i.e., bleeding ulcer, cholecystitis) but are discussed in other publications.

Esophageal spasm can become nearly disabling requiring esophageal dilation by a specialist. If episodes become frequent and poorly responsive to NTG or a "waiting period," then a liquid diet may help.

Recurrent, prolonged hyperventilation episodes alarm the patient and surrounding personnel. They should not be ignored. Valium 5 mg po tid and an appropriate modification of duty may be necessary for a few days.

4. PNEUMONIA:

DISCUSSION: Pneumonia (PNEUMO) is an alveolar infection caused by a bacterium, virus, or other non-bacterial pathogen. Pneumococcal (bacterial) pneumonia is most likely in the isolated case. Mycoplasma and viral pneumonia (both are non-bacterial) are more common in outbreaks of pneumonia involving groups of people who are ill. Chest pain as a component of pneumonia is due to pleural or bronchial irritation. The pain may be felt anywhere in the thorax and is exacerbated by coughing or deep breathing. The "pleuritic component" to the pain distinguishes it from M.I. or ANGINA. Additionally, pneumonia is characterized by coexisting or recent upper respiratory tract symptoms, malaise, anorexia, fever, chills, cough, and sputum production. Dyspnea, tachypnea, and tachycardia may be present.

Physical exam reveals varying degrees of vocal fremitus, egophony, dullness to percussion, rhonchi, and rales. These signs are worse with bacterial pneumonia and generally less severe in case of a non-bacterial etiology.

A lung infiltrate is usually visible on chest roentgenogram, but this study is unavailable aboard ship. The white blood cell count is elevated in bacterial pneumonia, but near-normal or depressed otherwise. Mycoplasma pneumonia is common in young adults and varies in appearance from the milder illness of a viral pneumonia to the more serious bacterial pneumonia. A right lower lobe pneumonia will occasionally present as abdominal discomfort in a younger person. A compatible history and rales in the lung field, that do not clear with cough, are the best indicators of the presence or absence of pneumonia. The ECG is normal except for sinus tachycardia.

DIFFERENTIAL DIAGNOSIS - Pneumonia is clinically distinguishable from other chest pain syndromes. The complex of malaise, anorexia, fever, cough, sputum production, rales, rhonchi, tachypnea, tachycardia, and pleuritic chest discomfort is diagnostic.

Once the diagnosis of pneumonia has been made, the major differential diagnostic challenge is to distinguish a bacterial from a non-bacterial pneumonia. The sputum gram stain is invaluable in this regard. For this reason, microscopic analysis of a gram-stained sputum specimen should be performed. The sputum should be collected after coughing and should not have the appearance of saliva. A precleaned slide should be liberally smeared with purulent sputum, allowed to air dry, heat-fixed, gram-stained, and examined first under low power (to select a suitable area for viewing) then under high power. Only slides with rare or no epithelial cells should be

accepted for viewing. Multiple epithelial cells denote a poor sputum specimen; if this is seen a new specimen should be obtained.

Interpretation of the nuances of a sputum smear requires experience. Basically, one is looking for: A) white cells (appear red) with minimal or no bacteria, or B) white cells with a plethora of bacteria. In instance "A" a non-bacterial (viral or mycoplasma) pneumonia is likely. In instance "B" a bacterial pneumonia is likely. A smear with white cells and bacteria requires further differentiation into a gram positive cocci-laden smear or a gram negative bacilli-laden smear. A smear with predominantly gram negative cocci or gram positive bacilli usually suggests a contaminated (poor) specimen since these are common organisms in the upper respiratory tract but rarely cause pneumonia.

Smears with: C) no white cells but many bacteria, or D) some white cells and a mix of different bacteria, both represent non-diagnostic smears. Another smear should be made in these cases.

In some instances, the patient cannot produce an adequate sputum specimen or the smear cannot be easily categorized as "A" or "B". The following clinical generalities may help differentiate a bacterial from non-bacterial pneumonia when smear results are inconclusive.

