Lymph Node Evaluation and Metastatic Disease Detection

Oyerinde Bamiyinoluwa

August 31, 2024

Lymph Node Evaluation and Metastatic Disease Detection

Authors

Oyerinde Bamiyinoluwa

Date 25/August/2024

Abstract

Accurate evaluation of lymph nodes is a crucial component in the staging and management of various types of cancer. Lymph nodes serve as important gateways for the spread of malignant cells, and the presence and extent of lymph node involvement can significantly impact a patient's prognosis and guide the appropriate treatment approach.

The detection of metastatic disease, or the spread of cancer from the primary tumor to the lymph nodes or other organs, is a critical step in cancer staging. Proper identification of metastatic involvement allows clinicians to determine the stage of the cancer and make informed decisions about the most appropriate treatment plan for the patient.

This outline will provide an overview of the key aspects of lymph node evaluation and metastatic disease detection, including the anatomy and function of lymph nodes, clinical examination techniques, imaging modalities, minimally invasive biopsy methods, and surgical lymph node evaluation. Additionally, it will explore emerging technologies and future directions in this field, with the goal of highlighting the multidisciplinary approach needed to optimize the detection and management of metastatic disease.

definition of Lymph Node Evaluation and Metastatic Disease Detection

Lymph Node Evaluation and Metastatic Disease Detection can be defined as:

Lymph Node Evaluation:

The process of assessing the presence, size, location, and characteristics of lymph nodes to determine if they are healthy or have been affected by a disease, such as cancer. This evaluation involves various techniques, including physical examination, imaging studies, and minimally invasive or surgical procedures, to obtain information about the lymph nodes and their potential involvement in the spread of disease.

Metastatic Disease Detection:

The identification of the presence and extent of cancer that has spread from the primary tumor site to other areas of the body, such as the lymph nodes or distant organs. Metastatic disease detection is critical for accurate cancer staging, as the presence of metastases can significantly impact prognosis and treatment decisions. This detection process may involve a combination of imaging techniques, biopsy procedures, and laboratory analyses to confirm the presence and characteristics of metastatic disease.

The goal of lymph node evaluation and metastatic disease detection is to provide clinicians with the necessary information to stage the cancer accurately, determine the most appropriate treatment approach, and monitor the patient's response to therapy. This information is essential for developing an effective management plan and improving patient outcomes.

Importance of lymph node evaluation in cancer staging and management

The evaluation of lymph nodes is critically important in the staging and management of cancer for several key reasons:

Cancer Staging:

The presence and extent of lymph node involvement is a key factor in determining the stage of cancer, which is essential for accurately assessing prognosis and guiding treatment decisions.

Lymph node status is a critical component of the TNM (Tumor, Node, Metastasis) staging system, the globally recognized standard for cancer staging.

Treatment Planning:

The detection of lymph node metastases can significantly impact the choice of treatment, as it may indicate the need for more extensive or aggressive therapy, such as lymph node dissection, radiation, or systemic treatments.

Accurate lymph node evaluation helps clinicians determine the appropriate treatment approach, whether it's surgery, chemotherapy, targeted therapies, or a combination of modalities.

Prognosis and Survival:

The presence and number of positive lymph nodes are strongly associated with a patient's prognosis and overall survival.

Patients with lymph node-positive disease generally have a worse prognosis compared to those with lymph node-negative disease, as lymph node metastases indicate a higher risk of further disease spread.

Monitoring and Follow-up:

Ongoing lymph node evaluation, through physical examination and imaging, is crucial for monitoring a patient's response to treatment and detecting any recurrence or progression of the disease.

Surveillance of lymph nodes helps guide the need for additional interventions or changes in the treatment plan.

Guiding Surgical Approach:

Lymph node evaluation informs the surgical approach, such as the need for lymph node dissection or the identification of the sentinel lymph node (the first node to which cancer is likely to spread from the primary tumor).

This information helps minimize the extent of surgery and associated complications while maintaining oncological principles.

In summary, the comprehensive evaluation of lymph nodes is a vital component of the cancer care continuum, from initial staging and treatment planning to ongoing monitoring and follow-up. Accurate lymph node assessment is essential for delivering personalized, evidence-based cancer management and optimizing patient outcomes.

