What to do With a Patient Who Has Chest Pain?
CP

Rule-based system

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1. Introduction

CP is a rule-based system that helps a doctor determine what actions should be taken for a patient who comes to his office complaining of chest pain. For example, if the doctor feels that a patient is in danger of a heart attack, the doctor will send the patient to the emergency room (ER) by ambulance. If, on the other hand, the patient has symptoms suggesting esophageal disease, the doctor will evaluate and treat the patient. CP is programmed in Joshua, a rule-based system that performs backward and forward chaining on rules that have importance and confidence ratings.

CP is a backward chaining rule-based system that gives a confidence rating of 1.0 and an importance rating of 99 to all rules. CP is problematic because it prompts the user for lots of inputs. Chest pain diagnosis is a meaty domain with lots of factors to take into account. CP does not exhaustively handle all symptoms and/or causes of chest pain, but rather CP covers most of the common cases. Future implementations of CP should diminish the number of questions prompted to the user, add importance and certainty ratings to the rules, and exhaust the domain of chest pain even further.

2. What does CP do?

2.1 Example

CP determines between six possible actions to take on a patient who complains of chest pain:

1.) Send to ER by ambulance
2.) Send to ER unaided
3.) Evaluate and treat
4.) Treat only
5.) Evaluate only
6.) Send home

These actions on patients are generalized. For example, a patient with gastrointestinal problems may be treated with antacids and instructed to drink lots of water, but CP only specifies that the patient is to be treated. Similarly, how a patient is evaluated is ambiguous. The clearly specified actions are when patients are sent to the ER by ambulance or sent home. Patients sent to the ER unaided usually drive to the ER, but this does not rule out other means of reaching the ER such as being driven or taking public transportation.

The following conversation was had with CP. A 30 year old man comes into the doctor's office complaining of sharp chest pain. The patient newly experienced a syncope (loss of consciousness), he has T-wave and ST inversion on his EKG, the pain radiates to the interscapular region (shoulders), and the pain lasts 15 minutes at a time. The patient has no other symptoms. The following dialogue is cumbersome to follow because it asks lots of irrelevant questions and uses lots of medical jargon:

;;The program is attempting to answer what should be done to the patient by checking all
;;possible actions that could be taken on the patient. This is why all base level inputs are
asked of the user. Relevant inputs are highlighted in bold.

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Is it the case that FREDDY's pain lasts less than two seconds: No

Is it the case that FREDDY has too much diarrhea to keep up by
drinking: No

Is it the case that FREDDY's pain is relieved by antacids: No

Is it the case that FREDDY has excessive release of watery feces: No

Is it the case that FREDDY has dysphagia: No

Is it the case that FREDDY's pain is aggravated by meals: No

Is it the case that FREDDY does eat and taste again: No

Is it the case that FREDDY's EKG has loss of R wave: No
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Is it the case that FREDDY's EKG has ST inversion: Yes

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Is it the case that FREDDY's EKG does have ST elevation: No
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Is it the case that FREDDY's EKG has T wave inversion: Yes

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Is it the case that FREDDY has burning substernal pain: No

Is it the case that FREDDY has belches: No

Is it the case that FREDDY's pain is aggravated by respiration: No

Is it the case that FREDDY's pain is aggravated by lying down: No

Is it the case that FREDDY has a headache: No

Is it the case that FREDDY has pounding on one side of head: No

Is it the case that FREDDY has tightness in front of head or back of
neck: No

Is it the case that FREDDY's pain is relieved by medication: No

Is it the case that FREDDY's pain is relieved by sublingual
nitroglycerine: No

Is it the case that FREDDY's pain is relieved by nitrates: No

Is it the case that FREDDY has night pain: No

Is it the case that FREDDY has heartburn: No
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Is it the case that FREDDY coughs : No

