Medical Image Processing

Lecturer: Ph.D Bao-Thien Nguyen-Tat
Faculty of Information Science and Engineering
University of Information Technology

Chapter 1: Introduction

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1.1 Introduction to Disease Screening

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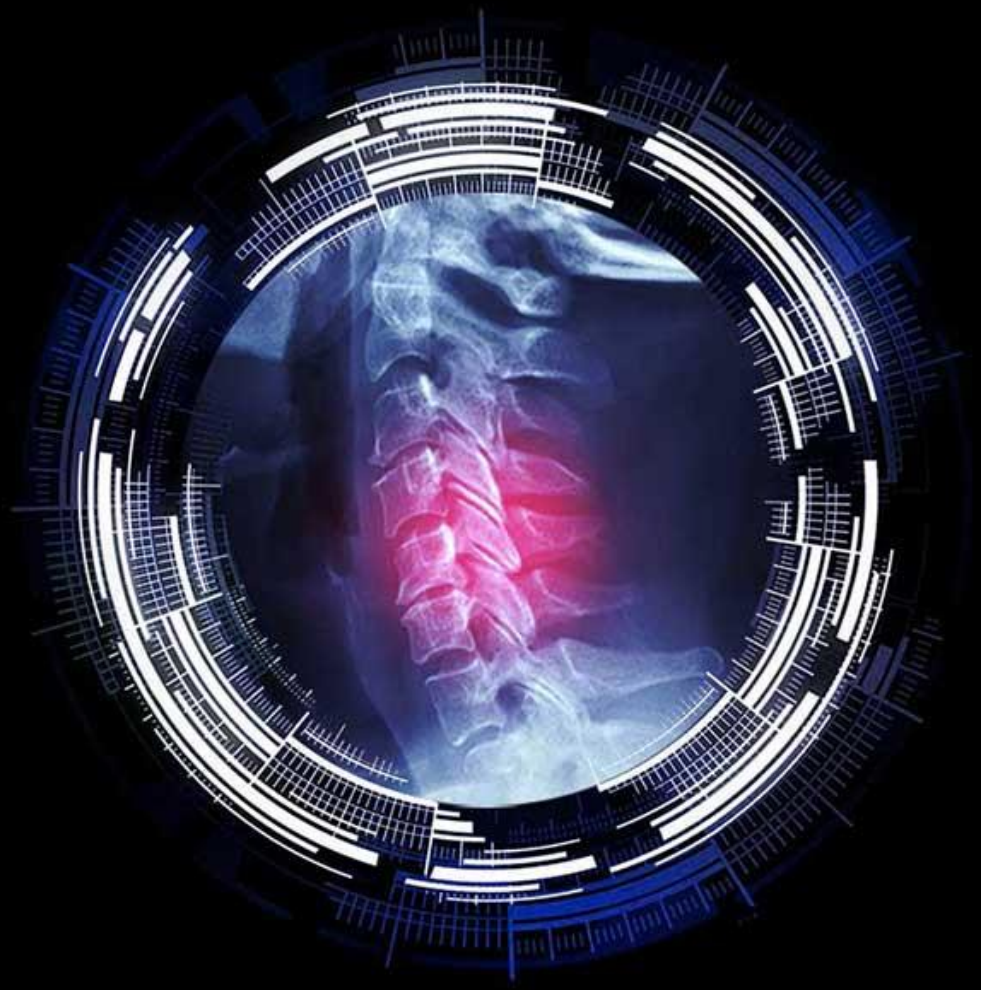

Chapter 1: Introduction

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- Recent developments in the science, technology, and medical domains have helped people live better lives.
- A considerable number of vaccinations and preventive medication has helped reduce infectious and communicable diseases.
- Advanced treatment facilities available in multi-speciality hospitals have also helped in detecting and curing diseases in their early stages.
- Scheduled health checkups recommended by doctors also help to identify and cure a number of acute and deadly diseases.

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- The incidence rate of new kinds of infections and communicable/noncommunicable diseases is rapidly rising, irrespective of age, race, and gender.
- To support the early diagnosis and treatment implementation for diseases, a number of diagnostic procedures are proposed and implemented in various disease diagnostic centres and clinics.
- The medical images recorded using a chosen modality gives required insight for the disease to be identified. Based on this insight, the doctor can plan what treatment is to be implemented.

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- Medical imaging can be recorded with a variety of procedures ranging from camera-assisted techniques to radiation-based methods.
- The choice of methodology depends upon the organ to be examined and the expertise of the doctor.
- The recorded image can be assessed by the doctor, assisted by a computerised algorithm.
- Modern image recording facilities support information in digital form, known as digital imaging, thus computer-assisted diagnosis is widely adopted.

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- At the present, although a considerable number of medical facilities are available, disease occurrence rates among humans are gradually rising due to various unavoidable causes.
- These illness in humans can be classified into several categories, such as: (i) infectious disease, (ii) deficiency disease, (iii) hereditary disease, and (iv) physiological disease.
- The above mentioned diseases can further be grouped as communicable and non-communicable.

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- A pre-screening procedure is recommended as essential to detect the disease in its premature phase.
- If the disease and its severity are identified in its premature phase, a treatment procedure could be recommended and implemented to control and cure the disease.
- This could be could imply less effort compared to a disease diagnosed in its delayed phase.

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- Diseases of internal organs such as the brain, lungs, heart, breast, the digestive system, and blood are normally diagnosed using a chosen imaging method associated with a prescribed imaging modality.
- After registering the image of the organ, the disease can be diagnosed using a computerized disease examination procedure or a personal check by a clinical expert.

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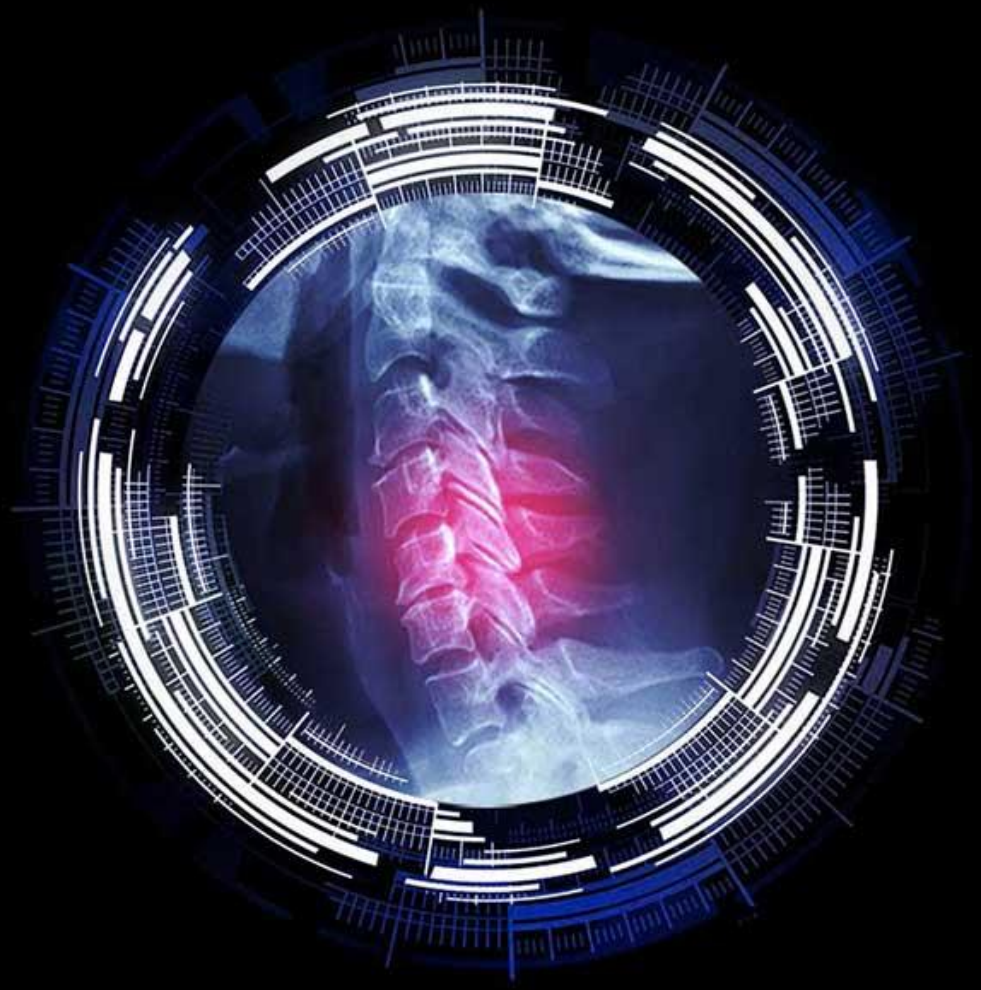
- semi-automated/automated disease detection procedures are implemented to speed up the diagnostic process.
- The report prepared with these techniques are used as supporting evidence regarding the patient, which will help the doctor during decision making and treatment planning process.
- the availability of the computing facility helps to develop a large number of computer aided detection procedures, which considerably reduce the burden on doctors during conventional disease detection and also during mass screening processes.



1.1 Introduction to Disease Screening

1.1 Introduction to Disease Screening

- Diseases are classified either as communicable or non-communicable depending on the occurrence rate and its nature.
- Diseases of the human body can be diagnosed in a variety of procedures, and a visual check is preferred due to its accessibility.
- In some moderate/acute cases, along with a personal check, a suitable signal/image-based disease evaluation is also recommended by the doctor to verify and confirm the disease.

1.1 Introduction to Disease Screening

- Diseases in vital internal organs are more when compared with external organs, hence more care needs to be taken during diagnosis.
- Most of the diseases in internal organs such as the heart, lungs, brain, kidney, respiratory tract, stomach, and blood are normally diagnosed using carefully chosen bio-signalling/bio-imaging procedures.
- Medical imaging-assisted disease diagnosis has emerged as a common and recommended technique.

1.1 Introduction to Disease Screening

- Developments in medical imaging techniques helped to achieve a two-dimensional (2D) or the three-dimensional (3D) picture of the organ in greyscale or RGB form.
- These images would help the physician to get an insight regarding the disease in the body and also helps to track the progression of the disease with respect to time.
- Identification of the disease in its premature phase is very essential to plan for the appropriate treatment.
- The scheduled body screening will help to identify number of diseases in its premature phase, even though the symptoms are absent.

1.1 Introduction to Disease Screening

- The procedures executed to test the patient for confirmation of the disease is technically known as Disease-Screening (DS) process and it varies according to the disease to be detected.
- The procedures commonly employed in DS involves (i) personal check by an expert, (ii) clinical test ranging from sample collection and testing of the bio-signal/bio-image-based methods, (iii) intermediate level detection based on the bio-signals and images collected from the patients, and (iv) verification of report by the doctor for authentication of disease.

1.1 Introduction to Disease Screening

- Figure 1.1 illustrates the initial-level verification and recommendation by the doctor a patient approaches.

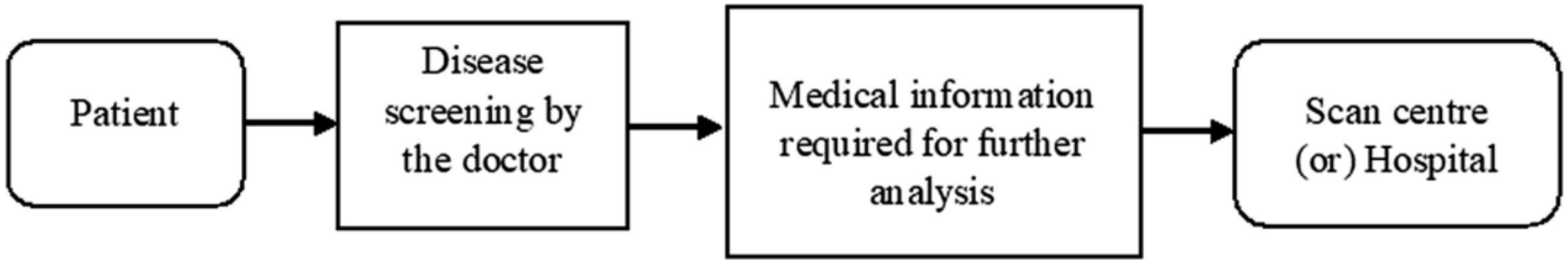


FIGURE 1.1 Initial Level Verification and Recommendation by the Doctor.

1.1 Introduction to Disease Screening

- This protocol includes common demographic parameters such as gender, age and weight, followed by previous history of disease, the number of days the patient has been afflicted by the symptoms, heart rate, temperature, and other recommended parameters to identify the cause and nature of the disease.
- If the disease is in any internal organ then along with personal verification, the doctor will also suggest a clinical checkup to collect more information about the disease. The doctor can then plan for appropriate treatment to control the disease and take necessary steps for curing after careful inspection of the clinical report.

1.1 Introduction to Disease Screening

- Figure 1.2 depicts various phases involved in the recording of diseases in vital internal organs using the appropriate imaging modality.

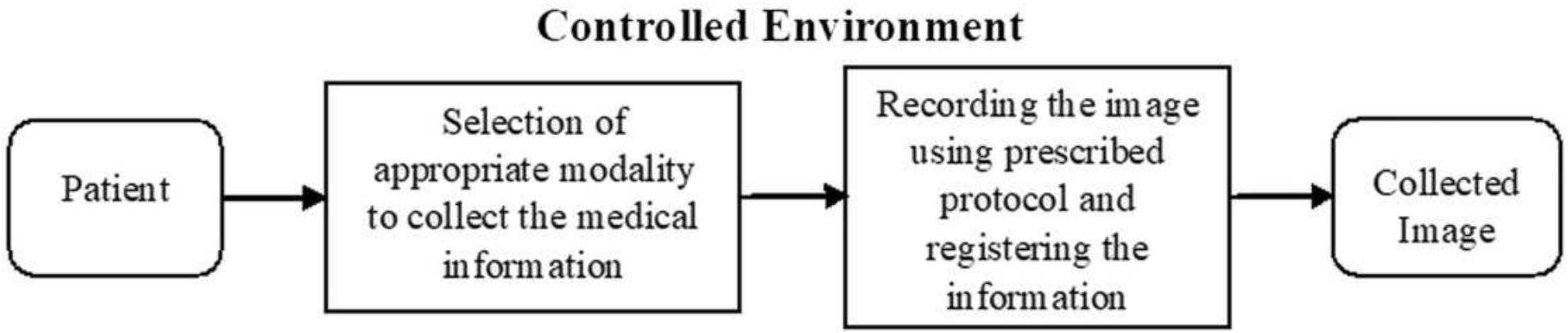


FIGURE 1.2 Collection of Disease Information Using a Prescribed Protocol.

1.1 Introduction to Disease Screening

- Diseases in the internal organs are initially evaluated by a doctor and, for further assessment, the image of the organ is recorded with a chosen modality.
- To maximize quality and maintain confidentiality, the image recording procedure is performed in a controlled environment where all the prescribed protocols are followed during recording. This also helps avoid ethical and legal issues.
- After recording the image, an initial-level assessment is performed in the scan/imaging centre. The recorded image, along with the prediction during the imaging, is then sent to the doctor for further evaluation. The doctor examines the image and report and, based on the observation, a conclusion regarding the orientation, cause and harshness of the disease can be computed

1.1 Introduction to Disease Screening

- The general image processing system presented in Figure 1.3 assesses the medical images recorded by the chosen modality.

