IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS)
e-ISSN: 2278-3008, p-ISSN:2319-7676. Volume 9, Issue 1 Ver. I (Jan. 2014), PP 40-45
www.iosrjournals.org

Role of Robotic Asistancefor CT Guided Interventions.

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Abstract:*Robot attached to Computed Tomography is recently a new modality in Radiology and Pain practices. Use of robotic assistance technique has significant benefits over conventional techniques [1] . It is very helpful in assessing depth of structures like vessels, nerves, tissues, bony structures. It is very help full in biopsy procedures ,in FNAC[2],in RF ablation procedures , in drainage of fluids ,in giving various types of nerve blocks for pain relief. A robot can hold ,orient and guide a needle with CT and fluoroscopic guidance . Physician's radiation exposure is also negligiable during CT fluoroscopy . The source of information is pub med .*

Key words:- *Computed Tomography, Robotic arm, FNAC,*

I. Introduction:--

This review looks at the recent technological developments in image guidance for percutaneous interventional procedures .Robots intended to enhance accuracy are briefly discussed .It Also describes the new techniques and unconventional approaches that help provide safe acess to difficult to reach lesions. Diagnostic and interventional CT has an established role in many areas of medicine, but not one often been performed by anesthetist(Pain Physician) . Computed tomographic fluoroscopy offers much advantage for performance of Interventional procedures. With CT fluoroscopy the trajectory of a needle can be tracked in real time which allows the physician to make necessary adjustments. Major limitation of CT fluoroscopy is high radiation exposure to patient and physician .Physicians hand exposure has been theoretically and empirically determined to be approximately 2mGY per procedure it has been calculated that on basis of annual dose limit of 500 msvfo continuous hand exposure would be limited to performing only 4 CT fluoroscopic Procedures per year .Experience and training may lead to minimize reduction in exposure. Paulson et al recently reported reducing radiation exposure by lowering the milliampere setting and acquiring intermittent spot images during the procedure. Intermittent spot check images has gained greater acceptance ,as it generally can allow successful completion of the intervention with a substantial reduction of radiation exposure [3]. Rabio Robotic arm , a next generation platform of robotic targeting system for cancer and pain care comes with an array of advanced targeting features making robot the hands of a physician with it possible for clinicians to perform complex procedures with high degree of accuracy , minimizing unwanted organ damage and with significantly high patient comfort.

Robots have been introduced to hold and move instrument precisely . Robots allow greater precision and accuracy and lack tremors when compared with humans' neurosurgeons use robots for stereotactic biopsies.

The use of robotic arm reduces complications which may occur during the procedure. robotic arm can provide excellent guidance for difficult blocks, epidural space identification and performing transforaminal injections ,for delineating nerve plexuses for chronic pain nerve blocks [4] .Pain physician needs to develop a thorough knowledge of CT anatomy and skills and technology to visualize various structures intended to be manipulated .

Robotic Arm:- A robot can be either computer or joystick controlled. Basic structure of Robotic arm is that it is an offline system useful for precise positioning of needle inside the human body for minimally invasive procedures based on image data obtained from a CT scanner in Dicom3.o format The system assists the pain physician to perform the block by a simple work flow [5] .

The main component of the system includes Robotic positioner, this robotic positioner can be wheeled and docked to the docking station installed near the CT table during procedure and moved out after the procedure.

Robotic arm in combination with CT table driven by planning all degree of freedom to reach the target site precisely [6]. It has an end effector operated by an electric button. The pain physician can insert the needle through the sterile needle guide bush clamped in the end

effector. The procedure can be done at different table lengths and different table heights .It can reach difficult to reach area that requires more angulations
The end effector allows the use of sterile needle guides /bushes to accommodate.. Commonly available needles are of sizes 114, 134, 144,---254. Selected as per procedure robotic arm can be disengaged from the needle after the insertion , by opening the end effector to facilitate check scans during the procedure .

II. Cadaver study

After cadaver studies using the robot to precisely position a needle in the lumber spine were successfully completed in the Department of Radiology at Georgetown University, a randomized clinical trial of 20 patients undergoing nerve and facet blocks was approved by the FDA and the local institutional review board. The procedure was done following the usual clinical practice except the robot was used to position, orient, and drive the needle under physician control. A/P fluoroscopy was used to position and orient the needle, and lateral fluoroscopy was used to monitor the depth of insertion.