Is it the case that FREDDY coughs up mucus: No

Is it the case that FREDDY has fever: No

Is it the case that FREDDY has abnormal breath sounds on stethoscope: No

Is it the case that FREDDY's pain lasts years: No

Is it the case that FREDDY's pain is occurring with less provocation: No

Is it the case that FREDDY's pain is increasing in intensity: No

Is it the case that FREDDY's pain is lasting longer: No

Is it the case that FREDDY' pain is increasing in frequency: No

Is it the case that FREDDY's pain is aggravated by cough: No

Is it the case that FREDDY's pain is aggravated by inspiration: No

Is it the case that FREDDY's pain is aggravated by movement: No

Is it the case that FREDDY's pain is aggravated by palpation: No

Is it the case that FREDDY's myocardium has high inflammation: No

Is it the case that FREDDY has panic episodes: No

Is it the case that FREDDY's pain lasts hours to days: No

Is it the case that FREDDY's pain is unrelated by exertion: Yes

Is it the case that FREDDY's pain is relieved by rest: No

Is it the case that FREDDY's pain is relieved by calcium channel blockers: No

Is it the case that FREDDY has loss of function: No

Is it the case that FREDDY has hypertension: No

Is it the case that FREDDY smokes : No

Is it the case that FREDDY has hypercholesterol: No

Is it the case that FREDDY has hyperlipidemia: No

Is it the case that FREDDY has left ventricular hypertrophy: No

Is it the case that FREDDY is obese: No

Is it the case that FREDDY has history of chest trauma: No

Is it the case that FREDDY had a recent infection: No

Is it the case that FREDDY has family history of angina: No

Is it the case that FREDDY uses sympathomimetic drugs: No

Is it the case that FREDDY has autoimmune disease: No

Is it the case that FREDDY uses cocaine: No

Is it the case that FREDDY uses procainamide, hydralize, or isoniazid: No

Is it the case that FREDDY has tenderness over joints where the ribs meet the breast bone: No

Is it the case that FREDDY's pain is precipitated by exertion: No

Is it the case that FREDDY's pain is localized to small area: No

Is it the case that FREDDY has muscular or ligament strain: No

Is it the case that FREDDY's pain lasts seconds to days: Yes

Is it the case that FREDDY's pain is sharp: Yes

Is it the case that FREDDY has tingling or electrical feeling: No

Is it the case that FREDDY has numbness: No

Is it the case that FREDDY has vibrating sensation: No

Is it the case that FREDDY has heightened sensitivity near rash: No

Is it the case that FREDDY has a rash: No

Is it the case that FREDDY has chills: No

Is it the case that FREDDY has painful breathing: No

Is it the case that FREDDY's lung sound can be heard on stethoscope: Yes

Is it the case that FREDDY's pain radiates to both arms: No

Is it the case that FREDDY's pain does come and go: No

Is it the case that FREDDY's EKG QRS complex is widened: No

Is it the case that FREDDY has changes in way impulses are directed through heart: No

Is it the case that FREDDY has abnormal awareness of sinus rhythm: No

Is it the case that FREDDY has irregular heart rhythm: No

Is it the case that FREDDY's pain has sudden onset: No

Is it the case that FREDDY's pain radiates to interscapular region: Yes

Is it the case that FREDDY has numb arm: No

Is it the case that FREDDY has diaphoresis: No

Is it the case that FREDDY has nausea: No

Is it the case that FREDDY has dyspnea: No

Is it the case that FREDDY has syncopy: No

Is it the case that FREDDY is able to take deep breath: No

Is it the case that FREDDY's pain radiates to jaw: No

Is it the case that FREDDY's pain radiates to neck: No

Is it the case that FREDDY radiates to lower back: No

Is it the case that FREDDY's pain radiates to upper abdomen: No

Is it the case that FREDDY's pain radiates to arm: No

Is it the case that FREDDY has substernal discomfort: No

Is it the case that FREDDY has mitral insufficiency: No

Is it the case that FREDDY's pain is more likely to occur in afternoon than morning: No

Is it the case that FREDDY's pain does inhibits activity: No

Is it the case that FREDDY has new symptoms: Yes

Is it the case that FREDDY has rest pain: No

Is it the case that FREDDY has bruit heard on stethoscope: No

Is it the case that FREDDY has difference in blood pressure between two arms: No

Is it the case that FREDDY's pain is maximal from start: No

Is it the case that FREDDY has a pulse deficit: No

Is it the case that FREDDY has a neurological deficit: No

Is it the case that FREDDY has loss of or diminution major peripheral

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pulse: No

Is it the case that FREDDY's pain is ripping or tearing in quality: No

Is it the case that FREDDY has sudden onset of shortness of breath: No

Is it the case that FREDDY has hemoptysis: No

Is it the case that FREDDY's normal breath sound can be heard at top of
chest on stethoscope: Yes

Is it the case that FREDDY is suicidal: No

Is it the case that FREDDY has worst headache ever: No

Is it the case that FREDDY has loss of strength: No

Is it the case that FREDDY has diabetes: No

Is it the case that FREDDY had past heart attack: No

Is it the case that FREDDY has low oxygen: No

Is it the case that FREDDY's heart is racing: No

Is it the case that FREDDY has low blood pressure: No

Is it the case that FREDDY is breathing rapidly: No

Is it the case that FREDDY's abdominal wall is tender and rigid: No

Is it the case that FREDDY's abdomen is swollen: No

Is it the case that FREDDY has bowel sounds on stethoscope: No
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Is it the case that FREDDY had syncopal episode: Yes
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[WHAT-TO-DO FREDDY SEND-TO-ER-BY-AMBULANCE]
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CP ultimately determines from the user input that Freddy has unstable angina, and therefore he should be sent to the ER by ambulance. CP determined that Freddy had angina from his abnormal EKG showings of ST and T-wave inversion, and used the recent syncopal episode to determine that Freddy has new symptoms. The presence of new symptoms tells CP that the angina is unstable, and that Freddy should therefore be sent to the ER by ambulance.