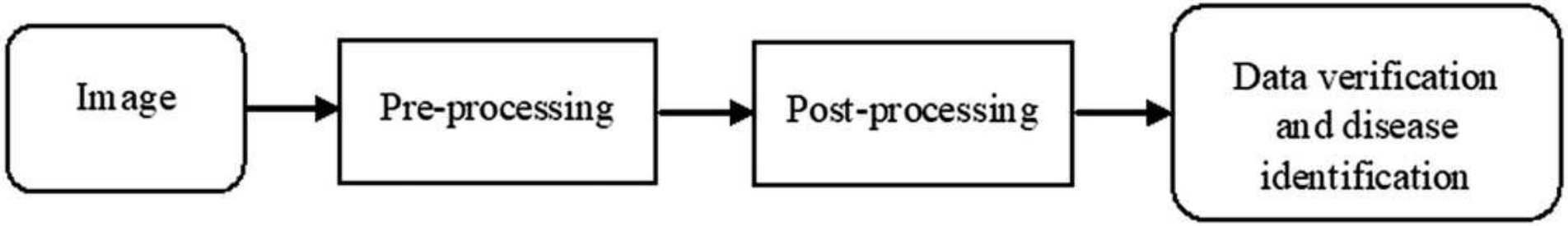
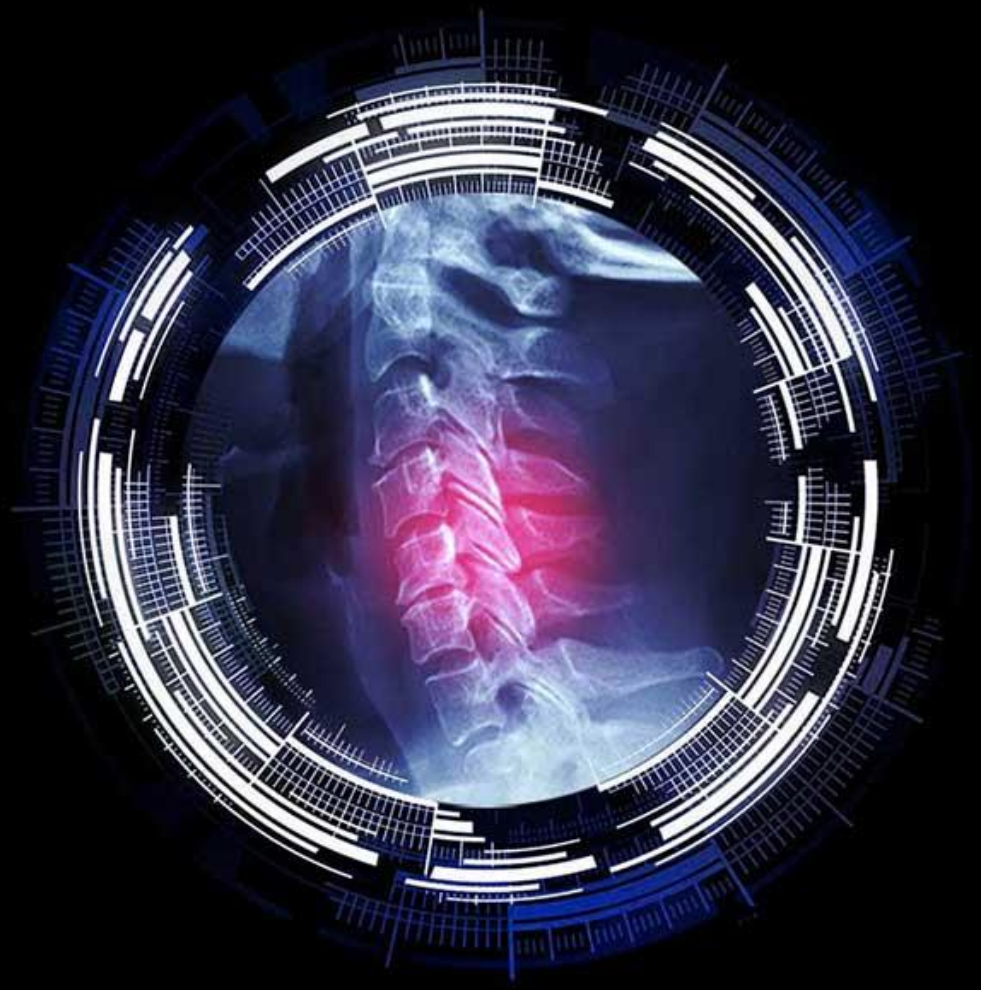


FIGURE 1.3 Image Assessment Technique to Convert the Raw Information into Understandable Information.

1.1 Introduction to Disease Screening

- The raw image recorded from the patient using standard acquisition protocol undergoes a variety of pre-processing procedures based on what is needed.
- Some of the commonly used image preprocessing techniques include (i) image orientation adjustment, (ii) resizing, and (iii) filtering.
- After pre-processing, a post-processing technique may then be employed to extract the essential section or the necessary features from the image. This procedure assists the doctor in diagnosing the disease using a dedicated computerised software



1.1.1 Screening of Blood Sample

1.1.1 Screening of Blood Sample

- Blood sample screening is a commonly recommended procedure by doctors during routine health examinations.
- It is handled as an initial-level screening for infections and communicable diseases.
- Blood testing is a common lab analysis technique widely performed to measure the blood cell count and the infection in the cells.
- An essential amount of blood is collected from the patient during this process as per the prescribed protocol. This is then used to evaluate the Complete Blood Count (CBC), blood chemistry, and blood enzymes.
- This section presents the image-assisted assessment of White Blood Cell (WBC) detection for Malarial and *Trypanosoma cruzi* (*T. cruzi*) infection.

1.1.1 Screening of Blood Sample

- Once a sufficient volume of the blood is collected from the patent using the prescribed protocol, the collected blood is converted into blood film/peripheral blood smear (thin/thick) using the glass microscope slide.
- These are then marked in such a way as to observe different blood cells.
- The marking/staining agents are used to enhance the visibility of the information to be collected from the peripheral blood smear.

1.1.1 Screening of Blood Sample

- The WBC, also known as leukocytes, is a major component of the immune system. It protects the body from infectious microorganisms and foreign intruders. There are certain categories of WBC that are generated from the hematopoietic stem cells of bone marrow.
- The WBC/leukocyte count plays a vital role. Normal count ranges from 4,000 to 11,000 cells/mcL. A decrease in the value indicates a lower immunity level, and an increase presents the possibility of infection.
- there are five WBC categories present in the human body, each having its own function and texture pattern. The clinical-level recording of the WBC is achieved using digital microscopes.

1.1.1 Screening of Blood Sample

- Various WBC cells prepared from thin blood smear viewed under a digital microscope are presented in Figure 1.4.

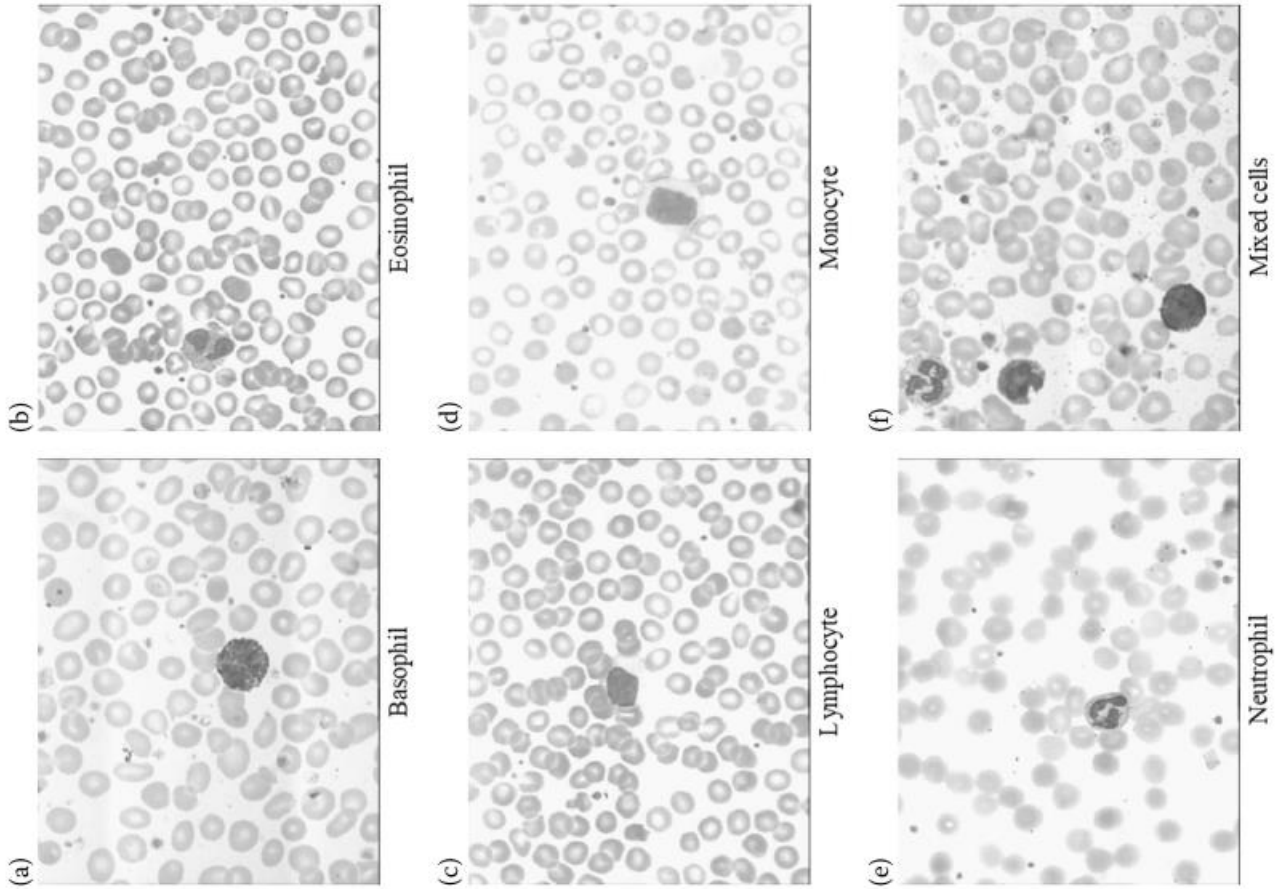


FIGURE 1.4 Sample Test Images of White Blood Cells (Leucocytes).

1.1.1 Screening of Blood Sample

- **Advantages:** The assessment of leukocyte type and its count in cells/mcL helps confirm infection in the human body and is one of the commonly accepted prescreening processes for a variety of diseases, including cancer and COVID-19.
- **Limitations:** This procedure requires the collection of a prescribed volume of blood from infected patients. Further, blood collection and preparation of the microscopic slide and staining requires care to avoid spread of the disease.

Malaria

- In most countries, mosquito-borne infectious diseases are common and can cause moderate to severe symptoms among humans. Malaria is one of the diseases caused by the single-celled microorganism Plasmodium. Even though a variety of plasmodium species exist, only five groups cause malaria. If malaria is identified in its early phase, a possible treatment procedure can be implemented to help the patient recover.
- Malaria infection develops mostly either from the liver or Red Blood Cell (RBC). A mosquito bite injects the plasmodium parasite into the body which later will reach and settle in the RBC. Within the RBC, the plasmodium multiplies further and causes severe illness to the patient.

Malaria

- It is essential to identify the severity of RBC infection and the type of Plasmodium which caused the illness to implement a possible treatment process.
- blood sample collection and microscopic examination with the blood film/peripheral blood smear (thin/thick) are normally performed in a clinical laboratory.
- After the identification of the infection level and the type of the parasite, the doctor can treat and prescribe the suitable drug for recovery.
- malaria due to P. falciparum is acute to humans compared to malarial infection by other species. Further, the hypnozoites developed by P. vivax remain in the body for several years.

Malaria

- Figure 1.5 (a) to (e) presents parasites such as *P. falciparum*, *P. malariae*, *P. vivax*, *P. ovale,* and *P. knowlesi* acquired from a thin blood smear.

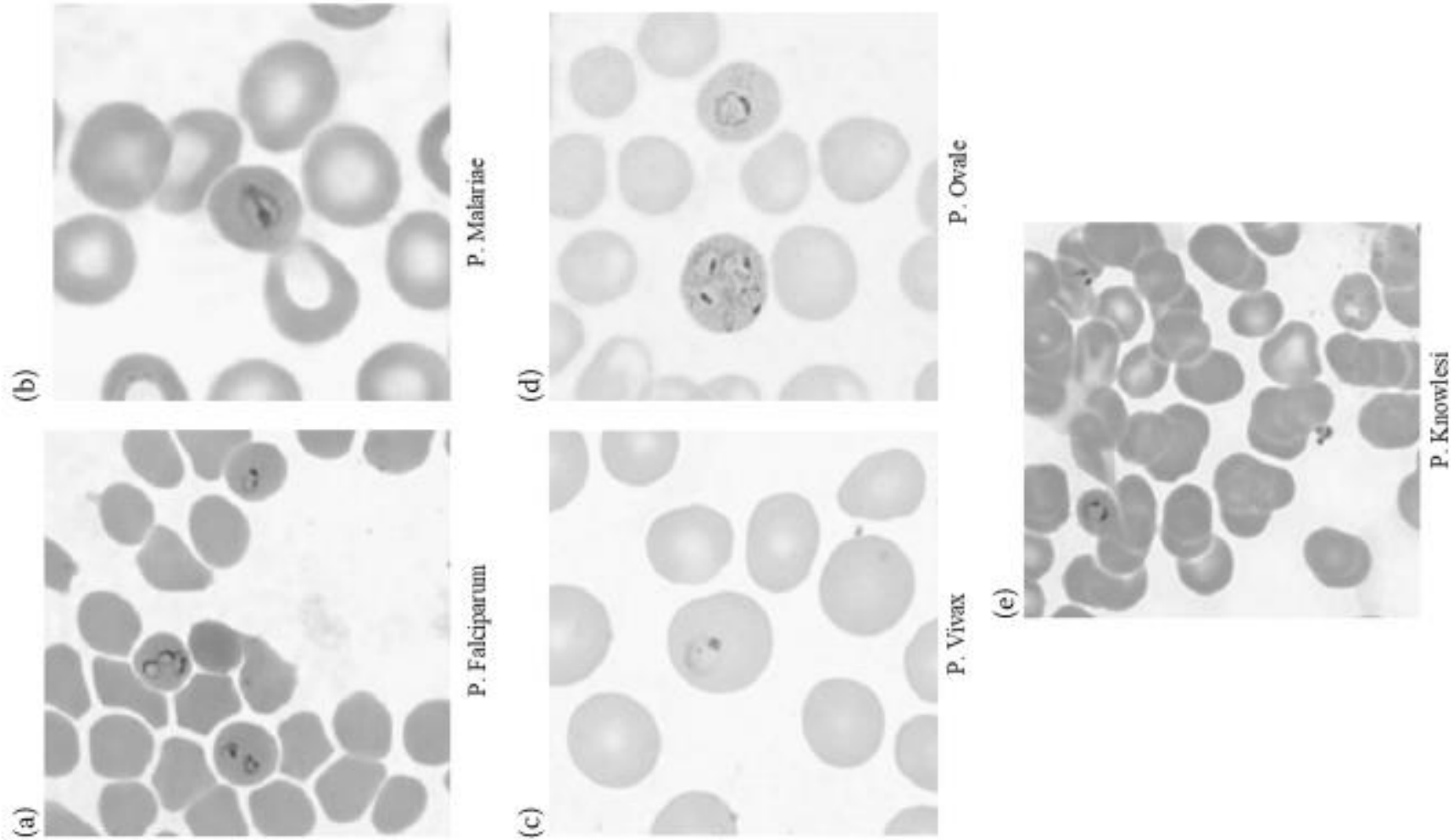


FIGURE 1.5 Sample Test Images of Plasmodium Species.

Malaria

Advantages: Malaria parasite and its infection level could be accurately detected and identified using microscopes. Further, this technique is a traditional and accepted clinical practice to detect blood infections.

Limitations: This examination requires the gathering of an approved volume of blood from the infected person. Further, the preparation of the microscopic slide and staining, as well as the disposal of the collected blood, requires utmost care.

Chagas disease

- The infected bug normally carries the parasite called Trypanosoma cruzi (T. cruzi). When the bug bites, it injects the parasite into the blood stream where it can grow and multiply.
- This disease severely affects the blood tract, including the heart. If left untreated, the disease can cause various illnesses

Chagas disease

- The infected bug normally carries the parasite called Trypanosoma cruzi (T. cruzi). When the bug bites, it injects the parasite into the blood stream where it can grow and multiply.
- This disease severely affects the blood tract, including the heart. If left untreated, the disease can cause various illnesses.
- In the severe stage of illness, parasites can be felt travelling in the blood. The analysis of illness can be made by inspecting for the parasite in a blood smear by microscope.
- The common procedure followed to diagnose *T. cruzi* infection is blood sample analysis from a stained thick/thin blood smear.

Chagas disease

Figure 1.6 shows the *T. cruzi* in blood smears, wherein Figure 1.6 (a) shows the adult and Figure 1.6 (b) shows the premature *T. cruzi*.