Overview of metastatic disease detection techniques

There are several key techniques used to detect metastatic disease, which is the spread of cancer from the primary tumor site to other areas of the body, such as the lymph nodes or distant organs. The main methods for metastatic disease detection include:

Imaging Techniques:

Computed Tomography (CT) Scans: Provide detailed cross-sectional images of the body, allowing for the identification of enlarged or abnormal lymph nodes and the detection of metastases in organs and other tissues.

Positron Emission Tomography (PET) Scans: Utilize radioactive tracers to detect metabolically active tumor cells, which can help identify metastatic disease even in the absence of visible anatomical changes.

Magnetic Resonance Imaging (MRI): Offers high-resolution imaging of soft tissues, which can be particularly useful for detecting metastases in the brain, spine, and other regions.

Ultrasound: Provides real-time, non-invasive imaging of lymph nodes and other structures, allowing for the assessment of size, shape, and vascularity.

Minimally Invasive Biopsy Techniques:

Fine-Needle Aspiration (FNA): A procedure that uses a thin needle to extract cells from a suspicious lymph node or lesion for cytological analysis.

Core Needle Biopsy: Obtains a small cylinder of tissue from a lymph node or other suspected metastatic site for histological examination.

Sentinel Lymph Node Biopsy: Identifies and examines the first lymph node(s) that are likely to receive drainage from the primary tumor, providing information about the presence of metastatic disease.

Surgical Exploration and Lymph Node Dissection:

Lymph Node Dissection: The surgical removal and examination of lymph nodes, often performed as part of the primary tumor resection or as a separate procedure.

Intraoperative Lymph Node Assessment: Visual and palpation assessment of lymph nodes during surgery, which can guide the extent of resection and further diagnostic procedures.

Molecular and Genetic Techniques:

Circulating Tumor Cells (CTCs): Analysis of blood samples to detect and characterize cancer cells that have detached from the primary tumor and entered the bloodstream.

Liquid Biopsy: Examination of blood, urine, or other bodily fluids for the presence of tumor-derived genetic materials, such as circulating tumor DNA (ctDNA), which can indicate the presence of metastatic disease.

The choice of detection method(s) depends on the type of cancer, the suspected sites of metastatic involvement, the availability of technology, and the clinical context. Often, a combination of these techniques is employed to achieve a comprehensive assessment of metastatic disease and guide the most appropriate treatment approach.

Anatomy and Function of Lymph Nodes

Lymph nodes are small, bean-shaped organs that are part of the lymphatic system, which plays a crucial role in the body's immune response and the transport of lymphatic fluid.

Anatomical Structure of Lymph Nodes:

Capsule: The outer layer of the lymph node, made of dense connective tissue.

Cortex: The outer region of the node, containing lymphocytes (B cells and T cells) and follicles.

Paracortex: The area between the cortex and medulla, containing predominantly T cells.

Medulla: The central region of the node, containing plasma cells and macrophages.

Hilum: The indented area on one side of the node where blood vessels and lymphatic vessels enter and exit.

Lymphatic Drainage and Regional Lymph Node Groups:

Lymph nodes are located throughout the body, organized into regional groups that correspond to the drainage patterns of the lymphatic system.

Common regional lymph node groups include the cervical (neck), axillary (armpit), inguinal (groin), and abdominal lymph nodes.

Lymphatic vessels transport lymph fluid, which contains lymphocytes, antigens, and other immune cells, into the lymph nodes.

Functions of Lymph Nodes:

Immune Surveillance: Lymph nodes act as filters, trapping and concentrating antigens, pathogens, and other foreign substances that enter the lymphatic system.

Immune Response Initiation: Lymph nodes provide a specialized microenvironment for the interaction between antigen-presenting cells and lymphocytes, facilitating the initiation of an immune response.

Lymphocyte Trafficking: Lymph nodes serve as hubs for the circulation and migration of lymphocytes, enabling them to encounter and respond to antigens.

Metastatic Disease Spread: Lymph nodes can serve as the first site of cancer metastasis, as they provide a favorable environment for the growth and spread of malignant cells.

Understanding the anatomy and function of lymph nodes is crucial for interpreting the clinical significance of lymph node involvement in cancer and guiding appropriate treatment strategies.