2.2 How does CP work?

CP works by performing backward chaining from the root. The root determines what action should be taken towards the patient. Joshua tries all rules on a chain that leads

to the root, which happens to be every rule in the knowledge base. The knowledge base contains 188 predicates and 172 rules. Thus, it is quite a hefty domain to deal with.

CP was initially intended to be an IF X THEN Y knowledge base that narrowed the discussion down to one or two root causes of the chest pain, and then used the predicted root cause to determine an action to take on the patient. However, because Joshua wants to increase certainty, it considers all possible actions and therefore all possible causes of chest pain.

3. The problem solving paradigm

3.1 The paradigm

CP uses a rule-based system. Rules were well suited to the domain because they get right to the point. For example, if the patient's EKG has a loss of R wave, then it is immediately inferred that the patient has myocardial infarction (heart attack), and therefore should be sent to the ER by ambulance. Likewise, if a patient complaining of chest pain had a past heart attack, then CP knows to send the patient to the ER by ambulance.

Frames and case-based reasoning were also considered. Frames were to represent a specific diagnosis and slots were to be values of age, symptoms, duration, etc. that complemented the diagnosis. For example, a diagnosis of myocardial infarction might have a slot for loss of R wave in EKG. However, the primary difficulty with frames was not having enough information to fill in all the necessary slots for diagnoses. Furthermore, many chest pain symptoms are atypical, and atypical symptoms can be more easily ignored with the conciseness of rules. Case-based reasoning was thought to be too cumbersome because of the enormity of cases and because of the potential difficultly in obtaining documented patient visits.

3.2 What problems does CP handle?

CP was designed to handle as many cases of chest pain as possible, especially the common cases. Particularly, CP handles all serious causes of chest pain. The serious causes of chest pain are life-threatening. Even with only a few key symptoms, CP will know to send patients with such symptoms to the hospital by ambulance. The life-threatening cases are myocardial infarction, unstable angina, aortic aneurysm, aortic dissection, pulmonary embolism, pneumothorax, suicide, emergent headaches, extensive pneumonia, looks seriously ill, dehydration and acute abdomen. In addition, CP deals with patients with high risk, esophageal disease, esophageal cancer, musculoskeletal problems, gastrointestinal problems such as diarrhea, myocarditis, pleurisy, psychogenic problems such as depression and anxiety, headaches, costochondritis, pneumonia, herpes zoster, and functional disorders.

CP is expected to handle most every patient who comes into the doctor's office complaining of chest pain. The above list of conditions dealt with by CP are not exhaustive,

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but represent a considerable portion of documented causes of chest pain.

3.3 What problems does CP not handle?

CP does not handle atypical symptoms. For example, women with diabetes often have atypical symptoms of angina. These atypical symptoms were not well documented in the papers read for this project and presented complexities beyond the scope of this project. Furthermore, CP does not deal with differences in gender and age. Instead, CP sticks with other high risk signs such as smoking, family history of premature angina, and hypertension. In reality, age and gender play a role in a doctor's decision to determine a patient's risk stratification, which is how likely someone is to have angina or other serious health conditions at the moment they enter the doctor's office and prior to any testing.

CP does not handle rare cases. For example, pre-cordial catch syndrome which happens primarily in youth was removed from the knowledge base after the expert said he had not heard of it in 20 years.

4. The knowledge

4.1 Knowledge acquisition

The knowledge acquisition process consumed 50% of the project. Particularly, speaking with the doctor from my church was difficult to work into his schedule and required T rides into Boston. The expert for this project was Dr. James Garland MD. Dr. Garland received his doctorate from Harvard Medical School and has been working as a general practitioner for over 20 years.

Five sessions were held with the expert over a two week period. Two of the sessions occurred at church and were 5-10 minutes long. Two sessions occurred at his work office and were about 30 minutes each. The final session was over the phone for 25 minutes or so. The expert was very informative, although it took him some time to pin down exactly what I was looking for in the short amount of time allotted. Ultimately, the knowledge was completely dependent on Dr. Garland. Dr. Garland gave me books and articles to review, but most of it was irrelevant because the pieces were much too difficult to put together. For every rule made based on the books and articles, Dr. Garland confidently either dismissed it or improved it. In the end, it was evident that the amount of medical knowledge needed was beyond what I could handle on my own, and the rule development process was completely dependent on Dr. Garland's input.

4.2 What does CP know?

CP knows what action to take on a patient with chest pain. The appendix provides a listing of the rules for the system. CP knows to send patients to ER by ambulance who have symptoms for myocardial infarction (hearth attack), unstable angina, pulmonary embolism,

acute abdomen, aortic aneurysm, aortic dissection, pneumothorax, suicide, emergent headaches, dehydration, highest risk of past myocardial infarction or diabetes, extensive pneumonia, life-threatening symptoms, or looks seriously ill. Furthermore, CP sends to the ER unaided patients who have diarrhea but look stable.