- Clinical generalities:
1. Scanty sputum seen more often in non-bacterial pneumonia.
 2. A normal or minimally elevated temperature (<101 F oral) seen more often in non-bacterial pneumonia.
 3. Myalgias and headache commonly found in mycoplasmal or viral pneumonia, less commonly in bacterial pneumonia.
 4. Rusty brown sputum seen in pneumococcal (a bacterial) pneumonia.
 5. Pleuritic chest pain suggests bacterial pneumonia.
 6. Severe shaking chills seen in bacterial pneumonia.

TREATMENT: The treatment of pneumonia consists of bed rest, hydration, adequate nutrition, an antipyretic, an antitussive, an antibiotic, and, possibly, an analgesic if pleuritic chest discomfort is disabling. Smoking is proscribed. Patients with dyspnea should receive supplemental humidified oxygen, the method of delivery and the flow rate dependent upon the degree of dyspnea.

Bed rest is essential for 48-96 hours, perhaps longer. Brief walks are advised; ladders are best avoided because of the often profound weakness accompanying pneumonia. Fluids, 16 oz po qid, help to maintain fluid respiratory secretions. At least one half-normal meal per day is needed. Aspirin or acetaminophen, 650 mg po q4h (when awake) relieve fever, headache and general discomfort. An antitussive (not quaifenesin - an expectorant) is

appreciated by patients and is not harmful. If Robitussin DM[®], or its equivalent is not available (not on AMAL) then codeine 7.5-15 mg po q4h can be added to quaifenesin 1-2 tsp po q4h.

An antibiotic is not indicated in viral pneumonia but is usually used in mycoplasma pneumonia and is always used in bacterial pneumonia. Viral and mycoplasma pneumonia are not distinguishable on clinical exam (chest x-ray, cold agglutinis, etc. are used ashore). Since an antibiotic is usually used in adults for mycoplasma pneumonia, it is best to start therapy when pneumonia is diagnosed at sea. Erythromycin 250-500 mg po qid (1st line) or Tetracycline 350-500 mg po qid (2nd choice) is used. Duration of therapy is 10-14 days.

For a gram positive bacterial pneumonia, penicillin 500 mg po qid is satisfactory. If the patient appears particularly ill, Penicillin G Procaine 500,000 units may be given IM, followed by the oral regimen. The penicillin-allergic patient should receive erythromycin 500 mg po qid. Duration of therapy is 10-14 days. It may require an extension of 7-14 days in some cases.

Gram negative bacterial pneumonia is unusual in a previously healthy person. The gram stain of the sputum should be repeated with a fresh specimen to reaffirm the diagnosis. If the staining and decolorizing procedure were carefully accomplished and the sputum sample was good, then treatment must be initiated with this diagnosis. The gram negative rod pneumonias are serious. Antibiotic therapy should be given parenterally. A two drug regimen of penicillin and gentamycin will cover a) most gram negative organisms and b) most gram positive organisms should there be a misleading gram stain. An example is as follows:

Penicillin-Gentamycin Regimen:

Penicillin 4-6 million units/day (depending on patient weight) by IV. Dilute and infuse per package insert.

Gentamycin 1.5 mg/kg q8h IV (or IM). (For IV, dilute with 50-200 ml of IV solution and infuse over 1/2 to 1 hr).

Erythromycin 500 mg po qid or cephapirin sodium 100 mg IV (or IM) q4-.6h may be substituted for penicillin in the penicillin-allergic patient. Cephapirin should only be used if the patient is quite ill and cannot tolerate oral erythromycin because of the 5-10% cross allergenicity with penicillin.

Parenteral therapy should be continued for 14 days. Monitoring the WBC count every 24-48 hours may help in assessing the adequacy of therapy. The IV site should be changed every 72 hours during this period. A medical consult should be obtained when ashore as this illness is unusual in healthy people.

Pleuritic chest pain can be quite disabling if left untreated, leaving the patient reluctant to cough or breathe deeply. Aspirin 650-975 mg po q4h will help somewhat. Codeine 15-60 mg po q4h may be added to the

aspirin, if necessary. Ideally, Motrin® 400 mg po q4-6h or Indocin® 50 mg po q8h should be used (if available) rather than aspirin or codeine. Both medications may be obtained from the Squadron Medical Officer. With the latter, sufficient pain relief requires dosages more likely to cause GI side effects and over-inhibition of coughing.