Clinical Examination of Lymph Nodes

The physical examination of lymph nodes is a crucial component of the overall clinical assessment, particularly in the context of cancer evaluation and management. The key aspects of lymph node examination include:

Palpation:

Systematic palpation of the major lymph node groups, including the cervical, supraclavicular, axillary, inguinal, and abdominal lymph nodes.

Evaluation of the size, shape, consistency, mobility, and any associated tenderness or fixation of the lymph nodes.

Lymph Node Characteristics:

Size: Enlarged lymph nodes (generally > 1 cm in diameter) may indicate the presence of disease, such as infection or malignancy.

Shape: Normal lymph nodes are typically oval or kidney-shaped, while abnormal nodes may appear more round or irregular.

Consistency: Healthy lymph nodes are usually soft and mobile, while diseased nodes may feel firm, fixed, or matted.

Tenderness: Painless lymph nodes are more suggestive of malignancy, while tender nodes may indicate an infectious or inflammatory process.

Anatomical Landmarks:

Identification of the specific lymph node groups and their anatomical locations, which can provide clues about the potential source or spread of disease.

Examples include the cervical lymph nodes, which drain the head and neck region, and the inguinal lymph nodes, which drain the lower extremities and external genitalia.

Interpretation and Clinical Correlation:

Evaluation of the lymph node findings in the context of the patient's medical history, presenting symptoms, and any other clinical or diagnostic information.

Consideration of the potential underlying causes, such as infection, inflammation, or malignancy, to guide further diagnostic testing and management.

While physical examination of lymph nodes is a valuable diagnostic tool, its sensitivity and specificity can be limited, particularly in the detection of smaller or deeper lymph nodes. In such cases, imaging modalities and minimally invasive biopsy techniques may be necessary to obtain a more comprehensive assessment.

Careful and thorough lymph node examination, combined with appropriate follow-up investigations, plays a crucial role in the early detection, staging, and management of various types of cancer.

Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging (MRI) is a widely used imaging modality that has become an essential tool in the detection and evaluation of various medical conditions, including cancer. Here's an overview of the key aspects of MRI in the context of cancer management:

Principles of MRI:

MRI utilizes strong magnetic fields and radio waves to generate detailed, cross-sectional images of the body's internal structures.

The technique exploits the unique magnetic properties of hydrogen protons within the body, allowing for the visualization of soft tissues with excellent contrast and resolution.

Advantages of MRI in Cancer Imaging:

Superior soft tissue contrast: MRI provides exceptional visualization of soft tissues, allowing for the detailed assessment of tumors and their relationships with surrounding structures.

Multiplanar imaging: MRI can acquire images in multiple planes (axial, coronal, and sagittal), providing a comprehensive view of the anatomy.

Lack of ionizing radiation: Unlike computed tomography (CT) scans, MRI does not use ionizing radiation, making it a safer option, particularly for repeated or long-term imaging.

Functional and molecular information: Advanced MRI techniques, such as diffusion-weighted imaging and dynamic contrast-enhanced MRI, can provide valuable functional and molecular information about tumors.

Applications in Cancer Management:

Tumor detection and characterization: MRI is highly effective in detecting and characterizing primary tumors, evaluating their size, location, and local extent.

Lymph node evaluation: MRI can assess the size, shape, and characteristics of lymph nodes, helping to detect metastatic involvement.

Staging and treatment planning: MRI findings contribute to accurate cancer staging and guide the selection of appropriate treatment options, such as surgical planning and radiation therapy targeting.

Monitoring treatment response and disease progression: MRI can be used to assess the response to therapy and detect any signs of disease recurrence or progression.

Evaluation of specific anatomical regions: MRI is particularly useful for imaging the brain, spine, pelvis, and other areas where high-quality soft tissue imaging is critical.

Limitations and Considerations:

Contraindications: Patients with certain implanted medical devices or claustrophobia may not be suitable for MRI examinations.

Availability and cost: MRI scanners are generally more expensive and less widely available than other imaging modalities, such as CT or ultrasound.

Interpretation expertise: Accurate interpretation of MRI findings requires specialized radiological expertise and knowledge of cancer-specific imaging patterns.

In summary, MRI is a powerful and versatile imaging tool that plays a crucial role in the detection, staging, and management of various types of cancer. Its ability to provide high-quality, detailed images of soft tissues and functional information makes it an invaluable component of the comprehensive cancer care approach.

