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Computational Cognitive Modeling Project

Introduction

For our project we decided to research different types of cancers and we ultimately ended up choosing bone cancer as our disease of interest. Most of the research is from the National Comprehensive Cancer Network (NCCN), which is an alliance of thirty-one cancer centers based in the United States. The NCCN develops guidelines on how to diagnose and treat many types of cancer. The specific bone cancer that we researched and modeled in our project is chondrosarcoma, which is a type of bone cancer that starts in the cartilage cells ("What is Bone Cancer?").

Background

We modeled a scenario under the assumption that it leads to a diagnosis and treatment plan, picking this approach for our model leads to less ambiguity. Our approach to this project is based on the decision trees that are labeled Figure 1, Figure 2, and Figure 3. It starts with a symptomatic bone lesion which leads to an abnormal radiograph. Then the next sequence of steps depends on the person's age, if the patient is less than forty years old, they will be referred to an orthopedic oncologist which will perform the biopsy. We are assuming for one patient it is low grade and intracompartmental which means the tumor has basically remained in the bone and the cells look normal and are less likely to grow and spread fast ("NCI Dictionary of Cancer Terms."). For the other patient we are assuming it is high grade which means that the cells look abnormal, and these cells tend to grow and spread faster than low grade ("NCI Dictionary of Cancer Terms."). Assuming the tumor is respectable, which means it can be removed with surgery, the surgery will be performed to remove the tumor. After the removal

there will be physical exams, radiographs of the site to make sure there is no local recurrence. If there is a sight of local recurrence then the tumor will be removed again with surgery and assuming there are negative margins indicates the tumor was removed successfully, then the patient is observed again like the first removal. Now, we should define what negative margins are, negative margins is when there are no more cancer cells at the edge of the tissue which suggests the cancer was successfully removed ("NCI Dictionary of Cancer Terms."). On the other hand, positive margins occur when there still are cancer cells at the edge of the tissue, which suggest that cancer was not successfully removed ("NCI Dictionary of Cancer Terms.").

There is a slight difference in the treatment plan if the patient age is greater than forty. That patient would go through numerous amounts of testing, for example: physical, bone scan, chest radiograph, Mammogram and more. If there are no other lesions, it is a possible case of bone cancer so the patient will be referred to an orthopedic oncologist which then a biopsy will be performed and then follows the same procedure as a patient would if they were less than forty.