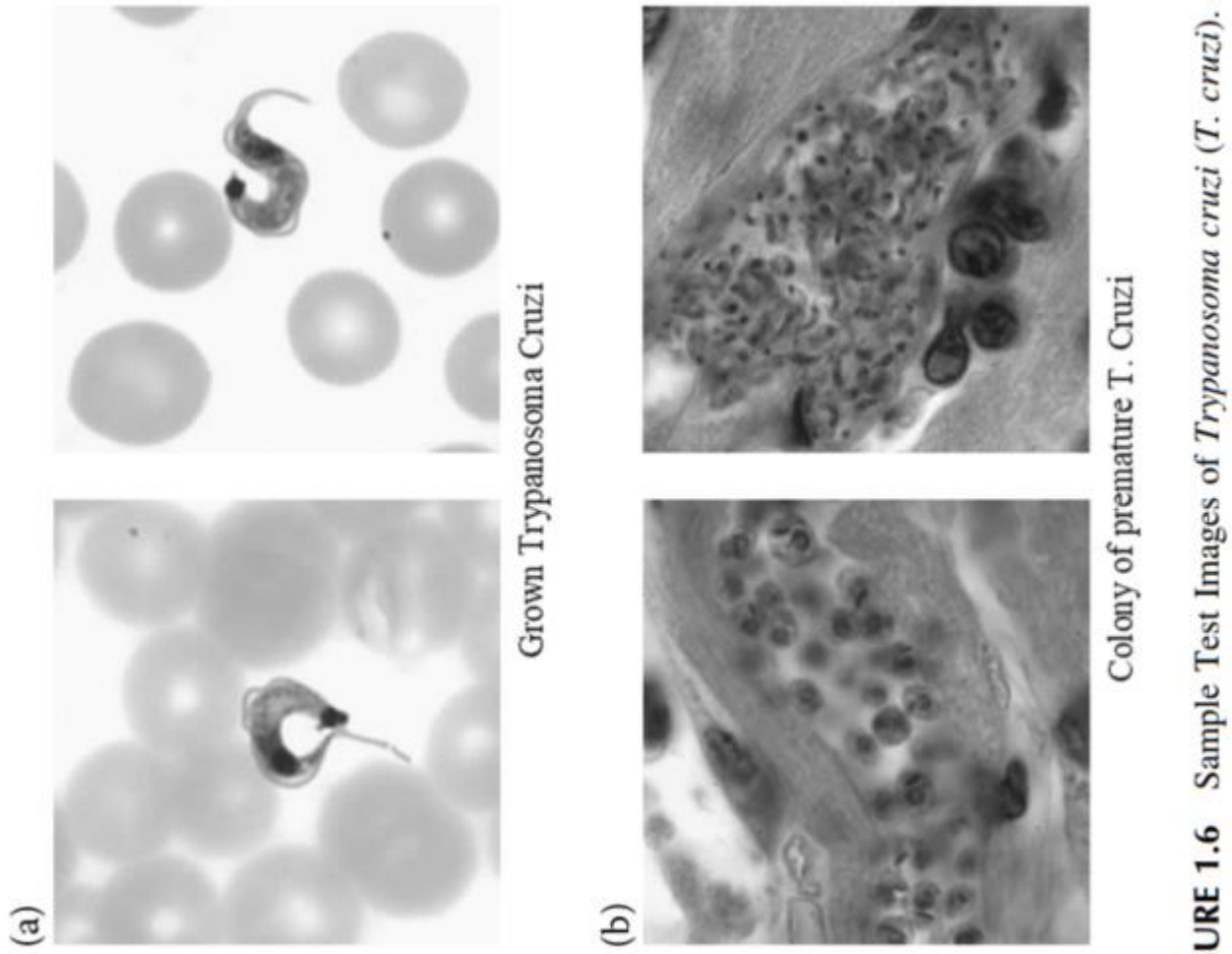
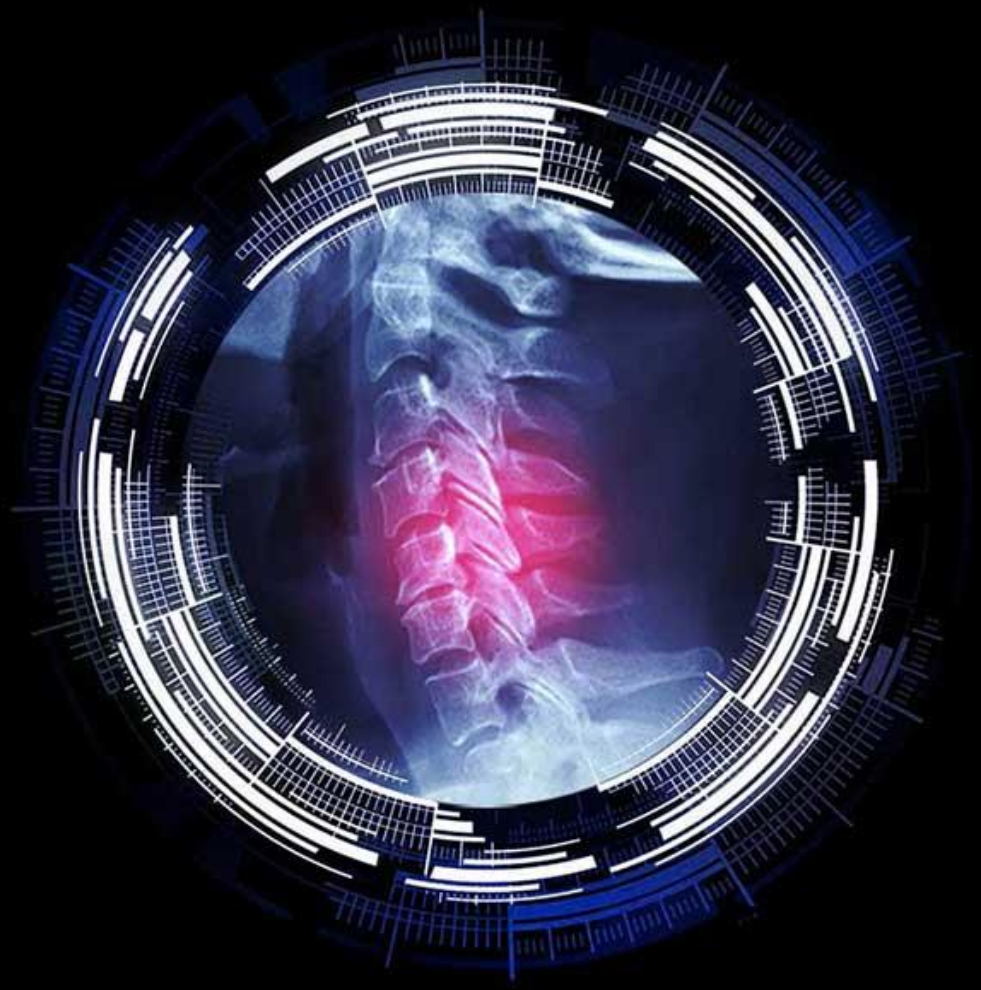


FIGURE 1.6 Sample Test Images of *Trypanosoma cruzi* (*T. cruzi*).



1.1.2 Screening for Skin Melanoma

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- Skin cancer (melanoma) is one of the most common cancers in particularly due to high exposure of the skin to ultraviolet (UV) rays. The high exposure of pigment-producing cells called melanocytes to UV rays increases the chance of skin cancer among humans.
- When it reaches the severe phase, melanoma will release cancer cells into the blood, thus allowing cancer to reach other vital parts and decreasing the chance of recovery. The identification of skin cancer in its early stages needs a self checkup followed by screening procedures done by an experienced dermatologist.
- The a dermatologist will recognise skin cancer using the commonly prescribed ABCDE rule, to distinguish the moles from melanoma.

1.1.2 Screening for Skin Melanoma

The ABCDE rule helps to detect the skin cancer based on the following parameters:

- Asymmetric: Common moles are likely be round and balanced, but one side of the cancerous mole will probably be dissimilar to the other.
- Border: The outer surface is irregular rather than smooth and may appear tattered, uneven, or blurred.
- Colour: Skin cancer section may tend to have patchy shades and colors including black, brown, and tan.
- Diameter: Melanoma can cause a change in the size of a mole.
- Evolving: Variation in a mole’s exterior over weeks or months can be a symptom of melanoma.

1.1.2 Screening for Skin Melanoma

- The clinical-level detection of skin cancer is achieved using the ABCDE rule with an examination with dermoscopy. The computerised dermoscopy will help record the suspicious skin sections for future assessment.
- The clinical-level diagnosis of skin melanoma includes (i) imageassisted and (ii) biopsy-assisted detection and confirmation.
- In the image-assisted diagnosis, the dermoscopy images are examined by a doctor or a computer algorithm to confirm the disease with the help of the parameters presents in ABCDE rule.
- During the biopsy test, a sample of the skin tissue is collected and tested based on standard medical protocol.

1.1.2 Screening for Skin Melanoma

Figure 1.7 (a) depicts the mole (nevus), Figure 1.7 (b) presents melanoma, and Figure 1.7 (c) and (d) shows the digital dermoscopic view of the suspicious skin lesion and the skin melanoma recorded along the hair section

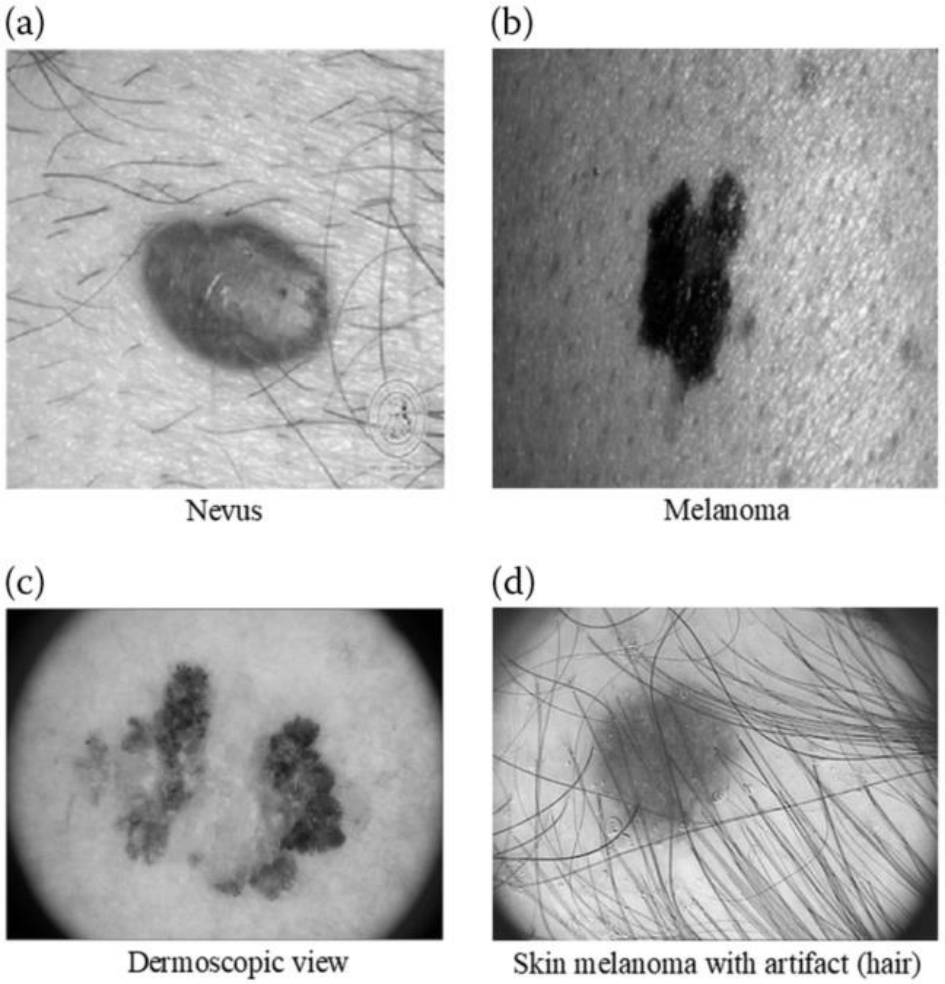
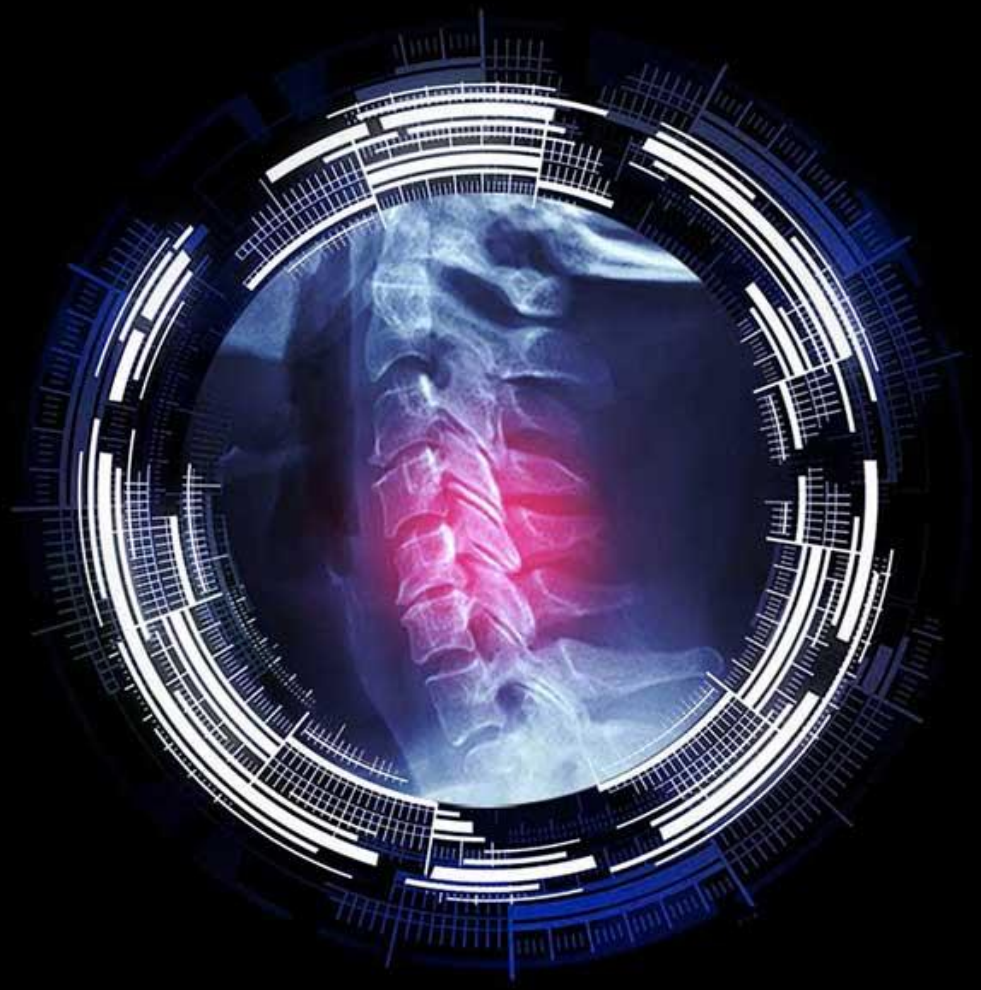


FIGURE 1.7 Dermoscopy Images to Assess the Skin Condition.



1.1.3 Stomach Ulcer Screening

1.1.3 Stomach Ulcer Screening

- Infections in the digestive tract cause Stomach Ulcer (SU), which is mainly caused by an infection in the wall of the gastrointestinal system. SU can also be caused by the frequent use of drugs that affect tissues in the digestive tract. The symptoms of SU can be felt in the upper and lower gastrointestinal tract. The common symptoms of SU include a continuous pain in the stomach, loss of weight, burping, vomiting blood, etc.
- SU occurs when the stratum, which guards the stomach lining from stomach acid, breaks down and permits injury to the stomach coating. Infection by Helicobacter pylori (H. pylori) and the frequent usage of non-steroidal antiinflammatory drugs also increase the impact of SU.

1.1.3 Stomach Ulcer Screening

Diagnosis and treatment of SU depends on the symptoms and severity felt by the patient. The common procedure to be followed involves:

- **Barium consumption**: In this technique, barium in liquid form is given to the patient. This forms a lining on the upper gastrointestinal tract, which is recorded using the X-ray. The X-ray then clearly records the barium lining for better visibility, which is further assessed by the physician with a visual or computer assisted check.
- **Endoscopy**: Endoscopy is a common technique used to record the inner body with the help of a digital camera. The endoscopy can be inserted in with a wire, or it could be a wireless capsule. An appropriate technique then assists the diagnosis after recording the essential image, assessing the severity and orientation of SU in the gastric tract.
- **Endoscopic biopsy**: This technique helps record/assess the tissue in the stomach wall for tissue-level analysis. This technique involves collecting a piece of stomach tissue which would then be analyzed in the lab.
- **Gastric polyps** are also a form of abnormality closely related with SU. It is an abnormal growth on the inner lining of stomach.