Additionally, CP handles the following conditions summarized in the table below:

Condition	Action
Myocardial infarction	ER by ambulance
Unstable angina	ER by ambulance
Pulmonary embolism	ER by ambulance
Acute abdomen	ER by ambulance
Aortic aneurysm	ER by ambulance
Aortic dissection	ER by ambulance
Pneumothorax	ER by ambulance
Suicidal	ER by ambulance
Emergent headache	ER by ambulance
Dehydration and looks unstable	ER by ambulance
Had past myocardial infarction	ER by ambulance
Has diabetes	ER by ambulance
Has extensive pneumonia	ER by ambulance
Has life-threatening symptoms	ER by ambulance
Looks seriously ill	ER by ambulance
Extensive pneumonia	ER by ambulance
Dehydration and looks stable	ER unaided
Stable angina	Send home
Pain lasts < 2 seconds	Send home
Anxiety	Send home
Myocarditis	Evaluate and treat
Depression	Evaluate and treat
Pleurisy	Evaluate and treat
Panic episodes	Evaluate and treat
Non-dehydrating diarrhea	Evaluate and treat
Esophageal disease	Evaluate and treat
Esophageal cancer	Evaluate and treat

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Condition	Action
High risk	Evaluate and treat
Costochondritis	Evaluate and treat
Musculoskeletal problem	Evaluate and treat
Never injury	Evaluate and treat
Herpes zoster	Evaluate and treat
Infection	Evaluate and treat
Viral pleurisy	Treat
Migraine headache (non-emergent)	Treat
Muscle-tension headache (non-emergent)	Treat
GERD	Treat
Esophageal spasms	Treat
Pneumonia	Treat
Functional condition	Treat
Belching	Evaluate

The important point to keep in mind when looking at this table is that a patient may have multiple conditions at the same time. This requires that conditions requiring evaluation or treatment do not overlook more serious life-threatening conditions. To ensure life threatening conditions are not overlooked, the CP database contains a rule that specifies whether or not all important organic considerations are ruled out. Only when all important organic considerations are ruled out does CP recommend an action to evaluate or treat the patient. Ideally, in practice if a patient has life-threatening symptoms or anything close to life-threatening, the patient should be sent to the ER by ambulance.

5. What was learned?

5.1 What went well?

CP has made a step towards allowing a computer to act as a doctor and to properly diagnose and recommend actions for patients with chest pain. Rules permit knowledge and reasoning to be represented explicitly. For example, if a patient with angina chest pain has new symptoms, the doctor infers the patient has unstable angina and sends the patient to the ER by ambulance. This information is easily and directly encoded in an IF X THEN Y ontology.

Knowledge acquisition for CP was successful primarily because of the willingness of Dr. Garland to take time out of his schedule to teach me the way he evaluates patients

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with chest pain. Particularly, knowledge acquisition sessions were productive and permitted the expert to give clear and concise answers with a reasonable level of confidence.

5.2 What went badly?

CP's primary drawback is Joshua. The enormity of the knowledge domain does not lend itself well to the way in which Joshua attempts to fire every rule that leads to a certain goal. Particularly, the root node in CP, "what-to-do," is a predicate that takes the six possible actions to take as options. This causes Joshua to try every rule that leads to an action for "what-to-do." Unfortunately, trying every possible rule causes all 118 base-case inputs to be prompted to the user. A better implementation of CP would first try important rules that infer sending a patient to the ER by ambulance. For the first important rule that fires, the system should notify the user to send the patient to the ER by ambulance without trying more rules. For example, after determining that a patient has unstable angina, the system should not prompt the user for information regarding esophageal, gastrointestinal, psychogenic or other non life-threatening conditions.

CP's second drawback with Joshua is that it must infer either a yes or no value for each Boolean predicate, whereas CP was initially designed to fire only rules that are true. For example, if a patient has a bruit heard on stethoscope then CP infers that the patient has an aortic aneurysm and recommends that the patient be sent to the ER by ambulance. However, if there is no rule that specifies when an aortic aneurysm does not occur, then Joshua prompts the user asking if the patient has an aortic aneurysm. This was not the intended behavior of the system, and therefore the knowledge base was increased by negating all conclusions. From a knowledge point of view, the negated rules added no meaningful knowledge.

The introduction of negated rules also suggests that the knowledge base is not completely honest. For example, if a patient does not have diarrhea so severe that the patient is dehydrated, does not necessarily imply in the real world that the patient is not dehydrated. In other words, the introduction of negated rules is a hack to improve the interface to Joshua, and they should not be considered as part of the knowledge. Future implementations of CP should take negated conclusions into account because they may have real world significance. However, the present implementation of CP includes negated conclusions that were not acquired from the expert, and therefore they do not represent knowledge useful in evaluating patients with chest pain.