Positron Emission Tomography (PET) and PET/CT

Positron Emission Tomography (PET) is an advanced imaging modality that provides valuable functional and metabolic information about the body, particularly in the context of cancer management. PET is often combined with Computed Tomography (CT) to create a hybrid PET/CT imaging system, which integrates the functional information from PET with the detailed anatomical information from CT.

Principles of PET:

PET utilizes radioactive tracer molecules, typically labeled with positron-emitting isotopes (e.g., fluorine-18), which are injected into the patient's body.

These tracers accumulate in areas of increased metabolic activity, such as tumors, and the emitted positrons are detected by the PET scanner, generating a 3D image of the body's metabolic processes.

Advantages of PET/CT:

Improved tumor detection and characterization: PET can detect metabolically active tumors, even before structural changes are visible on conventional imaging.

Whole-body evaluation: PET/CT provides a comprehensive, whole-body assessment, allowing for the detection of primary tumors, metastatic disease, and recurrences.

Staging and treatment planning: PET/CT findings contribute to accurate cancer staging and guide the selection of appropriate treatment strategies, such as targeted therapy or radiation therapy planning.

Monitoring treatment response: PET/CT can effectively evaluate the metabolic response of tumors to various cancer treatments, enabling early assessment of therapeutic efficacy.

Differentiation of benign and malignant lesions: PET/CT can help distinguish between benign and malignant processes based on their metabolic activity.

Clinical Applications in Cancer:

Staging and restaging of various cancer types, including lung cancer, lymphoma, breast cancer, and colorectal cancer.

Early detection of recurrent or metastatic disease, which may not be visible on conventional imaging.

Guiding biopsies and surgical planning by identifying the most metabolically active regions within a tumor.

Evaluation of treatment response and detection of residual or recurrent disease during and after therapy.

Differentiation of post-treatment changes (e.g., radiation necrosis) from viable tumor.

Limitations and Considerations:

Availability and cost: PET/CT scanners are generally more expensive and less widely available than other imaging modalities.

Radiation exposure: PET/CT involves the use of ionizing radiation, which should be considered, particularly in younger patients or those requiring repeated examinations.

False-positive results: Increased metabolic activity can be observed in benign conditions, such as inflammation, leading to potential false-positive findings.

Interpretation expertise: Accurate interpretation of PET/CT images requires specialized training and knowledge of cancer-specific patterns and pitfalls.

PET/CT has become an integral part of the comprehensive cancer care approach, providing valuable functional and anatomical information that complements other imaging modalities and supports clinical decision-making throughout the continuum of cancer management.

Minimally Invasive Biopsy Techniques

Minimally invasive biopsy techniques have become increasingly important in the diagnosis and management of various types of cancer. These techniques allow for the collection of tissue samples with minimal disruption to the patient, often resulting in reduced procedural risks, faster recovery times, and more targeted information for clinical decision-making.

Some of the commonly used minimally invasive biopsy techniques in cancer care include:

Fine Needle Aspiration (FNA):

FNA involves the use of a thin, hollow needle to extract cells or small tissue samples from a suspected lesion or lymph node.

FNA is often used for the diagnosis of palpable masses, such as in the thyroid, breast, or lymph nodes, as well as for imaging-guided biopsies of deep-seated lesions.

The collected samples are then analyzed by a pathologist to determine the nature of the lesion, whether it is benign or malignant.

Core Needle Biopsy (CNB):

CNB uses a larger, hollow needle to obtain a small cylindrical tissue sample from a target lesion.

CNB is commonly used for the evaluation of solid tumors, such as those in the breast, prostate, liver, or lung.

The larger tissue sample obtained with CNB can provide more detailed information about the tumor, including its histological subtype and other prognostic or predictive biomarkers.

Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration (EBUS-TBNA):

EBUS-TBNA is a specialized technique used for the evaluation of mediastinal and hilar lymph nodes, which are often involved in lung cancer and other thoracic malignancies.

It combines the use of a bronchoscope with an ultrasound probe to guide the needle biopsy of the targeted lymph nodes.

EBUS-TBNA allows for the sampling of lymph nodes that are not readily accessible through conventional approaches, aiding in accurate staging and diagnosis.