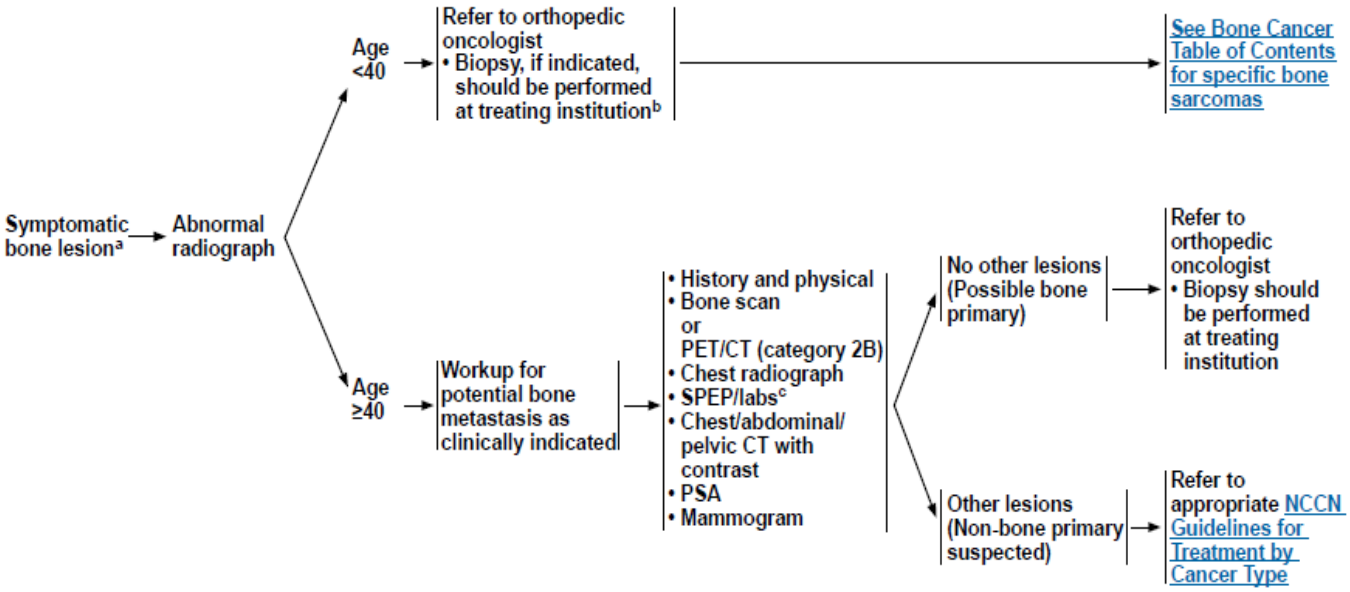

Fig. 1 NCCN Guidelines Version 2.2022 Bone Cancer Workup

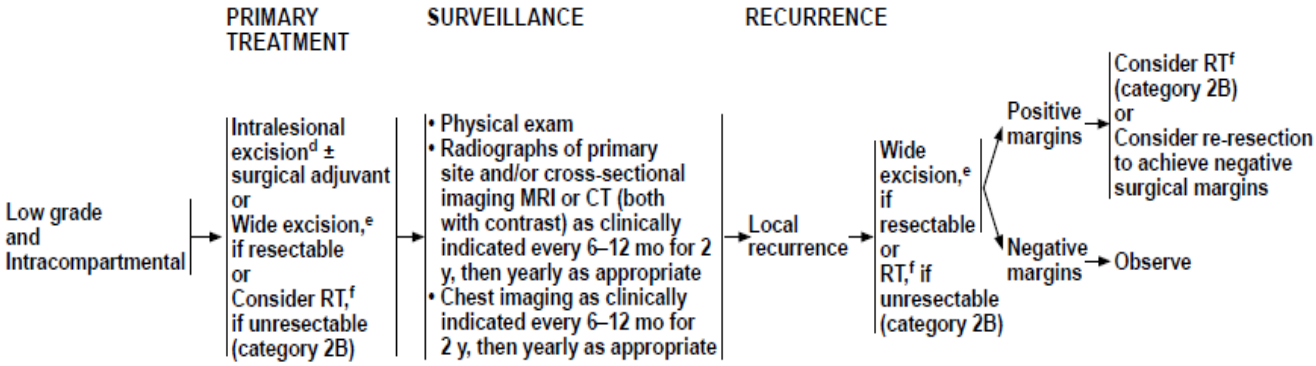

Fig. 2 NCCN Guidelines Version 2.022 Chondrosarcoma - Low Grade/Intracompartmental