1.1.3 Stomach Ulcer Screening

- Figure 1.8 shows a sample gastric polyps collected from the CVC-ClinicDB

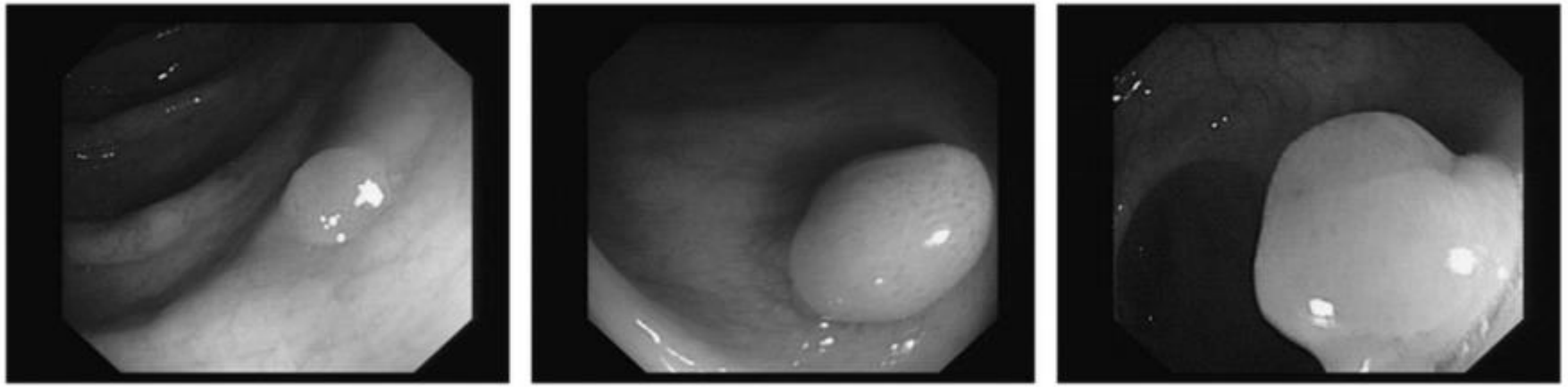
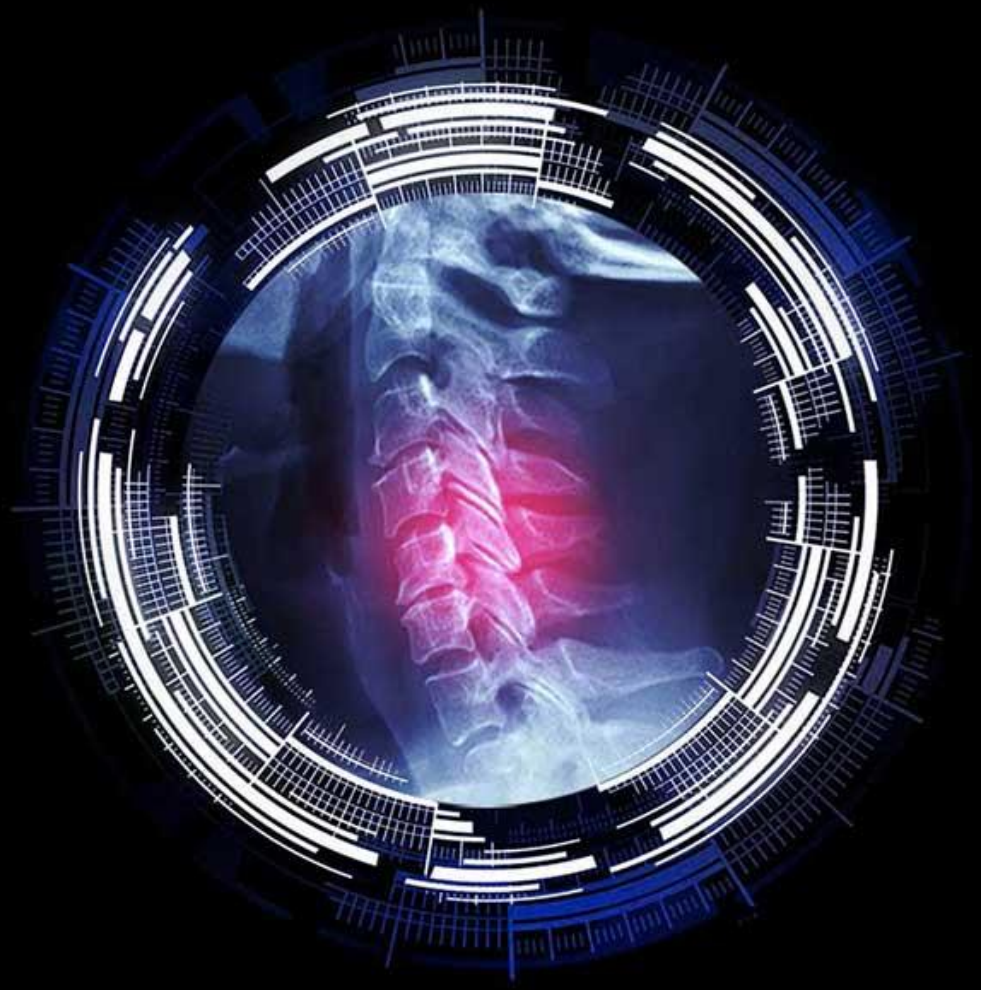


FIGURE 1.8 Stomach Abnormality Recorded Using Endoscopy.



1.1.4 Screening for Breast Abnormality

1.1.4 Screening for Breast Abnormality

- Breast cancer normally develops from breast cells that form as either lobules or ducts of the breast.
- The initial stage of breast cancer is diagnosed through an abnormality known as Ductal Carcinoma In Situ (DCIS). These abnormal cells are usually found in the milk ducts of the breast. DCIS is known as the earliest form of the breast cancer.
- Clinical detection of DCIS and breast cancer is possible with imaging modalities such as Magnetic Resonance Imaging (MRI), mammogram, ultrasound imaging, and thermal imaging.

1.1.4 Screening for Breast Abnormality

- Lumps found in the breast indicates the presence of irregular or abnormal breast tissue called a tumor.
- Mammogram and MRI are widespread radiology practices used to detect grown tumors. These techniques occasionally fail to discover breast abnormalities when the cancer is in its early stages.
- Hence, in recent years, thermal and sonography have been adopted to record and analyze breast malignancy due to its risk-free and contactless nature.

1.1.4 Screening for Breast Abnormality

Figure 1.9 (a) to Figure 1.9 (c) presents sample breast MRI slices of the axial, coronal, and sagittal views extracted from a three-dimensional (3D) breast MRI

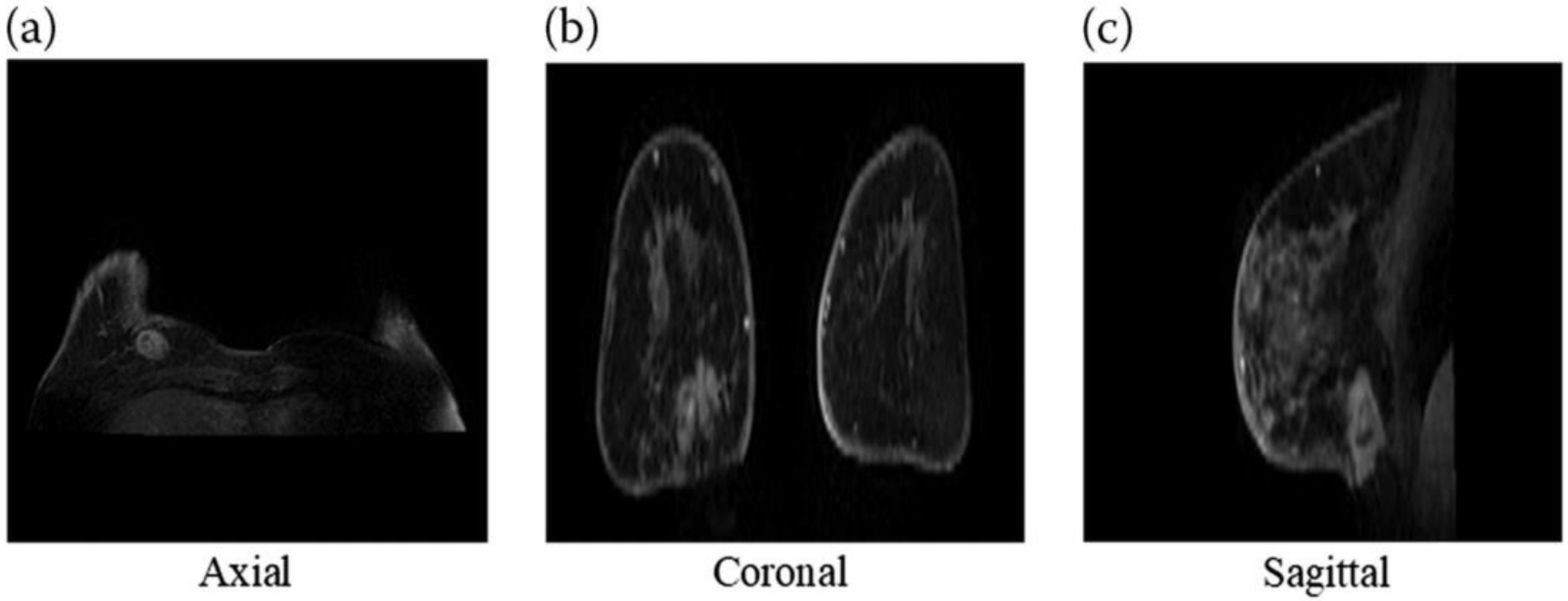


FIGURE 1.9 Breast Cancer Recorded Using MRI System.

1.1.4 Screening for Breast Abnormality

Advantages: MRI is an imaging technique used to asses a variety of internal organs. The breast MRI is recorded using varied modalities, providing a 3D view of the abnormal breast section. The visibility is accurate in MRI compared to other imaging modalities.
Disadvantages: The assessment of the 3D MRI is complex, hence conversion to 2D is essential. It is a radiological technique that should be performed in a controlled environment under the guidance of an experienced radiologist. This acquisition modality sometimes requires the injection of a contrast agent to get better visibility of the cancerous section, which can cause several side effects.

1.1.4 Screening for Breast Abnormality

- Mammogram another imaging technique used to record the breast section. During this imaging procedure, a specially designed X-ray source is used to record the breast section with the help of either a traditional film base or a digital technique.
- Due to the availability of modern X-ray systems, digital mammogram recording is now commonly used. The recorded mammogram is then examined by the doctor to detect abnormalities.

Advantages: Mammogram is preferred technique for breast cancer assessment due to its low cost and simple characteristics.

Disadvantages: The recording of mammogram involves radiation and may cause mild irritation and/or pain to the breast tissues

1.1.4 Screening for Breast Abnormality

Figure 1.10 shows sample test images from the mini-MIAS database.

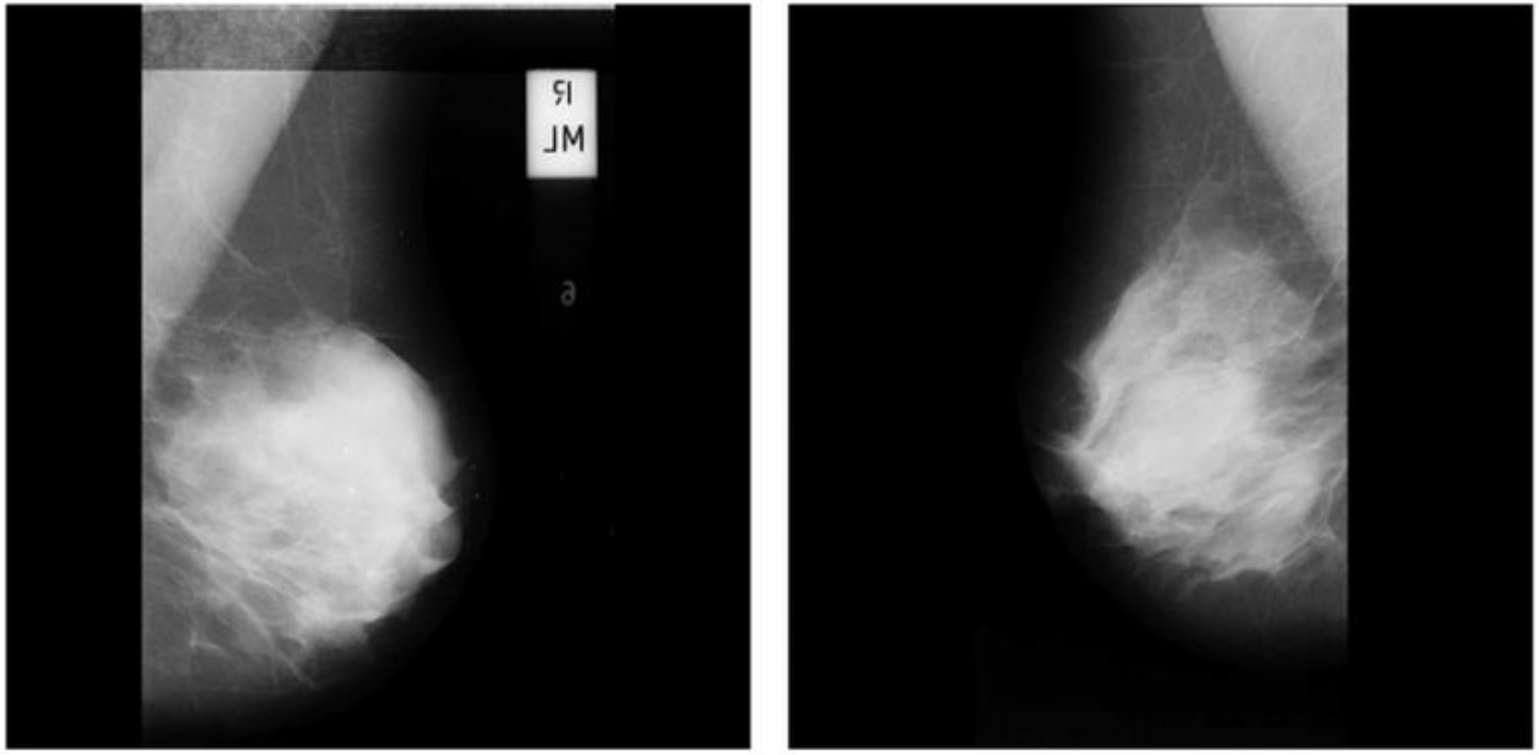


FIGURE 1.10 Breast Abnormality Recorded Using Mammogram.

1.1.4 Screening for Breast Abnormality

- For over two decades, ultrasound imaging procedures have been widely used in medical procedures to record information on the activity of internal organs, tissues, and blood flow.
- This procedure uses high-frequency sound waves (sonography) to record essential information. Compared to other imaging modalities, it is proven to be safe and causing no damage on the tissue or organ level.
- Recently, this imaging technique has become widely adopted for screening a variety of diseases including breast abnormalities.
- **Advantages**: A simple and efficient technique to assess abnormality and activity of organs with non-invasive and simple imaging procedures.
- **Disadvantages**: The quality of the image is very poor compared to the MRI. Ultrasound imaging requires a special diagnostic procedure detecting abnormalities.