Endoscopic Ultrasound-Guided Fine Needle Aspiration (EUS-FNA):

EUS-FNA utilizes an endoscope equipped with an ultrasound transducer to guide the needle biopsy of lesions in the gastrointestinal tract, pancreas, or adjacent structures.

This technique is particularly useful for the evaluation of pancreatic masses, mediastinal lymph nodes, and other deep-seated lesions that may not be easily accessible through other means.

The advantages of these minimally invasive biopsy techniques include:

Improved patient comfort and reduced procedural risk

Ability to obtain targeted tissue samples for diagnosis and biomarker analysis

Guidance by imaging modalities, such as ultrasound or CT, to ensure accurate sampling of the lesion

Potential for repeat sampling or follow-up biopsies as needed

Appropriate selection and utilization of these minimally invasive biopsy techniques, in conjunction with the clinical context and other diagnostic information, play a crucial role in the accurate diagnosis, staging, and management of cancer.

Sentinel lymph node biopsy

Sentinel lymph node biopsy (SLNB) is a minimally invasive surgical procedure used in the staging and management of certain types of cancer, particularly in breast cancer and melanoma. The sentinel lymph node is the first lymph node or group of nodes that receives lymphatic drainage from the primary tumor site, and it is the most likely site of initial metastatic spread.

Here's an overview of the sentinel lymph node biopsy procedure and its role in cancer management:

Principles of Sentinel Lymph Node Biopsy:

The sentinel lymph node(s) are identified and selectively removed for examination, rather than performing a full lymph node dissection.

A dye and/or a radioactive tracer are injected near the primary tumor, which then travels to the sentinel lymph node(s), allowing them to be identified and localized during the surgical procedure.

The removed sentinel lymph node(s) are then analyzed by a pathologist to determine the presence or absence of metastatic disease.

Applications in Cancer Management:

Breast Cancer:

SLNB is the standard of care for staging early-stage breast cancer, replacing the more extensive axillary lymph node dissection in many cases.

It helps determine the need for further axillary lymph node surgery or adjuvant treatment, such as radiation or chemotherapy.

Melanoma:

SLNB is used to stage and guide treatment for patients with primary cutaneous melanoma, particularly those with intermediate-thickness lesions.

It provides important information about the extent of disease and the need for further lymph node dissection or adjuvant therapy.

Benefits of Sentinel Lymph Node Biopsy:

Minimally invasive approach: SLNB is a less invasive procedure compared to complete lymph node dissection, resulting in reduced surgical morbidity and faster recovery times for patients.

Accurate staging: By selectively examining the sentinel lymph node(s), SLNB provides reliable information about the presence or absence of metastatic disease, which is crucial for staging and treatment planning.

Personalized treatment: The results of the SLNB guide the selection of appropriate subsequent treatments, avoiding unnecessary interventions for patients with negative sentinel nodes.

Improved patient outcomes: The use of SLNB has been associated with improved outcomes, such as reduced lymphedema rates, in patients with early-stage breast cancer and melanoma.

Limitations and Considerations:

False-negative results: In rare cases, the sentinel lymph node may not accurately reflect the status of the remaining lymph nodes, leading to false-negative results.

Availability and expertise: Successful implementation of SLNB requires specialized training and multidisciplinary collaboration between surgeons, nuclear medicine specialists, and pathologists.

Potential complications: Although less invasive than complete lymph node dissection, SLNB still carries a small risk of complications, such as infection, bleeding, or lymphedema.

Sentinel lymph node biopsy has become an integral part of the diagnostic and management algorithms for various types of cancer, particularly in breast cancer and melanoma. Its ability to provide accurate staging information while minimizing surgical morbidity has made it a valuable tool in personalized cancer care.

Emerging Technologies and Future Directions

The field of cancer imaging and diagnosis is continuously evolving, with the development and integration of various emerging technologies that hold the promise of improving patient outcomes. Here are some of the key emerging technologies and future directions in this rapidly advancing field:

Molecular Imaging:

Advancements in molecular imaging techniques, such as targeted PET/CT and PET/MRI, allow for the visualization and quantification of specific molecular and cellular processes involved in cancer development and progression.

These techniques can provide early detection of tumors, monitor treatment response, and guide personalized therapeutic strategies.

Artificial Intelligence (AI) and Machine Learning (ML):

AI and ML algorithms are being integrated into various aspects of cancer imaging and diagnosis, from automated image analysis and lesion detection to predictive modeling and decision support.