5.3 What else was learned?

In designing and implementing CP, I learned the importance of knowledge representation and how to choose an appropriate knowledge representation for a particular domain. Particularly, I learned that the diagnosis of chest pain requires fine-grained tests and evaluations to properly deal with specific circumstances. In addition, I learned that frames are too ambiguous of a representation to properly catch what should be simple diagnoses and actions. That is, the IF X THEN Y ontology is the most direct way to

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evaluate patients complaining of chest pain.

Rules are not perfect, however, in that it takes some manipulation to strongly believe all IF X THEN Y statements. For example, the knowledge base could say that if Bill has pain that is aggravated by meals, has a normal EKG, and has burning substernal pain then Bill should be evaluated further. However, this would only be true if there was reason to believe that other more important conditions had been ruled out. This requires that a seemingly isolated rule take into account other rules that suggest other possible diagnoses. In CP, this is done by providing the predicate, "important organic considerations are ruled out," which specifies that all life-threatening symptoms do not exist in the patient under consideration.

6. Conclusion

CP is a rule-based system that determines whether a patient complaining of chest pain should be sent to the ER by ambulance, sent to the ER unaided, evaluated and treated, just evaluated or treated, or sent home. CP successfully diagnoses and recommends actions for many of the common conditions and/or symptoms a person with chest pain has. CP could be improved by increasing its knowledge and in refining the current rules for specific diagnoses. For example, the rules that determine whether or not a person has angina have overlap. This overlap is a consequence of bringing lots of information together from various sources and only having a short amount of time to thoroughly go over all rules with the expert.

CP has the potential to be used in a doctor's office, particularly as an aid to novice doctors or medical students. CP in its present form is not convenient for many doctors because its underlying implementation in Joshua requires prompting the user for all 118 base-level inputs. A future implementation of CP should ask users fewer questions and ask the most important considerations that deal with hospitalization first.

7. Appendix

<p style="text-align:center">What to do with a patient who has chest pain?
CP Rule base</p>

Myocardial infarction rules

IF Loss of R wave
THEN myocardial infarction

IF pain comes and goes
THEN myocardial infarction

IF radiation to both arms
THEN myocardial infarction

IF no loss of R wave
     pain does not come and go
     no radiation to both arms
THEN no myocardial infarction

Rules for EKG

IF ST elevation
THEN abnormal EKG

IF ST inversion
THEN abnormal EKG

IF T wave inversion
THEN abnormal EKG

IF loss of R wave
THEN abnormal EKG

IF no ST inversion
     no ST elevation
     no T wave inversion
     no loss of R wave
THEN normal EKG

Rules for unstable angina chest pain

IF angina has changed pattern
THEN unstable angina

IF rest pain or night pain
   has angina
THEN unstable angina

If crescendo in pattern
   has angina
THEN unstable angina

IF inhibits activity
   has angina
   crescendo in pattern
   rest pain or night angina
THEN unstable angina

IF angina has not changed pattern
   no rest pain or night pain, or does not have angina
   no crescendo in pattern, or does not have angina
   no inhibition of activity, or no crescendo in pattern, or no night/rest pain, or does not
   have angina
THEN no unstable angina

IF has angina
   new symptoms
THEN angina has changed pattern

IF does not have angina, or has no new symptoms
THEN angina has not changed pattern

IF occurring with less provocation
THEN pain has crescendo pattern

IF pain is increasing in intensity
THEN crescendo in pattern

IF pain is lasting longer
THEN crescendo in pattern

IF pain increasing in frequency
THEN crescendo in pattern

IF pain not occurring with less provocation
   pain is not increasing in intensity

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pain is not lasting longer
    pain is not increasing in frequency
THEN pain has no crescendo pattern

Rules for stable angina chest pain

IF has angina
    no new symptoms
THEN stable angina

IF no angina or has new symptoms
THEN no stable angina

IF stable angina
THEN send home

Rules for angina chest pain

IF abnormal EKG
THEN has angina

IF sudden onset
    precipitated by exertion, emotional stress, sexual intercourse, or meals
    alleviated by rest or nitroglycerine
THEN has angina

IF radiation to jaw, neck, shoulder, arm, back, or upper abdomen
    arm is numb, diaphoresis, nausea, dyspnea, syncopy or anxiety
    duration 2 – 20 min.
    substernal discomfort
THEN has angina

IF substernal discomfort
    alleviated by nitrates
THEN has angina

IF mitral insufficiency
    S4 or S3 gallop
    precordial movement at apex
THEN angina

IF more likely to occur afternoon than the morning
THEN angina

IF palpitations from ventricular ectopy, abnormal awareness of sinus rhythm, or atrial
fibrillation
THEN angina