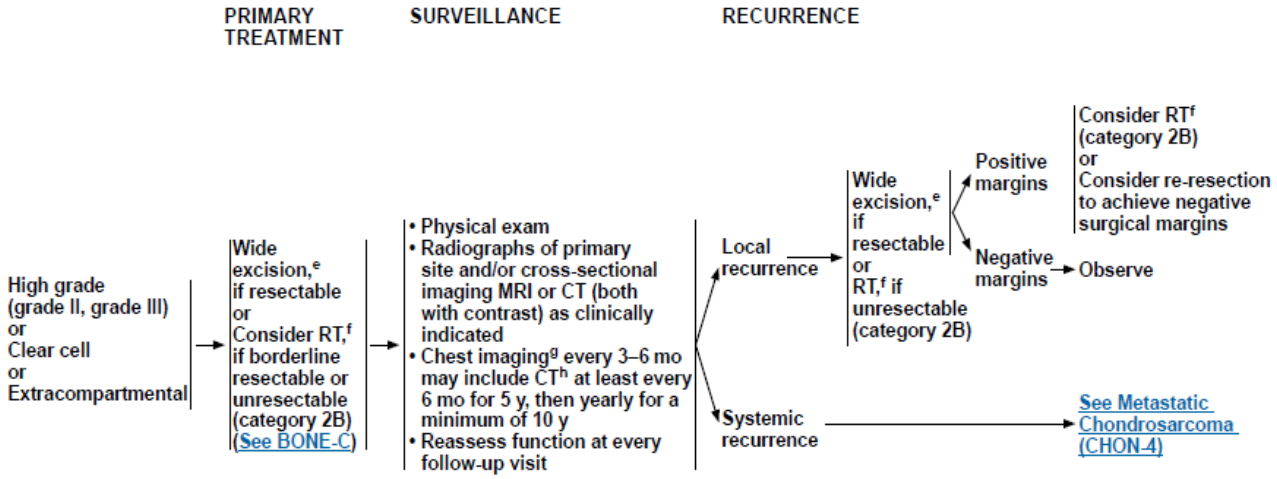

Fig 3. NCCN Guidelines Version 2.022 Chondrosarcoma - High Grade

Methods

Much of the modeling of our world has been done for us using the guidelines provided by the NCCN. The basics of which are, facts that would cause decisions to be made are written initially in the knowledge base, and rules are then called using those facts as the knowledge for the rules to make decisions from. However, this does not include the techniques for revising beliefs based on what those rules return.

The methodology behind the model is largely addition to beliefs rather than direct belief revision. After entering the basic information of a patient, including their name and age, the user is prompted to perform certain actions based on the input provided. Using information gathered from the newly acquired information we are able to give recommendations on the next step that a healthcare provider should be taking.

An important part of belief revision is to add new facts to the knowledge base while also making sure that the beliefs in the knowledge base are consistent with one another. For instance, if we say that our patient is 20 years old, we can't later add the fact that the patient is 40 years old. The rules must be built around this, making sure that they return non-contradicting information while still providing new information to add to the knowledge base. And the way that they are added to the knowledge base does support this theory. There is a problem however when new facts are added manually without use of the provided queries which can lead to contradictions. The elimination of contradictions is absent in this model and would be a very important step to improving it.

In addition, we need to ensure that the information that we are deriving from our rules is formatted in such a way that it can be easily added to the knowledge base. The solution to this was to make the facts dynamic, meaning that the facts could be added to the knowledge base at run time. This made adding new content to the database on the fly a viable option and made our job in diagnosing situations based on various parameters far easier.

Discussion

We modeled two different situations within our demo. This was done by having two different patients: Bob, and Steve. The demo also gives Bob and Steve two different variations of Chondrosarcoma: low grade/intracompartmental (see fig. 2) or high grade (see fig. 3). The model essentially takes the two patients' cancer type, age and gives them a diagnosis based on their information. Then the patient is given a treatment method based on their type of cancer and whether the cancer is low grade/intracompartmental or high grade. An example of the model would go as follows: the program starts with the patient being prompted to enter their name, and once they enter their name they will be a patient within the system. Next, the patient will be asked to enter their age. In our demo, the first patient enters their name as Bob and their age as 20, so now this information is saved within the knowledge base, Bob can then be diagnosed and treated. The diagnosis begins with asking what the result of the biopsy was, in Bob's case it was chondrosarcoma. It will then ask what type (either low or high grade) and now Bob can finally be treated. Upon completion of the treatment, the results will either be positive margins or negative margins and if the results are positive then treatment will be recommended again. If the margins were negative that means Bob would undergo surveillance to make sure the cancer does not reappear.