1.1.4 Screening for Breast Abnormality

Figure 1.11 presenting examples of benign (Figure 1.11 (a)) and malignant (Figure 1.11 (b)) breast cancer sections

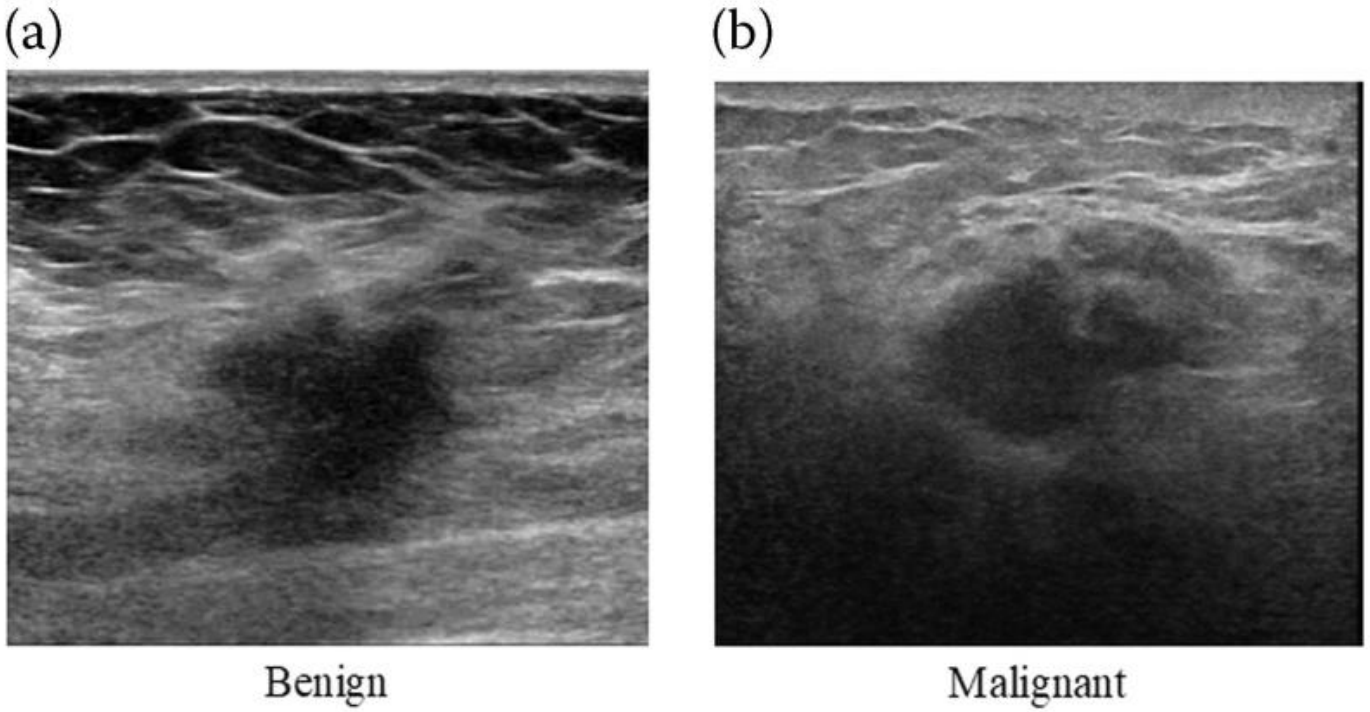


FIGURE 1.11 Breast Cancer Recorded Using Ultrasound Technique.

1.1.4 Screening for Breast Abnormality

- Thermal imaging is a recent imaging technique where infrared radiation (IR) is recorded using the standard protocol to construct an image of the section to be examined.
- Digital Infrared Thermal Imaging (DITI) is used to record the abnormal breast section for further evaluation. The level of IR wave coming out of a body organ mainly depends on its condition. The thermal camera captures the radiation and converts it into image patterns using a dedicated software unit.
- The recorded thermal image characterizes an image pattern based on the level of the IR wave. It is possible to detect the abnormality by analysing the recorded patterns from the image.
- Thermal imaging modality is a non-invasive technique considered to record the essential images from the infected person and can be used to diagnose the abnormality.

1.1.4 Screening for Breast Abnormality

Figure 1.12 (a) and (b) depicts the greyscale version of thermal imaging while Figure 1.12 (c) and (d) depicts the RGB scale version. Figure 1.12 (e) and (f) depicts the gray and RGB scale image of a chosen patient with the breast abnormality

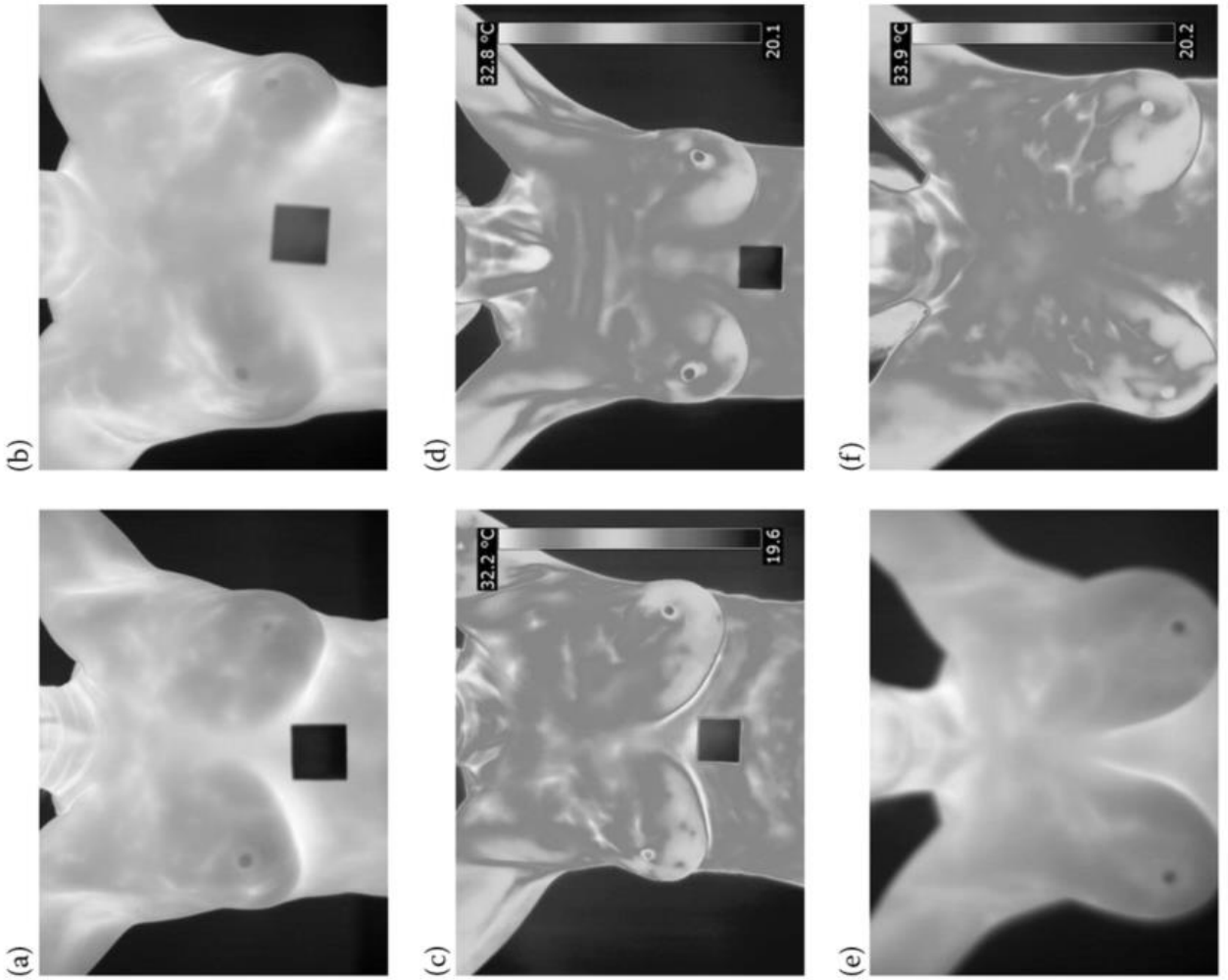


FIGURE 1.12 Breast Abnormalities Recorded Using Thermal Imaging technique.

1.1.4 Screening for Breast Abnormality

- Advantages: It is a recent and non-contact imaging system widely adopted by hospitals and scan centers. It is a handy system where a special digital camera is used to detect and convert the IR radiation into images.
- Disadvantages: The assessment of the thermal imaging needs special procedures since it is constructed using thermal patter.

1.1.4 Screening for Breast Abnormality

- **Histology** is a branch of study where the microanatomy of various cells, tissues, and organs are examined using digital microscopic images. This technique inspects the association among arrangement and functional difference between the healthy and disease samples collected from the patients. Normally, the histology based assessment is used to confirm the condition of the disease using biopsy samples.
- To confirm breast cancer, a needle biopsy is collects breast tissue and then it is examined using the digital microscopy.
- The histology analysis normally offers a better diagnostic vision regarding breast cancer evaluation and treatment.

1.1.4 Screening for Breast Abnormality

Figure 1.13 presents the histology images of the breast cancer samples, in which Figure 1.13 (a) shows the benign and (b) shows the malignant class.

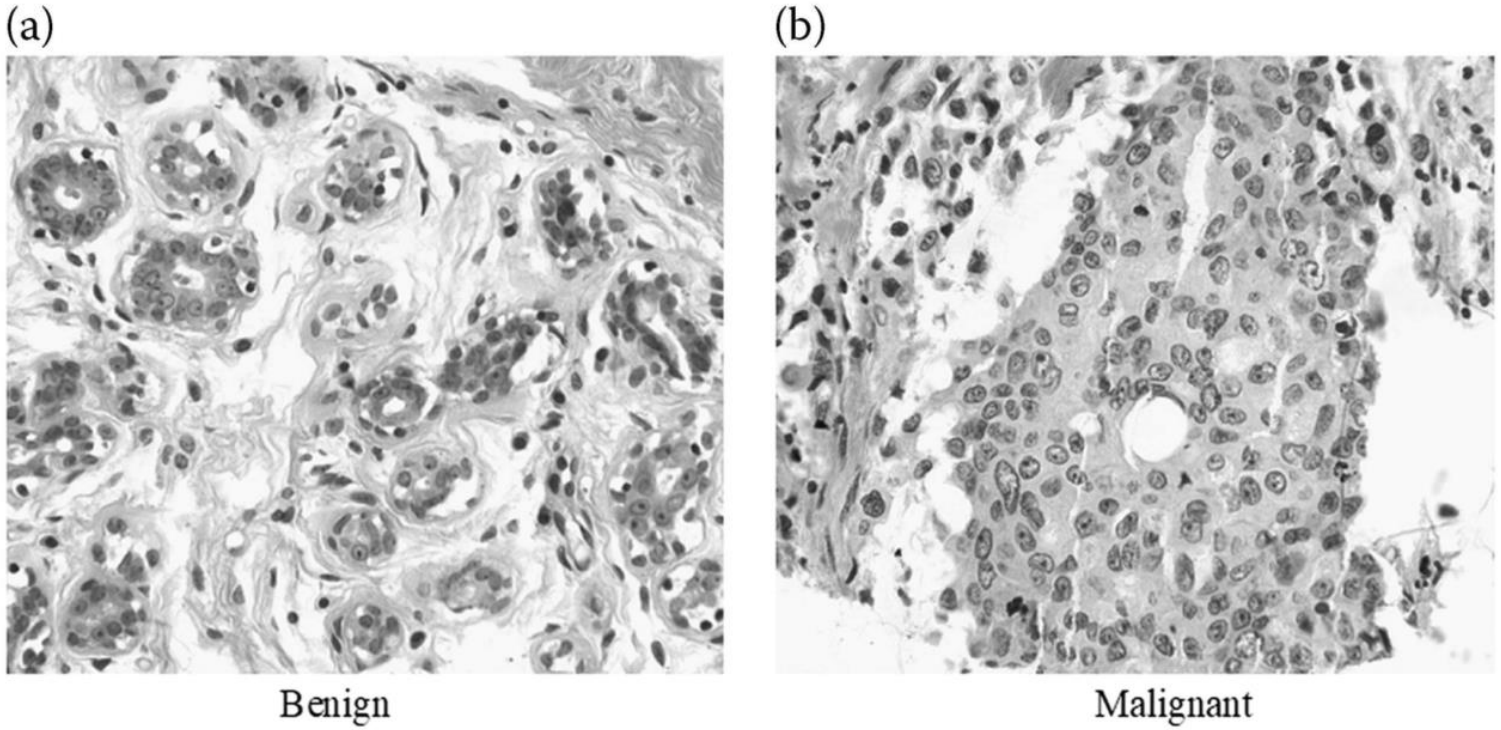
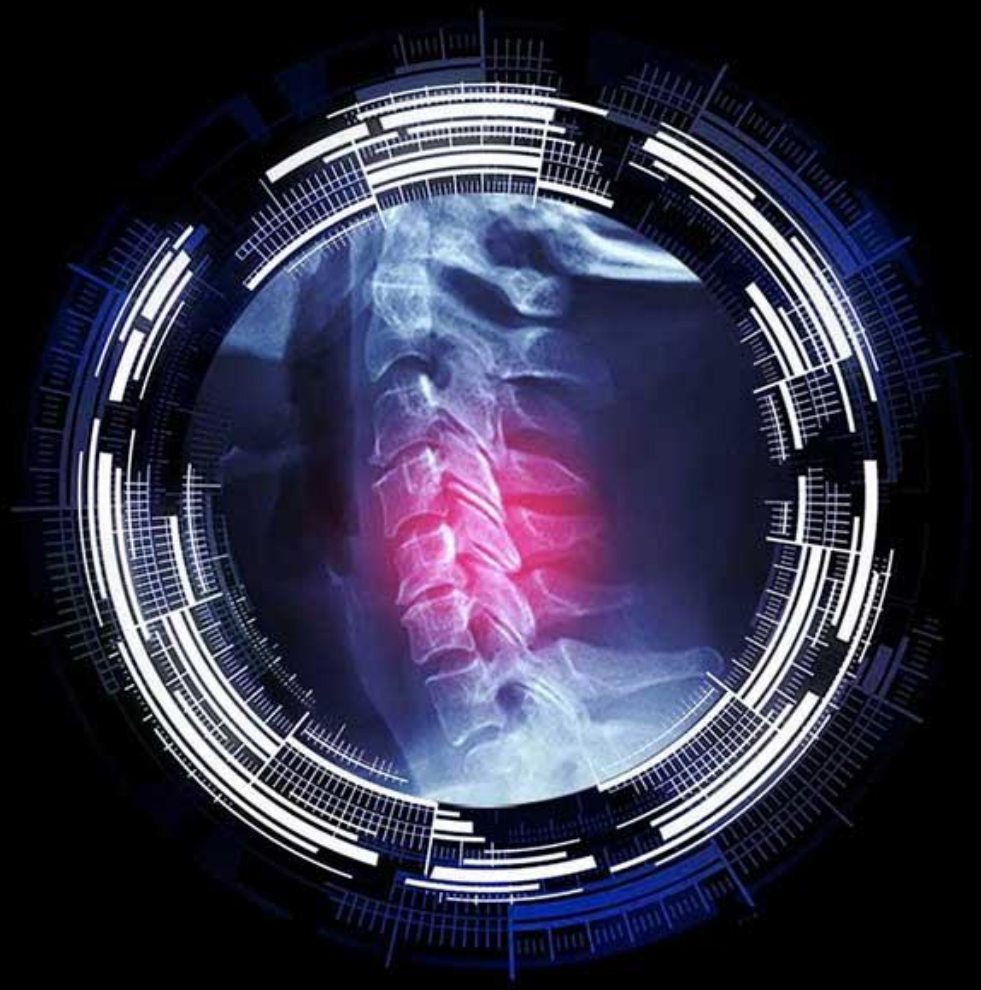


FIGURE 1.13 Microscopic View of the Breast Tissues with Cancer Cells.

1.1.4 Screening for Breast Abnormality

- **Advantages:** A tissue-level diagnosis of the disease is possible, helping design accurate treatment.
- **Disadvantages:** This technique requires tissue collection through needle biopsy which can be a painful procedure. The preparation of histopathological slides needs special care. Diagnosis is possible with an experienced doctor only.

There are various imaging modalities available to assess breast abnormalities. Each modality has its own merits and demerits, and the choice procedure depends on the doctor’s expertise. If the cancer is less visible in imagebased analysis, the doctor may suggest a biopsy-assisted examination to confirm the condition (benign/malignant) of the cancer. This helps design the essential treatment procedure. Imaging techniques such as breast thermogram and sonography appear to be harmless techniques compared to the mammogram and breast MRI.



1.1.8 Screening for Lung Abnormality

1.1.8 Screening for Lung Abnormality

- The lung is the vital organ responsible for supplying oxygen to the human body. The purpose of the respiratory arrangement is to extract oxygen from the atmosphere and shift it into the bloodstream while discharging carbon dioxide from the bloodstream into the atmosphere, a process of gas exchange.
- Humans have two lungs which are located in the thoracic cavity of the chest. The right lung is bigger than the left, which shares space in the chest along with the heart.
- The tissue of the lungs can be infected a variety of respiratory illnesses including pneumonia and lung cancer. The recently-emerged COVID-19 also infects the lungs at a considerable rate, causing medium/heavy pneumonia.

Chest Radiograph

- A chest radiograph (chest X-ray or chest film) is normally used to identify several conditions linking the chest wall, lungs, heart, and great vessels.
- Literature review confirms that pneumonia and congestive heart malfunction are normally diagnosed using chest X-ray.
- Normally, the chest X-ray is suitable for recording and evaluating the normal/abnormal conditions of the chest. It provides a good screening output for further diagnosis.