IF has normal EKG
 does not have sudden onset, or not precipitated by stress, emotional stress, sexual
 intercourse and meals, or not relieved by rest or nitroglycerine
 does not radiate to jaw, neck, shoulder, arm, back, and upper abdomen, or arm is not
 numb, no diaphoresis, no nausea, no dyspnea, no syncopy and no anxiety, or does not
 last 2-20 minutes, or no substernal pain
 no substernal discomfort, or not relieved by nitrates
 no mitral insufficiency, or no S4 or S3 gallop, or no precordial movement at apex
 not more likely to occur in afternoon than morning
 no palpitations from ventricular ectopy, no abnormal awareness of sinus rhythm, and
 no atrial fibrillation
THEN no angina

IF extra beat just before first heart sound
THEN S4 gallop

IF no extra beat just before first heart sound
THEN no S4 gallop

IF extra beat just before second heart sound
THEN S3 gallop

IF no extra beat just before second heart sound
THEN no S3 gallop

IF QRS complex widened
 changes in way impulses are directed through heart
THEN palpitations from ventricular ectopy

IF QRS complex not widened, or no changes in way impulses are directed through heart
THEN no palpitations from ventricular ectopy

IF irregular heart rhythm
THEN atrial fibrillation

IF no irregular heart rhythm
THEN no atrial fibrillation

Rule for acute coronary syndrome chest pain

IF myocardial infarction

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THEN acute coronary syndrome

IF unstable angina
THEN acute coronary syndrome

IF no myocardial infarction
    no unstable angina
THEN no acute coronary syndrome

IF acute coronary syndrome
THEN ER-by-ambulance

Rules to ensure important organic considerations are ruled out

IF no aortic aneurysm
    no aortic dissection
    no pulmonary embolism
    does not look seriously ill
    no acute abdomen
    no highest risk
    no acute coronary syndrome
    no pneumothorax
    not suicidal
    no emergent headache
    no dehydration
    no extensive pneumonia
THEN important organic considerations ruled out

IF aortic dissection or aortic aneurysm or pulmonary embolism or looks seriously ill or
acute abdomen or highest risk or acute coronary syndrome or pneumothorax or is suicidal
or emergent headache or dehydration or extensive pneumonia
THEN important organic considerations are not ruled out

Rules for aortic chest pain

If hear a bruit during examination
THEN aortic aneurysm

IF don't hear bruit during examination
THEN no aortic aneurysm

IF aortic aneurysm
THEN ER-by-ambulance

IF onset maximal from the start
    neurological deficits, loss or diminution of major peripheral pulse
    tearing or ripping in quality
    radiates to interscapular, neck, jaw, lower back, or legs
THEN aortic dissection

IF difference in blood pressure between two arms
    no pulse deficit
THEN aortic dissection

IF onset not maximal from start, or no neurological deficit, and no loss or diminution of
    major peripheral pulse, or not tearing or ripping in quality, or does not radiate to
    interscapular, neck, jaw, lower back, and legs
    no difference in blood pressure between arms, or not pulse deficit
THEN no aortic dissection

IF aortic dissection
THEN ER-by-ambulance

IF fever
    high sedimentation rate
    abnormal EKG
THEN myocarditis

IF no fever, or no high sedimentation rate, or no abnormal EKG
THEN no myocarditis

IF myocarditis
    important organic considerations ruled out
THEN evaluate and treat

IF high inflammation
THEN high sedimentation rate

IF no high inflammation
THEN no high sedimentation rate

Rules for pulmonary chest pain

IF sudden onset of shortness of breath
    hemoptysis
THEN pulmonary embolism

IF no sudden onset of shortness of breath, or no hemoptysis
THEN no pulmonary embolism

IF pulmonary embolism
THEN ER by ambulance

IF aggravated by cough or inspiration
   aggravated by movement
   not aggravated by palpation
THEN Inflammation of the pleura (pleurisy)

IF not aggravated by cough or inspiration, or not aggravated by movement, or not
   aggravated by palpation
THEN no pleurisy

IF pleurisy
   important organic considerations ruled out
THEN treat and evaluate

IF can't hear normal breath sounds at top of chest by stethoscope
THEN accumulation of air or gas in the pleural cavity

IF can hear normal breath sounds at top of chest by stethoscope
THEN no accumulation of air or gas in the pleural cavity

IF accumulation of air or gas in the pleural cavity
THEN pneumothorax

IF no accumulation of air or gas in the pleural cavity
THEN no pneumothorax

IF pneumothorax
THEN ER by ambulance

IF listen to lungs and don't hear lung sound
THEN accumulation of fluid in pleural cavity

IF hear lung sound
THEN no accumulation of fluid in pleural cavity

IF aggravated by respiration
   aggravated by lying down
THEN viral pleurisy

IF not aggravated by respiration, or not aggravated by lying down
THEN no viral pleurisy