USUAL COURSE WITH TREATMENT - Viral and Mycoplasma pneumonia are generally self-limiting illnesses regardless of therapy. In 1-2 weeks the patient is well and may return to duty. Fatigue may persist for another 1-2 weeks, so continued rest is important. Half-shifts may be recommended at first until strength is normal.

Gram positive pneumonias respond well to the general measures plus an antibiotic. A classic defervescence occurs after a few days of antibiotic therapy. This is marked by a return of a feeling of well-being and recovery. Sufficient rest and limited duty are handled as above.

Gram negative pneumonias respond more slowly to antibiotic therapy as the patient is generally sicker to begin with. A modification of therapy should not be undertaken for at least 48-72 hours unless the course continues downhill. Gradual recovery of 10-14 days is usual but not guaranteed. If recovery seems near complete at 14 days, there isn't a need to continue antibiotic therapy. Such patients should be carefully monitored for another two weeks with rest and limited duty.

COMPLICATIONS AND THEIR MANAGEMENT - Complications from pneumonia are generally prevented by early institution of appropriate antibiotic therapy. Those complications that may occur can be separated into two categories: a) progression of the pneumonic infection; b) development of an empyema.

Progression of the pneumonic infection is marked by worsening cough, fever, tachycardia, dyspnea, tachypnea, cyanosis, and impaired consciousness. Humidified oxygen should be delivered by a face mask at 5-10 liters/min. Antibiotic therapy should be switched to and given intravenously as follows:

Penicillin-Gentamycin Regimen:

Penicillin 4-6 million units/day (depending on patient weight) by IV. Dilute and infuse per package insert.

Gentamycin 1.5 mg/kg q8h IV (or IM). (For IV, dilute with 50-200 ml of IV solution and infuse over 1/2 to 1 hr).

Erythromycin 500 mg po qid or cephapirin sodium 1000 mg IV (or IM) q4-6h may be substituted for penicillin in the penicillin-allergic patients. Cephapirin should only be used if the patient cannot tolerate oral erythromycin, because of the 5-10% cross-allergenicity with penicillin.

Fluid intake should be monitored and limited to about 2-3 liters per day (total po + IV) unless clear evidence of dehydration is present.

Fever and tachypnea increase the fluid requirements. The patient should be sitting up at a 30-45° angle to assist breathing.

As it is now mandatory to isolate the causative organism and administer specific therapy, arrangements for MEDEVAC should be made at once.

Empyema refers to a purulent exudate in the pleural cavity. In the setting of pneumonia, it occurs by extension of the pulmonary infection into the pleural space. It is seen clinically as relapse following an initial improvement or as a failure to improve after several days of antibiotic therapy. This is in contrast to the progressive downhill course in fulminant infection due to an antibiotic-resistant organism. Empyema is a complication of 5-15% of the cases of pneumonia, is generally caused by the original infectious agent, and is generally responsive to higher doses of an appropriate antibiotic. Surgical drainage through repeated needle aspirations or chest tube placement is occasionally necessary.

Chest roentgenogram, clinical appearance, and analysis of a sample of pleural exudate are used ashore for diagnosis. Of these measures, only clinical appearance and physical exam can be employed at sea. If persistent fever, leukocytosis, and ill appearance are present with (usually) unilaterally decreased breath sounds and dullness to percussion at the lung base, empyema should be assumed to be present. Most organisms causing bacterial empyema are sensitive to penicillin. High doses by the intravenous route must be employed. Oral therapy is suboptimal. The regimen employed is:

Penicillin G 3 million units IV q4h (12 million units per day). Dilute and infuse per package insert.

The therapy should continue for 10-14 days from diagnosis.

In the penicillin-allergic patient, it is probably best to use Cephapirin 2 grams IV q4h (12 grams per day). The risk of inadequate treatment with an oral antibiotic is great compared to the small chance of anaphylaxis from an allergic reaction. However, if an allergic reaction occurs, it can lead to death in minutes. One should be prepared to handle a severe allergic reaction by: a) having two large bore (16G-18G) catheters in place with two 1000cc bags of saline hung; b) having a syringe with 0.3-0.5 mg epinephrine and another with 50 mg Benadryl® ready for IV usage; c) having standby help available; d) starting with a small test dose (e.g. 0.1%-1% of anticipated dose).