Pneumonia diagnosis

- Pneumonia is caused by an infection in the respiratory tract due to the microorganisms such as bacteria, virus, and fungi.
- Pneumonia causes a range of abnormalities in respiratory system, preventing oxygen exchange to the bloodstream.
- Untreated pneumonia is acute for the children aged five years and below and the elderly aged 65 and above.
- To provide appropriate treatment for those affected, it is essential to diagnose the infection rate in the lung.
- Due to its clinical significance, a considerable number of semi-automated and automated disease diagnosis systems are proposed and implemented to diagnose various lung abnormality using the chest X-ray

Pneumonia diagnosis

Figure 1.22 (a) to (c) presents chest radiograph of the normal, bacterial and viral pneumonia cases respectively.

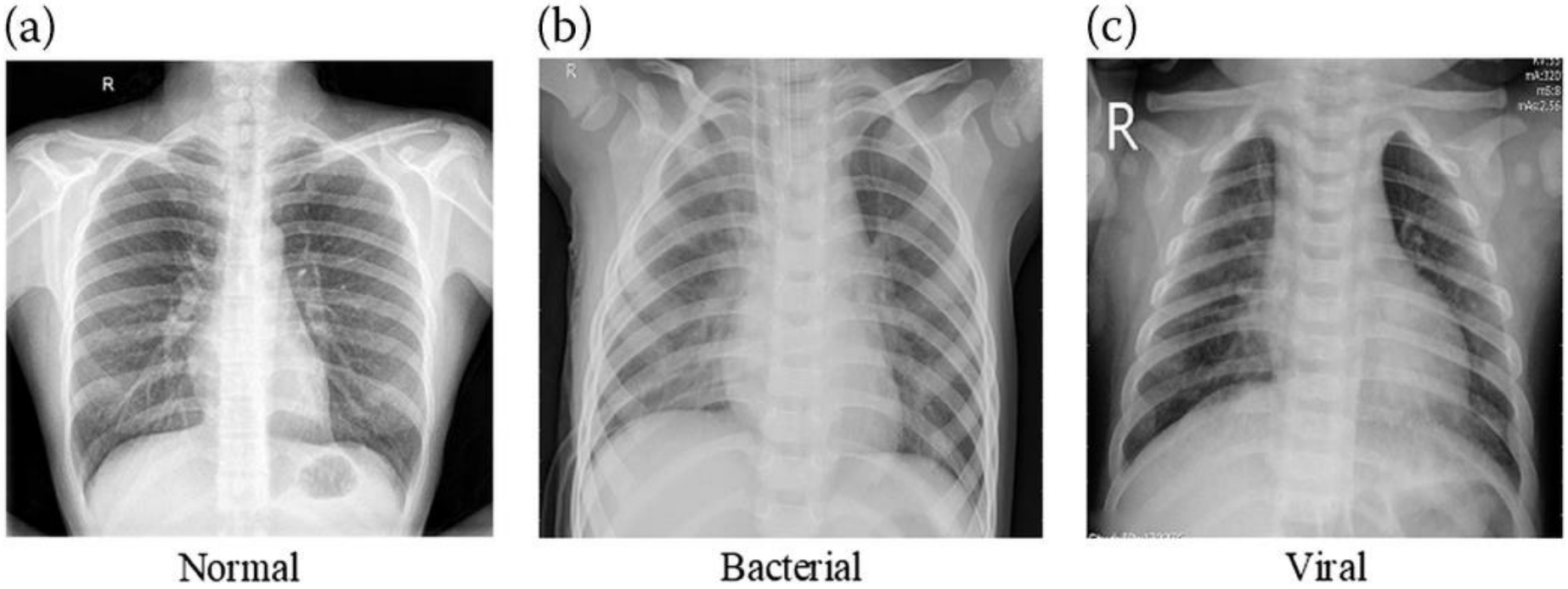


FIGURE 1.22 Chest Radiographs Collected from Normal and Abnormal Patients.

Tuberculosis diagnosis

- Tuberculosis (TB) is an acute lung disorder caused by the Mycobacterium tuberculosis bacteria. TB normally infects the lung and causes acute respiratory distress. In some special cases, TB infection can infect other body organs in what is known as extra-pulmonary TB. The assessment of TB is normally done using (i) imaging technique, (ii) endoscopy-assisted procedure, and (iii) needle biopsy.
- The image-assisted methodology based on chest X-ray or lung CT is the most commonly used modality to assess TB. Chest X-ray can be used for initial diagnosis, but due to its poor image interpretation, CT images are preferred to convey useful information.

Tuberculosis diagnosis

Figure 1.23 depicts the sample chest X-ray of a TB case collected from Radiopaedia.

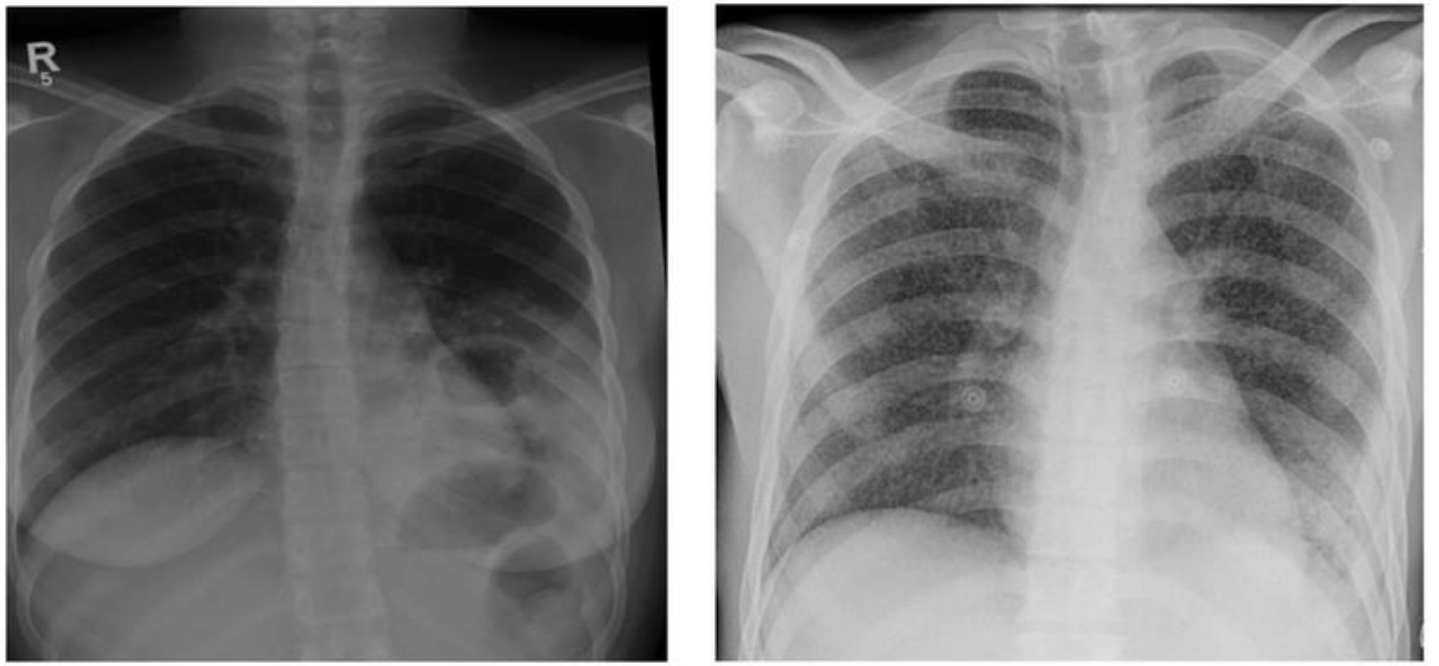


FIGURE 1.23 Chest Radiographs of Normal and Patients with Tuberculosis.

Tuberculosis diagnosis

- **Advantages:** Chest radiograph is a simple and commonly implemented imaging modality to examine infections of the lung.
- **Disadvantages:** It results in less visibility of the infected section compared to other imaging techniques such as CT scan.

Lung CT-Scan

- Computed Tomography (CT) scan is a widely adopted imaging technique in hospitals to assess a variety of organs including lungs.
- The main advantage of CT is that it offers a reconstructed 3D image which can be examined either in 3D or 2D form.
- The assessment of the CT helps to identify the disease accurately when compared to the chest X-ray.
- It can be noted from the literature that the CT scan slices of axial, coronal, and sagittal views are used in assessing abnormalities, and the choice of a particular orientation is decided by the physician.

Pneumonia

- The CT scan assisted pneumonia diagnosis is a widely adopted technique in health centres due to its proper diagnostic capability. Figure 1.24 depicts the sample test images acquired from the pneumonia infected patients. The highly visible section is due to the pneumonia lesion and can be extracted and evaluated during the assessment. Based on the infection level, the treatment process and follow up of the patients is decided by the pulmonologists

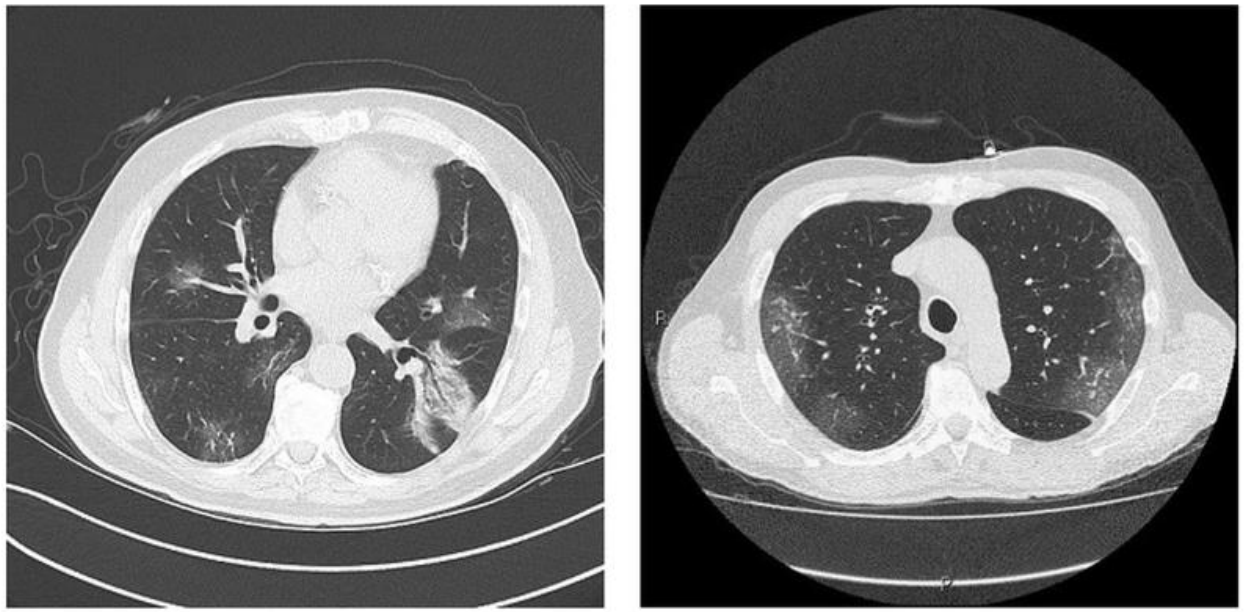


FIGURE 1.24 Lung CT Scan Slices (Axial View) Acquired from Patients with Pneumonia.

Tuberculosis

The CT scan is considered to examine pulmonary TB infection in lungs with better accuracy. Figure 1.25 presents information on lung infection existing in the axial and coronal views of CT scan slices. Compared to the chest X-ray, infection due to the TB is more visible in lung CT scan slices thus making it easier to be detected and interpreted by the technician or computer.

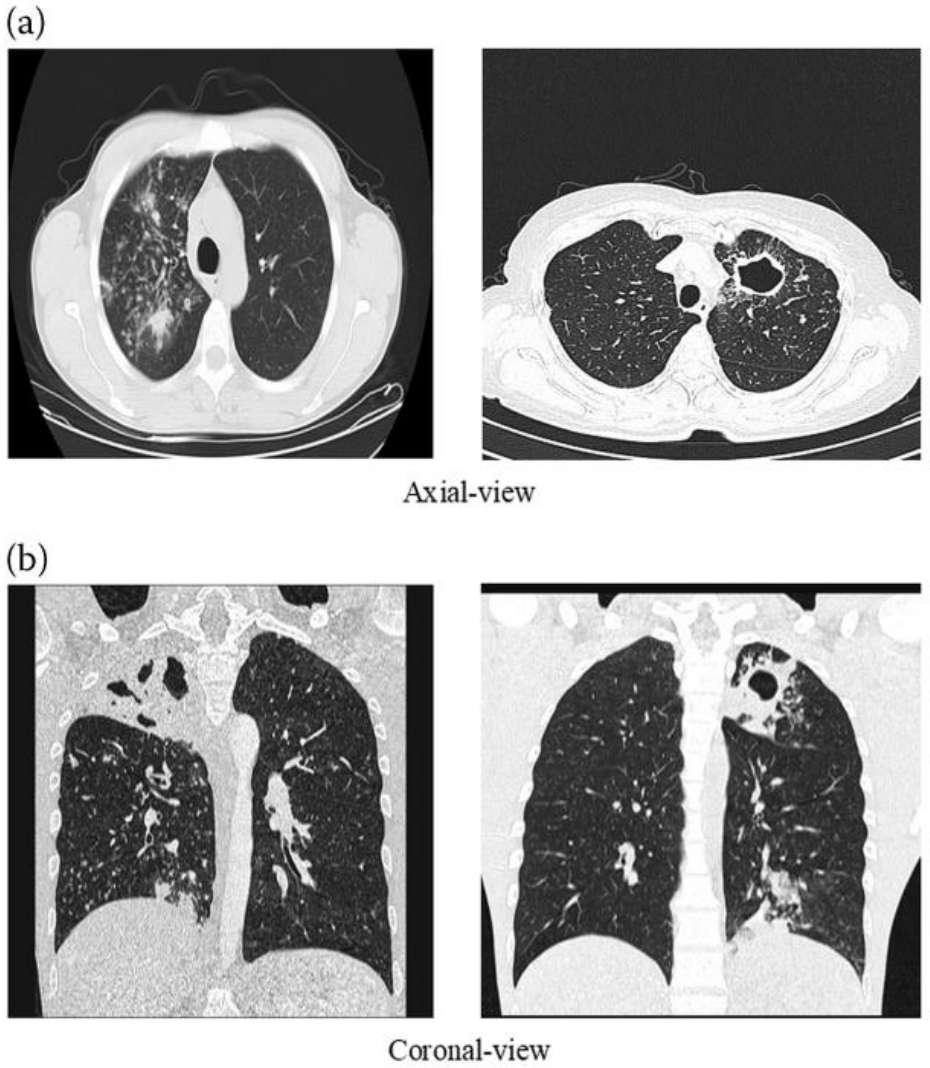


FIGURE 1.25 Lung CT Scan Slices Collected from Patients with Tuberculosis.