IF viral pleurisy

important organic considerations ruled out
THEN treat

Suicidal

IF suicidal
THEN ER by ambulance

Rules for headache chest pain

IF has headache
   pounding on one side of head
THEN migraine headache

IF no headache, or no pounding on one side of head
THEN no migraine headache

IF has migraine headache
   non-emergent headache
   important organic considerations ruled out
THEN treat

IF has headache
   tightness in front of head or back of neck
   alleviated by medication
THEN muscle-tension headache

IF no headache, or no tightness in front of head or back of neck, or not relieved by
medication
THEN no muscle-tension headache

IF muscle-tension headache
   non-emergent headache
   important organic considerations ruled out
THEN treat

IF has headache
   worst headache ever had
   not alleviated by medication
   loss of function or loss of strength
THEN emergent headache

IF no headache, or not worst headache ever had, or not relieved by medication, or no loss
   of function and no loss of strength

THEN no emergent headache

If emergent headache
THEN ER by ambulance

Rules for psychogenic chest pain

IF panic episodes
   important organic considerations ruled out
THEN evaluate and treat

IF depression
   important organic considerations ruled out
THEN evaluate and treat

IF anxiety
   important organic considerations ruled out
THEN send home

IF duration hours to days
   unrelated to exertion
   not relieved by rest
THEN depression

IF pain does not last hours to days, or related to exertion, or relieved by rest
THEN not depression

IF duration hours to days
   unrelated to exertion
   not relieved by rest
   inability to take deep breath
THEN anxiety

IF pain does not last hours to days, or related to exertion, or relieved by rest, or able to take
a deep breath
THEN not anxiety

Rules for gastrointestinal chest pain

IF dysphagia, aggravated by meals, or repeating
   normal EKG
   burning substernal pain
THEN gastro esophageal reflex disease (GERD)

IF no dysphagia, not aggravated by meals, and no repeating, or abnormal EKG, or no
    burning substernal pain
THEN no GERD

IF GERD
    important organic considerations ruled out
THEN evaluate

IF eat and taste again
THEN repeating

IF no eat and taste again
THEN no repeating

IF worse at night
    has repeating
    has heartburn
THEN acid reflux

IF not worse at night, or no repeating, or no heartburn
THEN no acid reflux

IF belching
    important organic considerations ruled out
THEN evaluate

IF alleviated by antacids
THEN gastrointestinal

IF not relieved by antacids
THEN not gastrointestinal

IF gastrointestinal
    has excessive release of watery feces
THEN has diarrhea

IF not gastrointestinal, or does not have excessive release of watery feces
THEN no diarrhea

IF too much diarrhea to keep up by drinking
    has diarrhea
THEN dehydration

IF not too much diarrhea to keep up by drinking, or no diarrhea
THEN no dehydration

IF has diarrhea
  no dehydration
THEN evaluate and treat

IF dehydration
  looks unstable
THEN ER-by-ambulance

IF dehydration
  looks stable
THEN ER-unaided

Rules for esophageal chest pain

IF relieved by nitrates or calcium-channel blockers
THEN esophageal disease

IF dysphagia, motor dysfunction, or acid reflux
THEN esophageal disease

IF pain has crescendo pattern
THEN esophageal disease

IF not relieved by nitrates or calcium-channel blockers
  no dysphagia, motor dysfunction, and acid reflux
  pain does not have crescendo pattern
THEN no esophageal disease

IF esophageal disease
  important organic considerations ruled out
THEN evaluate and treat

IF alleviated by nitrates
  has acid reflux
  has repeating, heartburn, or night pain
THEN esophageal spams

IF alleviated by sublingual nitroglycerine
THEN esophageal spasms

IF no relieved by nitrates, or no acid reflux, or no repeating, heartburn and night pain
  not relieved by sublingual nitroglycerine
THEN no esophageal spasms

IF esophageal spams

important organic considerations ruled out
THEN treat

IF dysphagia
THEN esophageal cancer

IF no dysphagia
THEN no esophageal cancer

IF esophageal cancer
   important organic considerations ruled out
THEN evaluate and treat

Rules for high risk

IF hypertension, smoking, hypercholesterol, hyperlipidemia, left ventricular
   hypertrophy, or obesity
   history of chest trauma, recent infection, family history of angina, uses
   sympathomimetic drugs, or has autoimmune disease.
   Cocaine use, uses procainamide, hydralize, or isoniazid
THEN high risk

IF no hypertension, no smoking, no hypercholesterol, no hyperlipidemia, no left
   ventricular hypertrophy and obesity, or no history of chest trauma, no recent infection,
   no family history of angina, does not use sympathomimetic drugs and does not have
   autoimmune disease, or does not use cocaine, procainamide, hydralize, and isoniazid
THEN no high risk