Should the patient already be on other antibiotics for the initial pneumonia syndrome, these may be continued. There is no firm rule for handling this complication.

If improvement on high dose penicillin is not seen in 48-72 hours, the need for surgical drainage is likely. Consideration for MEDEVAC should be made in this instance.

5. PNEUMOTHORAX:

DISCUSSION: Pneumothorax (THORAX) involves a degree of collapse of a lung secondary to entrance of air into the potential space between visceral and parietal pleura. Spontaneous pneumothorax develops de novo from rupture of an existing pulmonary bleb or occurs during respiratory infection. Cough or another mechanism whereby intra-alveolar pressure is elevated may be a precipitating factor. Penetrating chest trauma, rib fracture, and barotrauma from diving or flying accidents are other causes.

There is an acute onset of chest discomfort on the side of the pneumothorax, with a pleuritic quality to the discomfort. Dyspnea, tachypnea, and cyanosis may be present with a large pneumothorax.

Physical exam reveals absent breath sounds and tympany overlying the pneumothorax. The trachea may be deviated away from the affected side. There is no fever or accompanying respiratory infection, unless pre-existent. Subcutaneous emphysema may be present in the chest wall or neck area if the parietal pleura is torn. The ECG will show sinus tachycardia.

The pneumothorax is visible on chest roentgenogram, although this study is unavailable on a submarine. White blood cell count is normal unless there is acute distress, whereupon it might be elevated moderately. Occasionally, a "one-way valve" effect exists leading to the life-threatening tension pneumothorax. Usually, the non-tension pneumothorax stabilizes within a few minutes.

DIFFERENTIAL DIAGNOSIS - Other diagnoses which can mimic symptoms of pneumothorax are those in which an element of pleuritic chest pain and/or dyspnea is present.

- a. Musculoskeletal pain
- b. Pleurisy
- c. Pulmonary embolus
- d. Spontaneous mediastinal emphysema

a) Musculoskeletal chest pain is due to inflammation or trauma. The pain is often sharp, of moderate intensity, localized to the chest wall, and reproduced by direct manipulation of the affected area. While deep breathing may exacerbate the pain, there is no dyspnea and the lung exam is normal. Treatment includes mild analgesics, heat therapy, and, perhaps, rest.

b) Pleurisy denotes inflammation of the pleura. It is seen in the setting of bronchitis or pneumonia; the symptoms of both assist in differentiating pleurisy from pneumothorax. Chest discomfort is pleuritic. Unless there are signs of pneumonia, lung exam is normal except for a friction rub. Treatment includes rest, analgesics and an antitussive medication.

c) Pulmonary embolus is heralded by an acute onset of dyspnea, pleuritic chest pain, apprehension, cough, and occasionally hemoptysis. Upon

exam, tachypnea, tachycardia, diaphoresis and rales may be noted. There will be no areas of absent breath sounds, a fact which helps to differentiate this syndrome from a pneumothorax. Treatment includes bed rest, O₂, leg elevation, pain medication, and anticoagulation. Anticoagulation cannot be accomplished safely aboard ship.

d) Spontaneous mediastinal emphysema, while common in divers, is otherwise uncommon. The presentation involves precordial chest pain with, perhaps, a pleuritic component in an otherwise healthy-appearing individual. Subcutaneous emphysema may be palpable and a mediastinal crunch is noted upon auscultation. Treatment with an analgesic and reassurance is adequate.

TREATMENT: Most cases of pneumothorax stabilize within minutes or so, leaving a degree of pleuritic chest pain, dyspnea, tachypnea, and tachycardia. The extent of symptomatology depends upon the extent of the pneumothorax. In a young, healthy person, simple bed rest, reassurance, and a mild analgesic suffice. Oxygen at 2 liters/min. by nasal cannula should be used for up to 24 hours. An antitussive (i.e., codeine 15 mg po q4h) should be added if a cough is problematic. Monitoring the patient every 15 minutes for the first few hours of symptoms is important. If stable for 6 hours, less frequent monitoring (qid x 1 day) is fine. It is wise to limit duty until symptoms resolve and the breath sounds are normal. This may take 2-7 days.