Lung Nodule

A lung nodule is an abnormality that develops mostly from damaged cells due cancer. There are several image examination techniques present in the literature to examine lung nodules so as assess the different stages of disease severity. Figure 1.26 presents 2D CT scan slices of benign and malignant lung nodu images collected from Lung Image Datab Consortium (LIDC-IDRI) dataset

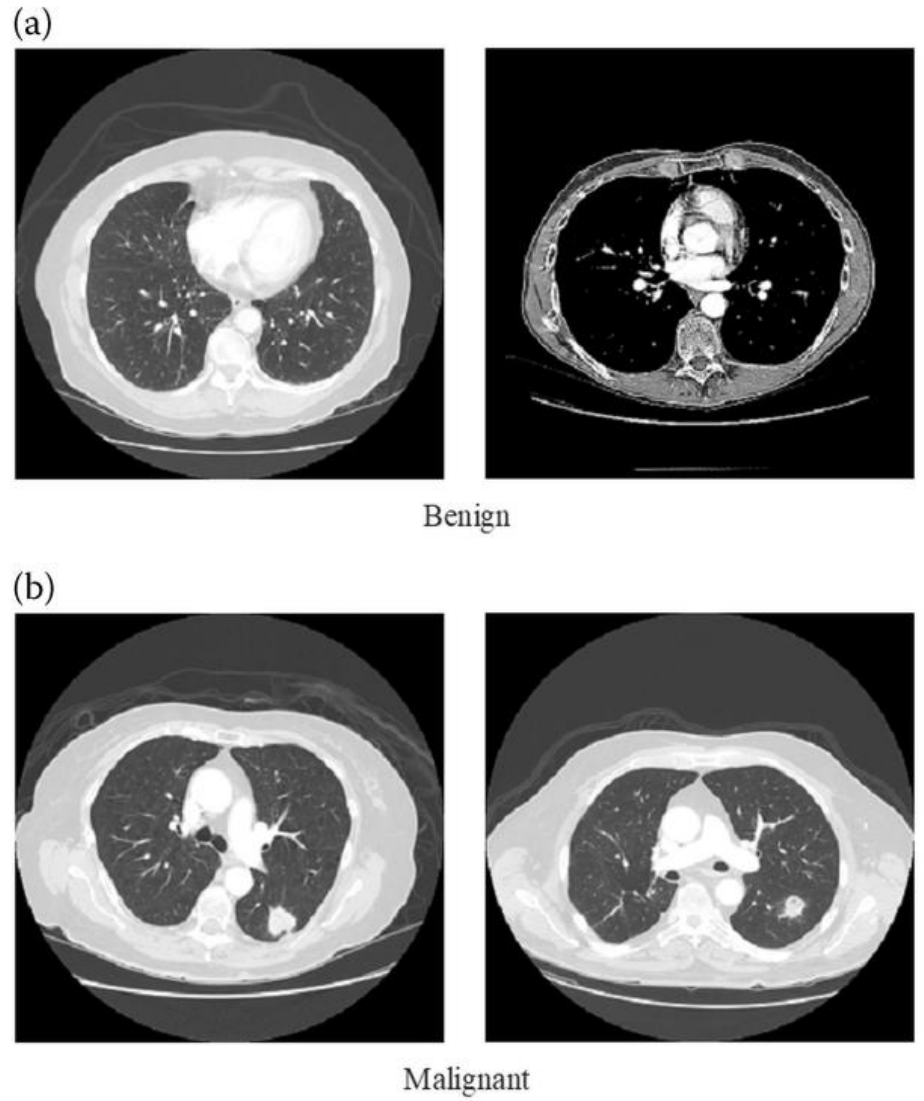
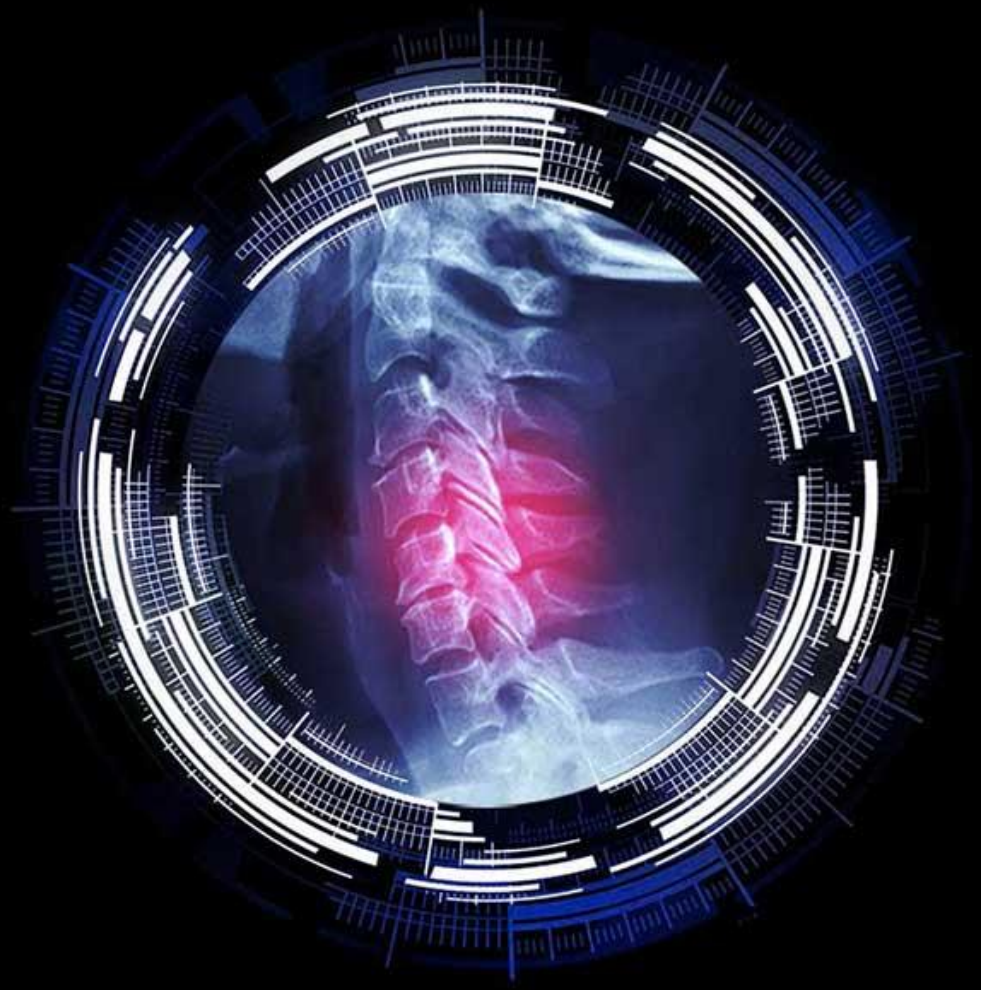


FIGURE 1.26 Lung CT Scan Slices (Axial View) Depicts Pulmonary Nodules.



1.2 Medical Image Recording Procedures

1.2 Medical Image Recording Procedures

- Many researchers have reported on the prognosis and diagnosis of diseases, confirming that signal/image-assisted DS procedures are implemented globally. Noninvasive procedures are preferred over invasive methods due to its simplicity and safety. Further, diagnosis based on images is preferred compared to the diagnosis arrived at through signals. The developments in digital imaging systems have paved a way for implementing image-assisted disease detection procedure in most of disease cases.
- Normally, medical images are recorded in a controlled environment by a standard imaging procedure. Each imaging procedure has its own protocol that is executed by a skilled technician under the supervision of a doctor if necessary

1.2 Medical Image Recording Procedures

Figure 1.31 depicts commonly followed imaging methods and the relevant internal/external organs.

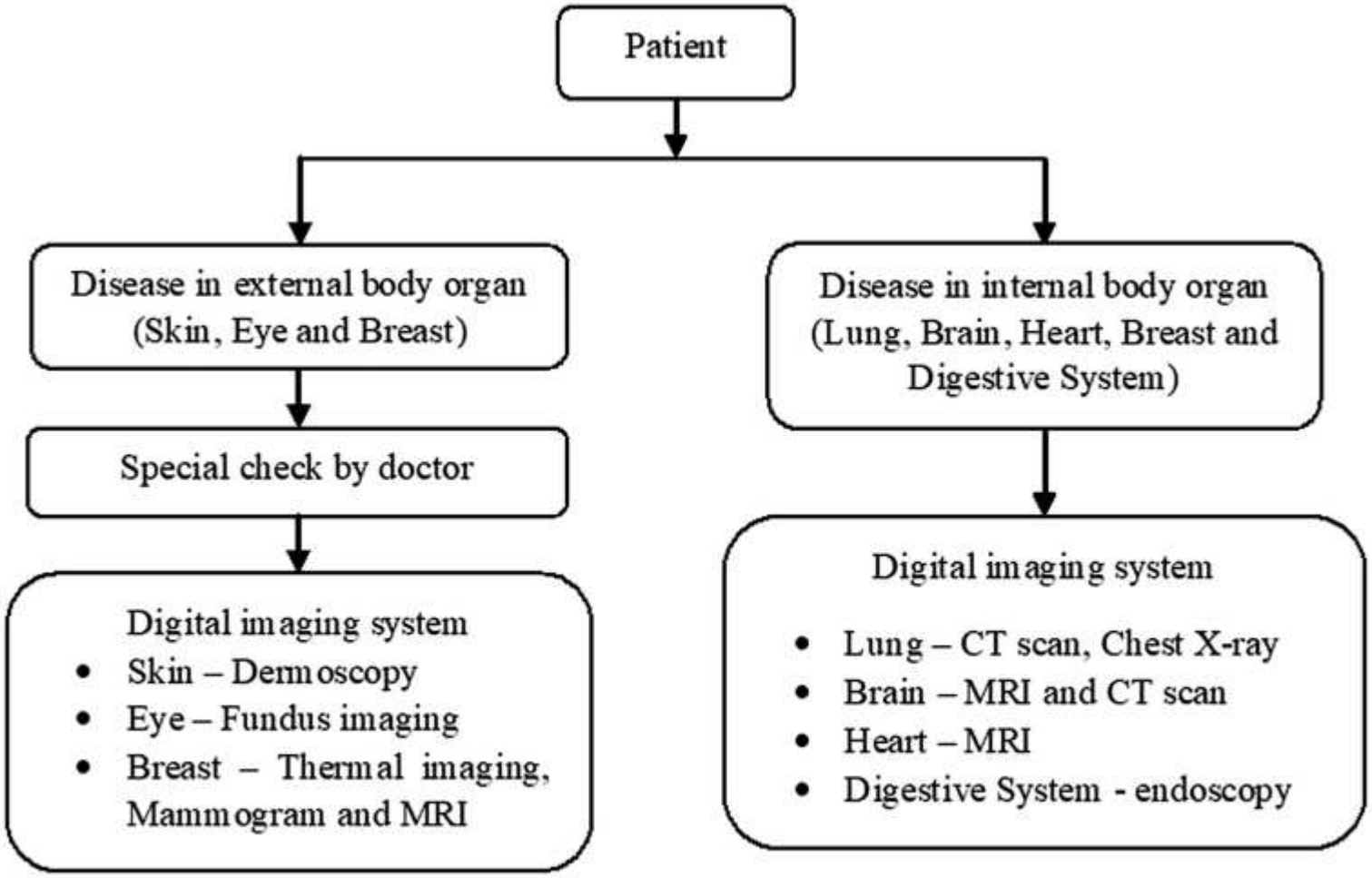


FIGURE 1.31 Image-Guided Diagnosis of Disease.

1.2 Medical Image Recording Procedures

- Medical imaging techniques are common procedures executed to assess diseases in various parts of the body. The imaging practice is implemented based on the need to record various sections such as the cell, tissue and organs.
- The choice of a particular image recording methodology mainly depends on the disease to be diagnosed and the choice of the doctor, who decides the flow of the procedure based on his expertise.

Blood screening

- Blood screening is initiated by collecting a required volume of blood from the patient whose condition is to be screened. After collecting blood, the screening procedure begins with the help of contrast-enhanced thin/thick blood films. The prepared blood film is then examined under a conventional or a digital microscope.
- Screening of the blood is a common procedure in hospitals and clinics, helping diagnose the initial condition of the patient with a considerable number of measurements from WBC to the fat and sugar level in the blood.

Blood

The common diagnostic stages involved in blood sample evaluation are presented in Figure 1.32. This procedure results in a microscopic image for further examination.

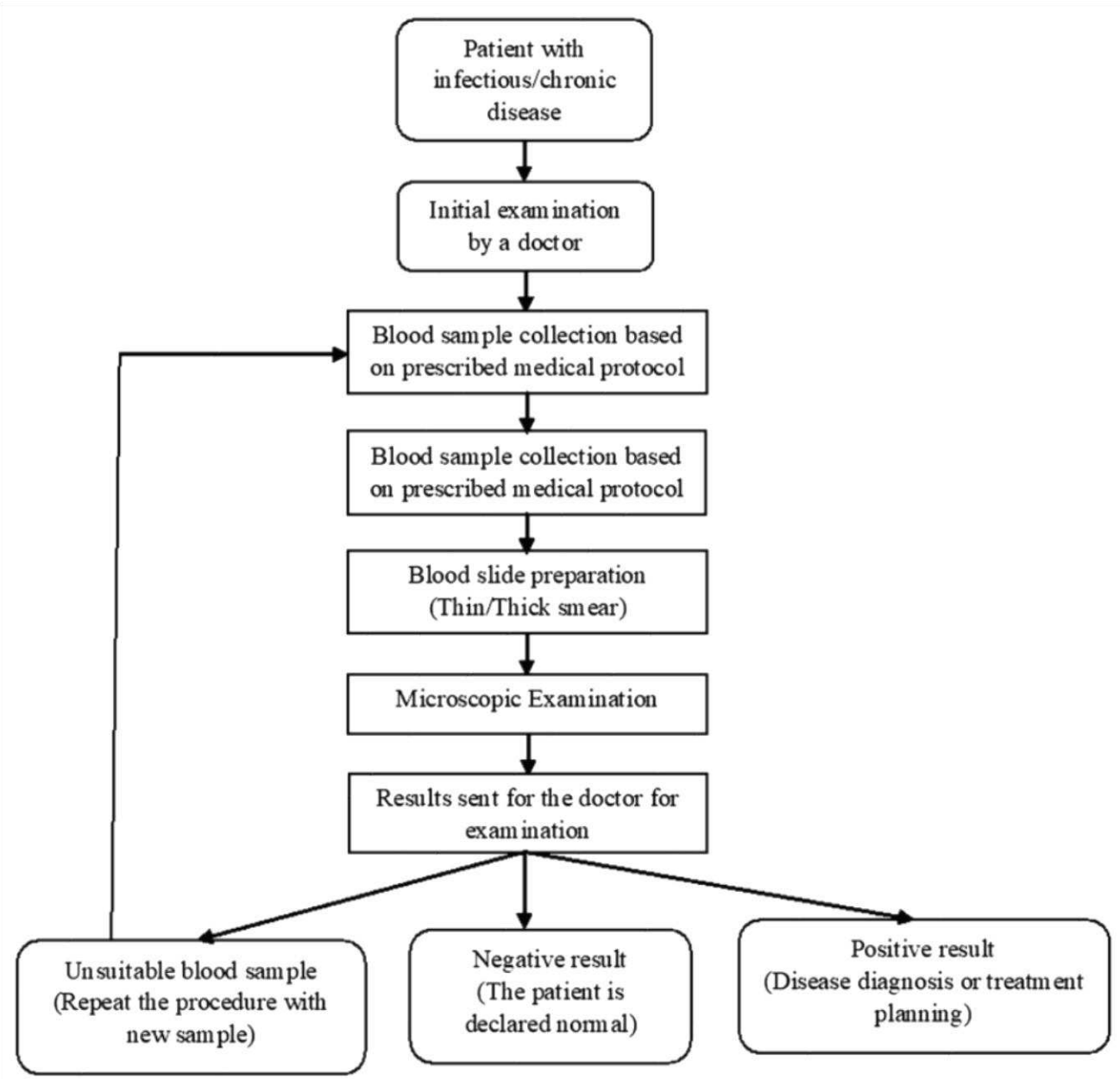


FIGURE 1.32 Conventional Screening Steps Followed for Blood Sample Assessment.

Skin cancer diagnosis

- Skin cancer a major diseases seen in the elderly and those who are exposed to high UV radiation. The common procedure followed in diagnosing the skin level infection using dermoscopy is presented below. If the imaging procedure presents a suspicious result, then biopsy is implemented to confirm the disease.

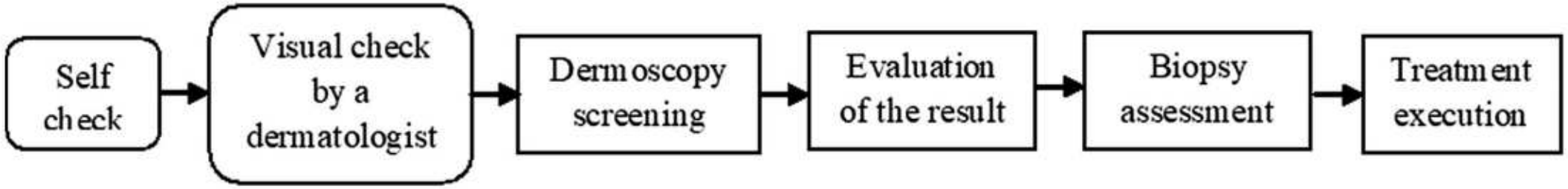


FIGURE 1.33 Diagnostic Stages Implemented to Detect Skin Cancer.

Stomach ulcer detection

- Stomach ulcer is an illness that develops due to a variety of reasons including uneven or poor diet. This disease is identified with appropriate care as, if left untreated, it may lead to stomach cancer. Normally, the infection rate is diagnosed with the help of a wired or a wireless endoscope, which provides a clear picture or a video of the stomach wall.