One Limitation would be that our model does not take into consideration the sex of the patient. This could be useful depending on what type of cancer we were dealing with. It wasn't so important for our model as testing or symptoms based on sex were not relevant in the diagnosing and treatment stages. This limitation would be something we would definitely change if we were to increase the scope of the model. Another aspect we could have done differently was to go into a bit more detail within the code. Implementing more prompts for the user to make more specific choices after the diagnosis to make the treatment more specific and detailed. I would say it is useful as a cognitive model, especially since it could be expanded upon by adding more detailed surveillance of a specific patient, adding more options in the event of systemic recurrence, as well as diagnosing and treating all types of bone cancers with the potential to expand even further by adding different types of cancers.

Conclusion

To summarize, we were able to research and then create a cognitive model that somewhat simulates a real-life experience with an Oncologist that is diagnosing and treating Chondrosarcoma. To diagnose the patients, we split the diagnosis into two separate sections based on age. Patients over forty years of age must go through a more rigorous diagnosis to rule out a different cause of their bone lesion and abnormal radiograph. Patients under forty years of age are directly referred to an orthopedic oncologist to perform the biopsy (see fig. 1). If we had the time and ability, it would be an interesting and useful model if we were able to add a more in-depth system that could diagnose and treat not just all types of bone cancer but also attempt to diagnose and treat all different types of cancer.

Works Cited

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Appendix

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%Being able to add and delete facts on the fly are important to the
% belief revision of this program.
:- dynamic patient/1.
:- dynamic age/2.
:- dynamic symptom/2.

%rules
olderThan40(Patient):- age(Patient, Age), Age >= 40.
observe(Patient) :- symptom(Patient, chondrosarcoma), symptom(Patient,
low_grade_and_intracompartmental), symptom(Patient, positive_margins), write("Consider RT
or consider re-resection to achieve negative surgical margins").
observe(Patient) :- symptom(Patient, chondrosarcoma), symptom(Patient,
low_grade_and_intracompartmental), symptom(Patient, negative_margins), write("Continue to
observe the patient.").
observe(Patient) :- symptom(Patient, chondrosarcoma), symptom(Patient, high_grade),
symptom(Patient, positive_margins), write("Consider RT or consider re-resection to achieve
negative surgical margins").
observe(Patient) :- symptom(Patient, chondrosarcoma), symptom(Patient, high_grade),
symptom(Patient, negative_margins), write("Continue to observe the patient.").

recurrence(patient) :- symptom(Patient, chondrosarcoma), symptom(Patient, high_grade),
symptom(Patient, local),write("Perform a wide excision if resectable or RT if unresectable."),nl,
write("Did the tumor display positive or negative margins?"),nl,read(Results),
assert(symptom(Patient,Results)), observe(Patient).
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recurrence(patient) :- symptom(Patient, chondrosarcoma), symptom(Patient, high_grade), symptom(Patient, systemic),write("This means that the cancer is Metastatic Chondrosarcoma which is out of the scope of this project."),nl.

diagnose(Patient):-
   \+olderThan40(Patient),
   write("Refer the patient to an orthopedic oncologist and perform a biopsy."),nl, write("What were the results of the biopsy?"),nl, read(Results), assert(symptom(Patient,Results)), nl, write("What was the grade of the cancer?"),
   read(Grade), assert(symptom(Patient,Grade)).

diagnose(Patient):-
   olderThan40(Patient),
   write("Workup for potential bone metastasis as clinically intended. Perform the following tests as needed: 1.)History and physical. 2.) Bone scan or PET/CT 3.) Chest Radiograph 4.) SPEP/labs 5.) Chest/abdominal/pelvic CT with contrast. 6.) PSA 7.) Mammogram. Record the results in the knowledge base."),nl,(test_results(Patient,no_other_lesions)->write("Refer the patient to an orthopedic oncologist. A biopsy should be performed at the treating institution."); write("There are lesions not on the bone, refer to the appropriate NCCN Guidelines for treatment by cancer type.")).