USUAL COURSE WITH TREATMENT: Most cases of pneumothorax require close observation for a few hours, minimal treatment, then limited duty for several days until symptoms clear.

COMPLICATIONS AND THEIR MANAGEMENT: The complications of a pneumothorax are: a) respiratory distress due to an extensive pneumothorax; and b) tension pneumothorax.

Healthy adults can sustain complete collapse of one lung without threat to life. The complete collapse may occur at once or as an extension of a smaller pneumothorax. Symptoms will be severe dyspnea at presentation (or worsening dyspnea if due to extension of smaller pneumothorax), tachypnea, tachycardia, and pleuritic chest pain. Absent breath sounds and hyper-resonance throughout one lung field are noted. A non-deviated trachea, lack of cyanosis, and a stable (normal) blood pressure may be found. Treatment includes bed rest, O₂ by face mask at 5-10 liters/min and frequent re-evaluation in the early stages. An antitussive is best avoided. Since morbidity is greatly prolonged without chest tube placement, and since the placement of a tube is not a trivial procedure, a recommendation to MEDEVAC should be made. If the patient labors too long in attempting to breathe, respiratory muscle fatigue may ensue. If this situation occurs prior to MEDEVAC, while maximal O₂ therapy has been used, then the protocol below (tension pneumothorax treatment) should be employed as a last resort.

Tension pneumothorax is a life threatening complication of a simple pneumothorax. It results from a "one-way valve" effect wherein air enters the

pleural space with each inspiration but cannot be expelled with expiration. The pressure in the pleural space exceeds atmospheric pressure and the lung collapses. Onset may be insidious (hours) or rapid (minutes). Exam reveals a severely ill patient with dyspnea and shock. The trachea is deviated away from the affected side, breath sounds are absent on the affected side, and tympany overlying the pneumothorax is noted. Removal of air may be lifesaving; failure to do so may well prove fatal to the patient. Following treatment, a MEDEVAC should be arranged.

Air may be removed by inserting a 19-gauge (or larger) needle (with catheter) into the chest anteriorly or laterally over the site displaying absent breath sounds and an enhanced percussion note. Safe sites are: a) 2nd intercostal space at the mid-clavicular line; b) 5th intercostal space at the mid-axillary line. The needle should be inserted at the superior border of the respective rib. The intercostal arteries lie just inferior to the ribs and must be avoided. Often a rush of air is felt and heard following this procedure and the patient shows remarkable improvement. The needle should be attached to a large syringe with a 3-way stopcock between the needle and syringe. Further suctioning will be helpful. When no more air can be suctioned, the needle is removed leaving the catheter in the pleural space. It is safe to simply pull the needle, stopcock, syringe assembly out, pushing the catheter in at the same time. A Penrose or similar collapsible rubber drain/tube is tied tightly to the catheter hub and left open. The needle should not be left in the chest as laceration of the lung parenchyma may occur with each inspiration of the re-expanded lung. The catheter hub may be affixed to the chest wall via a skin suture with a tight loop about the hub. This prevents accidental removal and recurrent tension pneumothorax. The catheter should be left in for at least 72 hours while awaiting MEDEVAC.

CAUTION: Because of the obvious risks associated with the above procedure, it should only be attempted when the diagnosis is reasonably certain and the crewmember appears extremely ill. If you're not sure, don't try it. If the crewmember goes into shock and becomes unconscious, breath sounds are unilaterally absent, and tympany is noted, then failure to attempt the procedure will lead to certain death.

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Item 20-- (NONSCP), pneumonia (PNEUMA), and pneumothorax (PNTHOR). Together, these categories account for nearly all causes of chest pain. Each protocol is divided into a discussion, differential diagnosis, treatment regimen, usual course with treatment, and complications and their management. Few medications are required that are not on the Authorized Medical Allowance List (AMAL). The protocols have been reviewed by a hospital-based internist and a Submarine Qualified Medical Officer, in addition to the normal review process.

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