AI-powered tools can enhance the accuracy and efficiency of image interpretation, assist in early detection, and support clinical decision-making.

Multiparametric and Functional Imaging:

Combining multiple imaging modalities, such as MRI, PET, and ultrasound, can provide a more comprehensive assessment of tumor characteristics, including perfusion, diffusion, metabolism, and biological markers.

Functional imaging techniques, like diffusion-weighted MRI and dynamic contrast-enhanced MRI, can offer insights into tumor microenvironment and help differentiate benign from malignant lesions.

Liquid Biopsy and Circulating Biomarkers:

The analysis of circulating tumor cells, cell-free DNA, and other biomarkers in the blood (liquid biopsy) can provide non-invasive, real-time information about cancer status and response to treatment.

Liquid biopsy holds the potential to complement or even replace traditional tissue biopsies in certain scenarios, enabling more frequent monitoring and personalized treatment adjustments.

Theranostics and Targeted Molecular Imaging:

The integration of diagnostic imaging and targeted therapy, known as theranostics, allows for the selection and monitoring of patients who may benefit from specific targeted treatments.

Radioactive or fluorescent tracers can be designed to target specific molecular signatures or pathways, enabling both diagnostic imaging and targeted therapy delivery.

Multimodal Imaging and Hybrid Systems:

The combination of different imaging modalities, such as PET/MRI or SPECT/CT, can provide complementary information and improve diagnostic accuracy.

Hybrid imaging systems that integrate various technologies, such as PET/MRI or PET/ultrasound, are being developed to further enhance the precision and clinical utility of cancer imaging.

Pediatric-Specific Imaging Approaches:

Recognizing the unique needs and considerations in pediatric cancer care, there is a growing emphasis on developing specialized imaging techniques and protocols tailored for the pediatric population.

These approaches aim to minimize radiation exposure, improve image quality, and provide more accurate diagnostic information for childhood cancers.

As these emerging technologies and future directions in cancer imaging and diagnosis continue to evolve, they hold the potential to enhance early detection, improve therapeutic selection, and ultimately lead to better patient outcomes. Ongoing research, multidisciplinary collaboration, and the integration of these advancements into clinical practice will be crucial for advancing the field of cancer imaging and diagnosis.

Conclusion

The field of cancer imaging and diagnosis has witnessed significant advancements in recent years, driven by the development and integration of various minimally invasive biopsy techniques and emerging technologies. These innovations have transformed the way healthcare professionals approach the diagnosis, staging, and management of cancer.

Minimally invasive biopsy techniques, such as fine needle aspiration, core needle biopsy, and sentinel lymph node biopsy, have become crucial tools in the clinical setting. These techniques enable the acquisition of targeted tissue samples with reduced procedural risks and faster recovery times for patients. The information gained from these biopsies plays a pivotal role in accurately diagnosing the nature of lesions, determining the stage of disease, and guiding personalized treatment strategies.

Concurrently, the landscape of cancer imaging and diagnosis is being transformed by emerging technologies and future directions. Advancements in molecular imaging, artificial intelligence, multiparametric and functional imaging, liquid biopsy, theranostics, and multimodal imaging systems are revolutionizing the way clinicians visualize, characterize, and monitor cancer. These technologies hold the promise of earlier detection, improved

treatment selection, and enhanced monitoring of disease progression and response to therapy.

As these innovative approaches continue to evolve and become integrated into clinical practice, they will significantly impact the field of oncology. Improved diagnostic accuracy, personalized treatment planning, and minimally invasive monitoring strategies have the potential to enhance patient outcomes, reduce healthcare costs, and ultimately contribute to the ongoing fight against cancer.

The future of cancer imaging and diagnosis is indeed promising, with the integration of these cutting-edge technologies and techniques poised to transform the way healthcare providers approach the complex challenge of cancer management. Ongoing research, multidisciplinary collaboration, and the continued advancement of these innovative approaches will be crucial in shaping the future of this dynamic and rapidly evolving field.

References

Yousef, A. F., Refaat, M. M., Saleh, G. E., & Gouda, I. S. (2020). Role of MRI with Diffusion Weighted Images in Evaluation of Rectal Carcinoma. Benha Journal of Applied Sciences, 5(1 part (1)), 43-51.