Medical Imaging

Introduction

Diagnosis
In order to choose the best treatment to cure a patient the doctor first needs to know what the patient’s problem exactly is. He or she listens, feels and looks at the outside of the patient in order to put up a diagnosis: an idea about what the problem is. But actually the doctor would like to examine the patient’s body on the inside. Although an exploratory operation to look inside is sometimes necessary, this introduces some risks such as inflammations, fever, stress and so on. For these reasons, during the last century the medical community has been searching for methods that don’t include opening up the patient: the so-called non-invasive imaging techniques.

Many different techniques have been developed to get a look inside the patient. They are all based on a signal travelling right through a patient: different kinds of electro-magnetic radiation (such as X-rays or gamma-rays) or sound waves. These signals interact with the tissues of the patient. By detecting the signal coming out of the body an image of the inside of the patient can be made. In this way the patient seems to become transparent – which explains the title of this unit: The Glass Patient.

Assignments

1 Visible light-rays are not suitable for medical imaging. Explain why not.
2 The first medical case is about a newborn baby with suspected malfunctioning of the heart. Click on cases, read the description of the case_1 and answer the following question:

- As far as you know, what could doctors do to find out what exactly is wrong by looking inside the patient’s body? Try to think of at least two possibilities, but preferably more than two. Note that at this point there are no right or wrong answers.

Imaging techniques
There are lots of non-invasive imaging techniques available for putting up a diagnosis. The ones most widely used in practice are given below. Examples of corresponding images are shown in Figure 1.

Figure 1 – From upper left clockwise: examples of images produced by X-ray Photography, Computed Tomography, Nuclear Medicine, Ultrasound and Magnetic Resonance Imaging techniques.
**X-ray Photography** – X-rays from a source outside the body are absorbed to a different degree by different parts of the body. The transmitted radiation is detected and processed into a two-dimensional shadow image of the body’s bones and organs.

**Computed Tomography or CT-scan** – A pile of X-ray images processed by a computer results in a virtual three-dimensional image of the body. The computer can then display vertical and horizontal cross sections of the body.

**Nuclear Medicine** – Radiation originating from radioactive substances brought into the body is detected outside the body and processed into an image.

**Magnetic Resonance Imaging or MRI-scan** – Hydrogen atoms in the body are forced to vibrate by radiating the body with radio waves. The radiation emitted by these atoms when loosing their vibration is detected outside the body and processed into an image.

**Ultrasound or Echoscopy** – Sound waves going through the body are reflected at the separating surface of two different types of tissue inside the body. These reflections are detected outside the body and processed into an image.

Additional background information: see importance of imaging techniques in the hospital.

**Central question**
Not all these techniques are suitable for putting up a diagnosis in a specific case, such as the patient’s problem in the case of the newborn baby. The different techniques make different structures (such as bones and soft tissues) visible. Some techniques produce static images, while other techniques are specifically suitable for imaging body processes (such as the beating of the heart). Moreover, some techniques are harmful to the patient, while others are not – as far as we know now.

This leads us to the following **central question** for this teaching/learning unit:
- Which kind of medical imaging is most appropriate (and why) for diagnostic purposes in specific medical cases?

**Assignment**
3 In the case of the newborn baby explored earlier in Assignment 2 a decision has to be made: which of the five imaging techniques available is most appropriate? But, before going into this decision-making, first answer the following questions:
- For assessing whether or not an imaging technique is appropriate, which kind of information about the technique would you need? Again: no right or wrong answers to this question.
- Do you have enough information required for assessing one or more of these imaging techniques? If so: which technique(s), and which information?

**Assessment of imaging techniques**
Establishing the most appropriate imaging technique in a specific medical case is a matter of decision-making. Figure 2 shows a relatively simple procedure for doing this. The procedure starts with identifying the problem. In this case a medical problem of a patient, where looking inside the patient’s body seems desirable or even necessary.

![Decision-making procedure](image-url)
The next step in the procedure is twofold: generating alternatives and developing criteria. In this case the alternatives are already given: the five different imaging techniques, ranging from X-ray to Ultrasound. Furthermore, you yourself have been working on developing criteria in Assignment 3: the different aspects of imaging techniques you need to know (more) about in order to be able to assess whether or not a technique is appropriate. The outcome of the discussion might reflect criteria such as the following:

- Applicability – What can be seen on the image? For which kinds of medical problems is the imaging technique suitable?
- Health effects – Are there any negative effects on the patient’s health? If so: which effects?
- Mental welfare – Are there any negative effects on the patient’s mental welfare? If so: which effects?
- Costs – How expensive is it?
- Availability – Are there any restrictions on its availability? If so, which restrictions?

The next step of evaluating alternatives in the procedure would consist of comparing the different imaging techniques on the above mentioned (or other) criteria: listing the strong and weak points (or the advantages and disadvantages) of each technique, processing the information gathered about these techniques in a structured way.

The final step in the procedure is, of course, choosing a solution: deciding which techniques are appropriate and which one of those is most appropriate. In this final step you will probably have to decide about how important the different criteria are in your view: which criteria are most important, and which ones less important? Or, in other words: which weight do the different criteria have? In most cases, only such a weighting of the comparisons made during the preceding step will result in a clear-cut choice.

The advantage of going through the above outlined decision-making procedure is that you will be (better) able to explain and defend your choice of the most appropriate imaging technique in the medical case under consideration.

### Investigations

After this introduction on medical imaging there are two options for continuing with this unit:

- **Investigation 1 – Medical decision-making**: Choosing the most appropriate imaging technique in a specific medical case – decision making about which of the available imaging techniques to use for the diagnosis of a patient with a specific medical problem.
- **Investigation 2 – Scientific/Technological background**: Investigating the scientific and technological principles underlying the different imaging techniques – finding out ‘how stuff works’.

Choose the appropriate option.