treatment(Patient):- symptom(Patient, chondrosarcoma), symptom(Patient, low_grade_and_intracompartmental),write("apply one of the following treatment methods : 1.)Intralesional excision + surgical adjuvant 2.) Wide excision, if resectable 3.)Consider RT is unresectable"),nl, write("Afterwards, the patient should undergo a physical examination as well as radiographs of the primary site as clinically indicated every 6-12 months for 2 years, then yearly as appropriate. Do this with the chest as well. If a recurrence occurs perform a wide
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excision is reectable or RT if unresectable."), nl, write("After performing treatment on the patient, what were the results?"),nl, read(Results), assert(symptom(Patient, Results)), observe(Patient).

treatment(Patient) :- symptom(Patient, chondrosarcoma),symptom(Patient, high_grade), write("Perform a wide excision if resectable or consider RT if borderline resectable or unrectable. For surveillance: Perform a physical exam, perform radiographs of primary site and/or cross-sectional imaging MRI or CT as clinically indicated, chest imaging every 3-6 months (may include a CT at least every 6 months for 5 years, then yearly for a minimum of 10 years), reasses function at every follow-up visit."),nl,write("If a recurrence occured, what type of occurence was it?"), read(Results), assert(symptom(Patient, Results)).

%convenience rules
createNewPatient :- write("Enter the name of the patient"), nl, read(Patient), assert(patient(Patient)),nl, write(Patient), write( " is now a patient. How old are they? "),nl, read(Age), assert(age(Patient,Age)).
diagnose :- diagnose(bob).

reviseSymptom(Patient, Symptom) :- retract(symptom(Patient, Symptom)),write("What is the revised symptom?"), nl, read(NewSymptom), assert(symptom(Patient,NewSymptom)).
deleteSymptom(Patient, Symptom) :- retract(symptom(Patient, Symptom)).
addSymptom(Patient, Symptom) :- assert(symptom(Patient,Symptom)).
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Prolog Demo

?- createNewPatient.

Enter the name of the patient

|: bob.

bob is now a patient. How old are they?

|: 20.

true.

?- diagnose(bob).

Refer the patient to an orthopedic oncologist and perform a biopsy.

What were the results of the biopsy?

|: chondrosarcoma.

What was the grade of the cancer?|: low_grade_and_intracompartmental.

true .

?- treatment(bob).

apply one of the following treatment methods : 1.)Intralesional excision + surgical adjuvant 2.) Wide excision, if resectable 3.)Consider RT is unresectable

Afterwards, the patient should undergo a physical examination as well as radiographs of the primary site as clinically indicated every 6-12 months for 2 years, then yearly as appropriate. Do this with the chest as well. If a recurrence occurs perform a wide excision is reectable or RT if unresectable.

After performing treatment on the patient, what were the results?

|: positive_margins.

Consider RT or consider re-resection to achieve negative surgical margins
true .

?- createNewPatient.
Enter the name of the patient
|: steve.

steve is now a patient. How old are they?
|: 35.

true.

?- diagnose(steve).
Refer the patient to an orthopedic oncologist and perform a biopsy.
What were the results of the biopsy?
|: chondrosarcoma.

What was the grade of the cancer?|: high_grade.

true .

?- treatment(steve).
Perform a wide excision if resectable or consider RT if borderline resectable or unrectable. For surveillance: Perform a physical exam, perform radiographs of primary site and/or cross-sectional imaging MRI or CT as clinically indicated, chest imaging every 3-6 months (may include a CT at least every 6 months for 5 years, then yearly for a minimum of 10 years), reasses function at every follow-up visit.
If a recurrence occured, what type of occurence was it?local.
Perform a wide excision if resectable or RT if unresectable.

Did the tumor display positive or negative margins?

|: positive_margins.

Consider RT or consider re-resection to achieve negative surgical margins

true .

?- reviseSymptom(steve, positive_margins).

What is the revised symptom?

|: negative_margins.

true.

?- observe(steve).

Continue to observe the patient.

true.