IF has high risk
   important organic considerations are ruled out
THEN evaluate and treat

IF had past heart attack
THEN Highest risk

IF has diabetes
THEN highest risk

IF highest risk
THEN ER by ambulance

IF no past heart attack
   no diabetes
THEN no highest risk

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Rules for costochondritis chest pain

IF chest wall is tender over joints where ribs meet the breast bone
THEN inflammation of the joints where ribs meet the breast bone

IF chest wall is not tender over joints where ribs meet the breast bone
THEN no inflammation of the joints where the ribs meet the breast bone

IF inflammation of the joints where ribs meat the breast bone
THEN costochondritis

IF no inflammation of the joints where the ribs meet the breast bone
THEN no costochondritis

IF costochondritis
THEN evaluate and treat

Rules for pneumonia chest pain

IF cough
   coughs up mucus
   fever
   abnormal breath sounds on stethoscope
THEN pneumonia

IF no cough, or does not cough up mucus, or no fever, or normal breath sounds on
   stethoscope
THEN no pneumonia

IF pneumonia
   important organic considerations ruled out
   not extensive pneumonia
THEN treat

IF pneumonia
   oxygen low
   looks seriously ill
THEN extensive pneumonia

IF no pneumonia, or oxygen not low, or does not look seriously ill
THEN no extensive pneumonia

IF extensive pneumonia
THEN ER-by-ambulance

Rules for looking seriously ill and unstable

IF heart racing
   low blood pressure
   breathing rapidly
   fever
THEN bad vital signs

IF heart not racing, or no low blood pressure, or does not breath rapidly, or no fever
THEN no bad vital signs

IF bad vital signs
THEN looks seriously ill

IF no bad vital signs
THEN does not look seriously ill

IF looks seriously ill
THEN ER-by-ambulance

IF nearly passed out
THEN looks unstable

IF not nearly passed out
THEN looks stable

Rules for musculoskeletal pain

IF chest wall pain
   aggravated by inspiration or cough
   aggravated by palpation or movement
   duration from a few seconds to several days
   quality is sharp, aching, dull, or tight
THEN musculoskeletal problem

IF precipitated by exertion
   muscular and ligament strain
THEN musculoskeletal problem

IF no chest wall pain, or not aggravated by inspiration or cough, or not aggravated by
   palpation and movement, or does not last seconds to days, or quality is sharp, aching,
   dull, and tight
   not precipitated by exertion, or no muscular or ligament strain

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THEN no musculoskeletal problem

IF musculoskeletal problem
    important organic considerations ruled out
THEN evaluate and treat

IF localized to small area
THEN chest wall

IF not localized to small area
THEN not chest wall

Rules for nerve injury chest pain

IF tingling, electrical feeling
    numbness
    vibrating sensation
THEN nerve injury

IF no tingling or electrical feeling, or no numbness, or no vibrating sensation
THEN no nerve injury

IF nerve injury
    chest wall pain
THEN evaluate and treat

Rules for abdominal chest pain

IF wall of abdomen tender and rigid
    abdomen swollen
    no bowel sounds on stethoscope
THEN acute abdomen

IF wall of abdomen is not tender and rigid, or abdomen is not swollen, or has bowel sounds
    on stethoscope
THEN no acute abdomen

If acute abdomen
THEN ER-by-ambulance

Rules for herpes zoster chest pain

IF heightened sensitivity near rash

THEH hyperesthesia

IF no heightened sensitivity near rash
THEN no hyperesthesia

IF hyperesthesia
    rash
THEN herpes zoster

IF no hyperesthesia, or no rash
THEN no herpes zoster

IF herpes zoster
    important organic considerations ruled out
THEN evaluate and treat

Rules for infection chest pain

IF pneumonia, chills, fever, or painful breathing and coughing
    fluid accumulation in pleural cavity
THEN infection

IF no pneumonia, no chills, no fever, and no painful breathing and coughing, or no fluid
    accumulation in the pleural cavity
THEN no infection

IF infection
    important organic considerations ruled out
THEN evaluate and treat

Rules for functional chest pain

IF lasts years
    no crescendo pattern
THEN functional

IF does not last years, or crescendo pattern
THEN not functional

IF functional
    important considerations ruled out
THEN treat

Rule for a case to send home

IF duration is < 2 sec.
     Important organic considerations ruled out
THEN send home

Rules for immediately life threatening conditions

IF maximum intensity from the start
    radiation into interscapular region, jaw, neck, lower back or legs
    neurological deficit or syncopal episode
THEN immediately life-threatening symptoms

IF no maximum intensity from the start, or no radiation into interscapular region, jaw, neck,
lower back and legs, or not neurological deficit or syncopal episode
THEN no immediately life-threatening symptoms

IF immediately life-threatening symptoms
THEN ER by ambulance