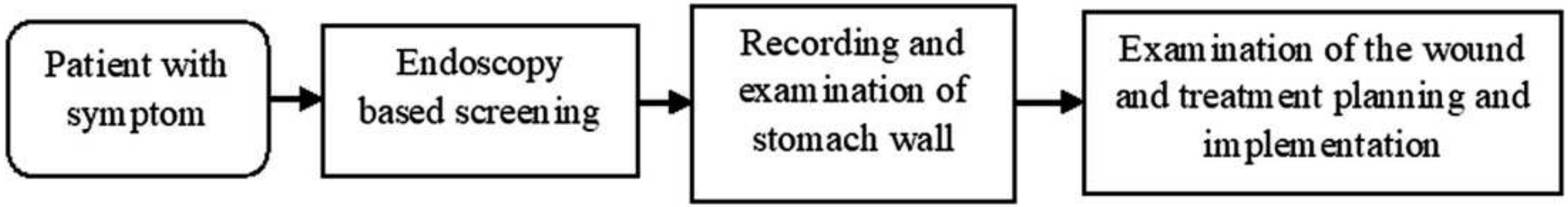


FIGURE 1.34 Stomach Ulcer Detection Based on the Endoscopic Imaging.

Breast cancer detection

- Breast cancer develops in women due to factors such as aging. The stage and severity of the disease for a person suffering from a developed breast cancer can be diagnosed through clinical biopsy, which helps examine the breast tissues and cells. Further, the image-assisted modalities such as MRI, ultrasound, mammogram, and thermal imaging are also used to examine the breast abnormality with better diagnostic accuracy. Compared to the needle biopsy, imaging techniques are noninvasive procedures done by visual examination of a physician or performed with the help of computer algorithm (Figure 1.35).

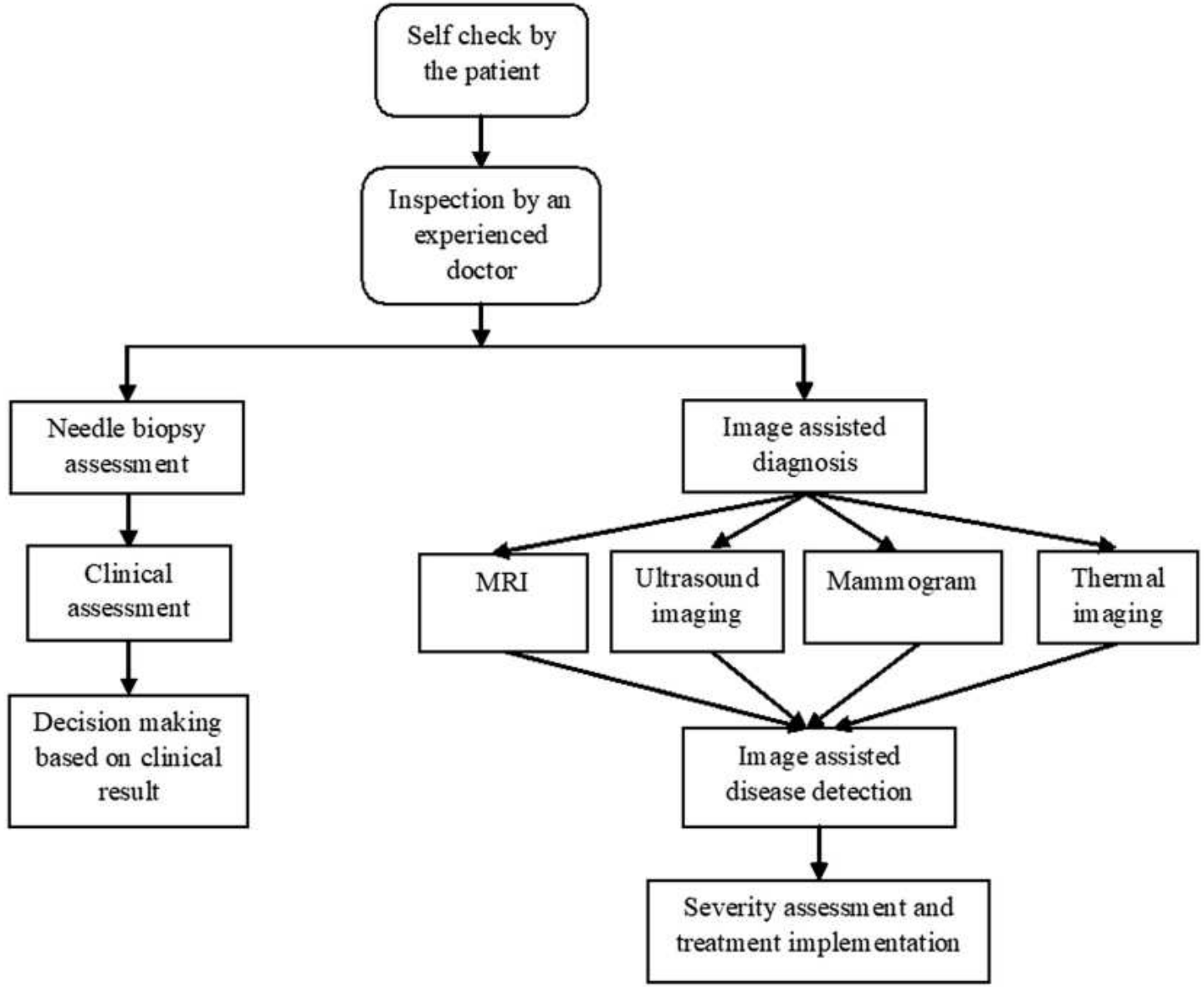


FIGURE 1.35 Commonly Used Breast Cancer Detection Procedure.

Lung infection detection

- Abnormalities in the lung can severely affect the respiratory system and disturb normal air exchange. Oxygen deficiency in the bloodstream can affect normal activities of other parts, cell movements are disturbed. If this problem persists, the body is negatively affected, which may lead to organ failure or death.
- Abnormalities in the lungs is diagnosed through a CT scan or a chest X-ray as it is covered by a complex bone section called the ribs. The clinical-based imaging system used in radiology to record the activity and condition of the lungs is presented in Figure 1.39. In this procedure, the 2D or 3D version of the image is recorded and is then assessed by a physician or a computer algorithm to accurately detect the abnormality.

Lung

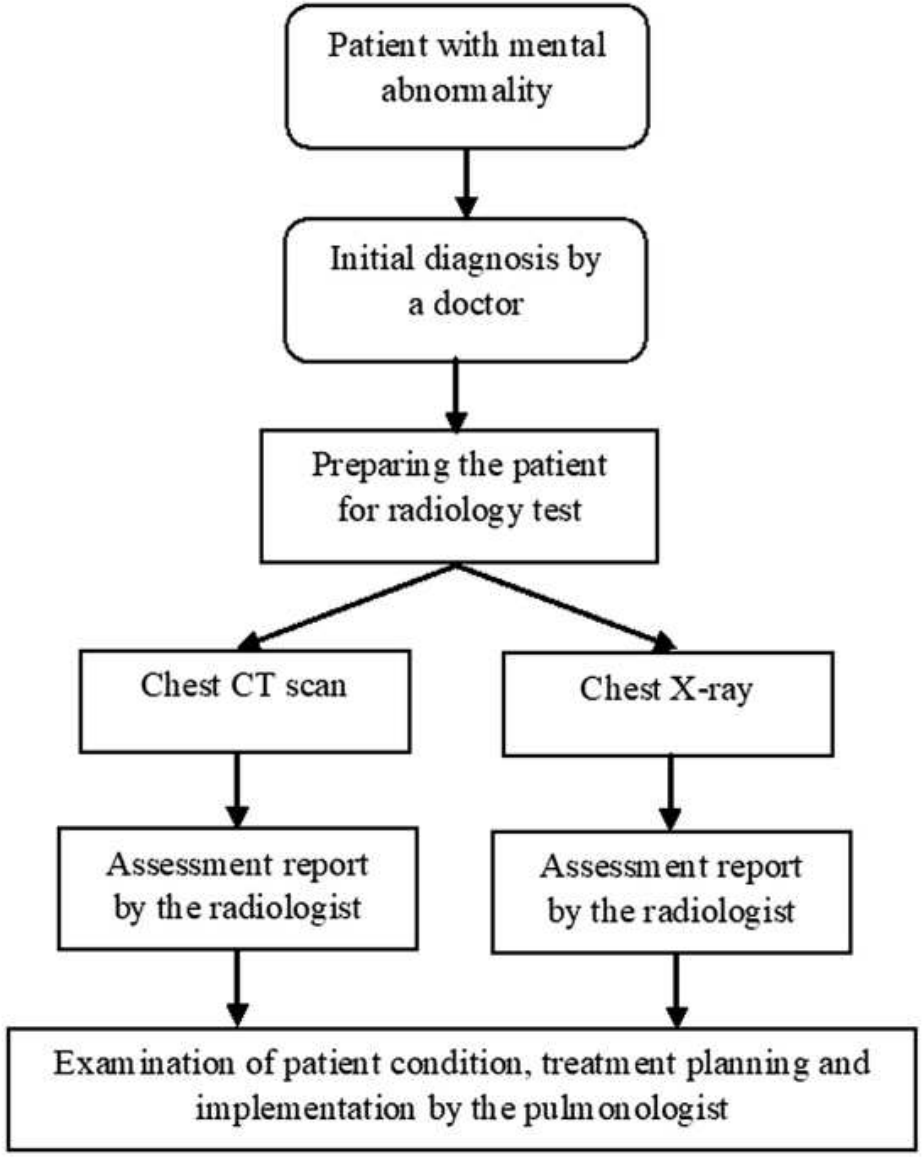


FIGURE 1.39 Clinical Level Screening of the Lung Abnormalities.

COVID-19 screening

- Recently, the infection caused by the novel SARS-CoV-2 (COVID-19) virus was declared as a pandemic by the World Health Organisation (WHO). This virus has caused a global health emergency. It can cause mild to severe infection in the respiratory tract, but timely screening and isolation of the disease can help control its spread.
- Screening for COVID-19 infection should follow WHO guidelines. It involves sample-assisted testing with the RT-PCR followed by an image-assisted diagnosis.

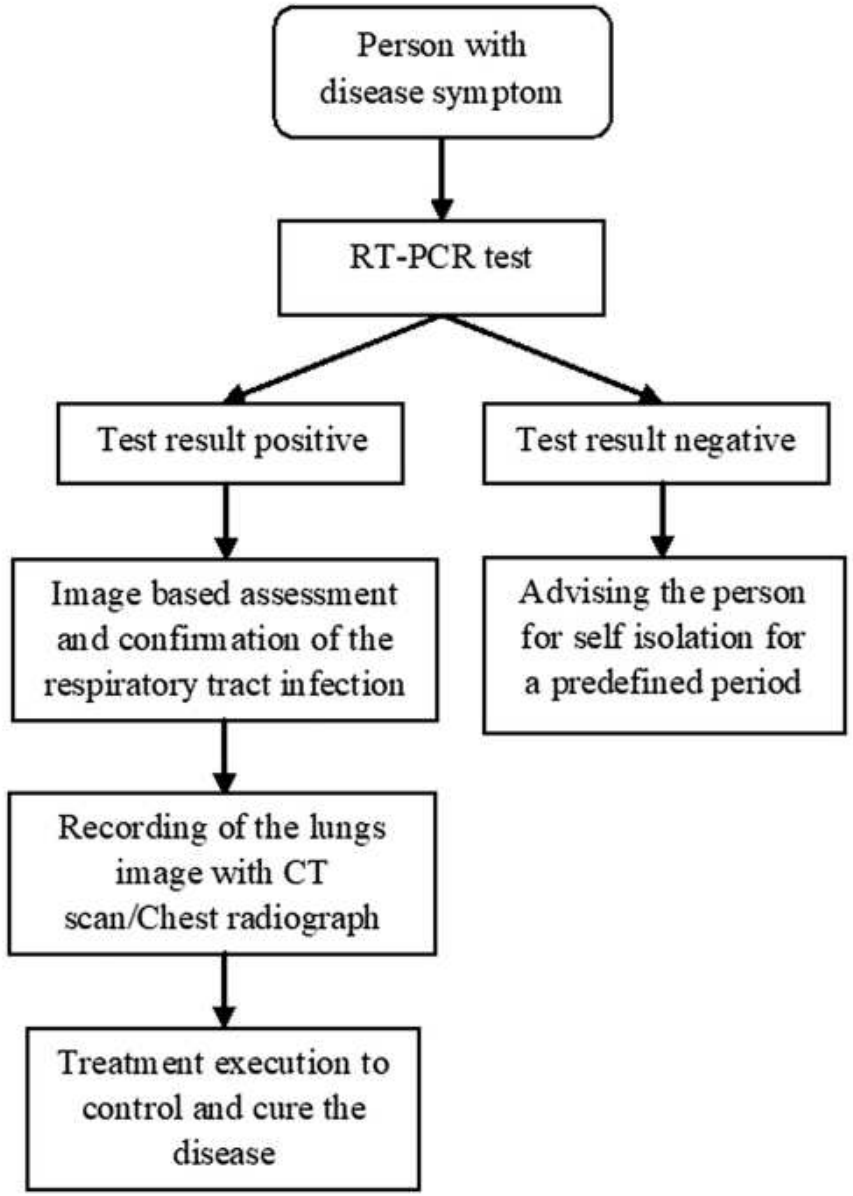
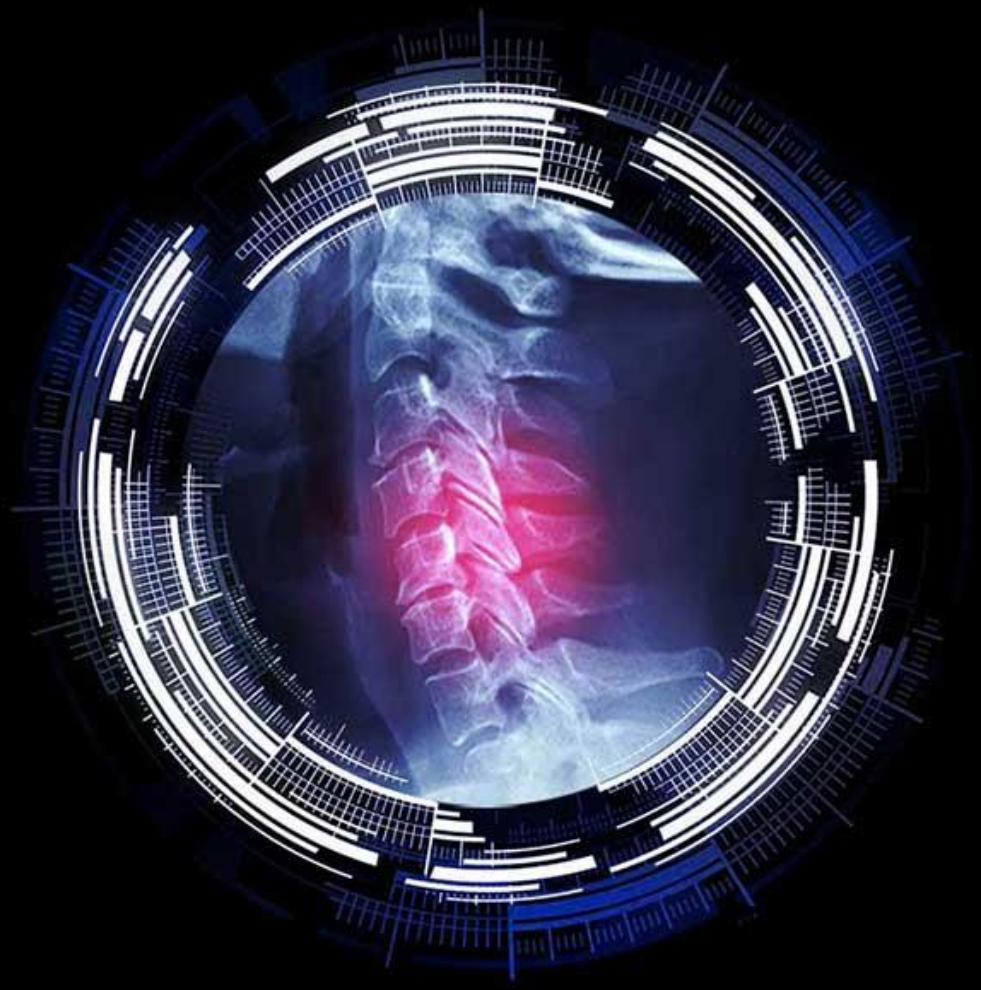


FIGURE 1.41 Screening Procedures Followed in COVID-19 Disease Diagnosis.



1.3 Summary

1.3 Summary

- For every organ, an appropriate imaging procedure is implemented to capture an image with better visibility under a controlled medical environment.
- A number of imaging techniques are available for the disease screening process for each organ where the choice of a particular procedure depends mainly on the expertise of the physician.
- The recorded images can be converted digitally and examined using a computer algorithm. This procedure aids the doctor to reduce the diagnostic burden. The outcome of the computerized technique as well as the observation by the doctor together can result in efficient planning of treatment.