The robot was mounted on the interventional table using a custom-designed locking mechanism. The robot was positioned initially near the skin entry point by loosening the passive gross positioning mechanism and moving the needle driver end of the robot by hand. Once this initial position had been attained, the mechanism was locked and the robot was switched to operate by physician control using the joystick.

The study was completed by a single fellowship trained interventional neuroradiologist at Georgetown University Hospital using a Siemens Neurostar biplane fluoroscopy system. The standard manual technique was used on ten patients and the robotic device was used on ten patients. The patients ranged in age from 30 to 70 years. The spine levels were from S-1 to L-5. No complications were observed in the study. One of the patients in the robotics arm had to be converted to a manual procedure due to slippage of the needle driver. This conversion was done without difficulty or complications
here were two outcome measures:

- accuracy of needle placement, and
- pain relief.

Accuracy of needle placement was determined as follows. Before the interventionalist began placing the needle, both an A/P and lateral image of the patient were obtained. The interventionalist would then annotate each image with an arrow to indicate the desired target location of the needle (the interventionalist was not blinded as to manual/robotic technique as this was not practical). After the needle was placed, an A/P and lateral image was again obtained. The two sets of images were compared to determine the distance between the intended location of the needle and the actual location of the needle. Pain relief was measured using a visual-analog scale, with 0 representing no pain and 10 representing excruciating pain.

The results to date show that it is feasible to use a joystick controlled robot for nerve and facet blocks. While this was a pilot study and not enough data was gathered for statistical significance, some general trends can be observed. The mean accuracy in the robot (1.105 mm) and manual (1.238 mm) is about the same. Therefore, it appears that the robot is capable of accurate needle placement.
As expected, the pain score post-treatment was significantly less than the pain score pre-treatment in both the robot and manual arms. In the robot arm, pain scores fell from a mean of 6.3 pre-treatment to 1.8 post-treatment. In the manual arm, pain scores fell from 6.0 pre-treatment to 0.9 post-treatment. Patients had to sign an informed consent form and were generally receptive to the use of the robot.

Procedure for intervention with help of Robotic arm:-

The patient is placed in predetermined position suitable for intervention (supine, prone or lateral) .The system is prepositional and firmly attached to the table with clamps . Based on the preinterventional images and the anatomical region of interest the table is moved using the laser vizier from the CT gantry . The CT version comprises laser light sensors at the upper part of the application module for automated registration .The arm moves back and forth; It returns so that the light detectors are alighned with laser (within +/_0.5mm) The laser light is switched off and the table can be moved into gantry until the position of the laser line matches with the zero position of the z axis of the scanner . If planning for MRI interventions .then it is performed using fast gradient echo sequences in transverse saggital or coronal oriented. suitable slices are selected and sent via the network in DICOM format to the computer of the robotic assistant system. The insertion site and a target point are selected on the graphical users interface and the corresponding coordinates are sent to the control unit. The drives are activated and the application module is moved with the tool centre point to the insertion site on skin. The cannula can then be inserted through a guiding sleeve or along an open angle.
In this section the following technical issues will be briefly discussed:

- Imager compatibility

- Registration
- Patient movement and respiration
- Force feedback
- Mode of control
- on the cannula existing force feedback devices are too bulky for the clinical environment. In addition, friction forces and tissue during insertion are high, which compromises the accuracy of force feedback measurements (27). Therefore, this topic must be considered a research issue at this time.
- **Mode of control**
- The "best" user interface for an interventional robot has yet to be determined. For many procedures, joystick control seems well-suited and keeps the physician firmly in control. Master/slave systems are also possible and as noted above force feedback may be helpful here. However, there are procedures such as biopsy where a straight-line trajectory needs to be followed and some degree of autonomy seems appropriate if robustness can be achieved.

Imager compatibility

For MRI systems, compatibility can be achieved by using nonmagnetic and nonconductive materials. For CT systems, radiolucency of the end-effector is important so that it can hold the instrument on the scan plane. The robot system must also be easily interfaced with the imaging system and allow quick access to the patient in emergency situations. When the robot system is actuated it should not interfere with the imaging system. The kinematic structure of the robot must allow it to reach inside the gantry, which is one reason why specially designed robots are needed for these procedures.

Registration

Active needle driver, at for a robot to target the anatomy based on the images, the coordinate system of the robot must be registered to the coordinate system of the imaging device. If the robot is permanently attached to the patient table of the imaging device, this registration can be done once through a calibration procedure. If the robot is designed to be moved from one imaging device to another or to be placed on the table for certain procedures, fast and accurate registration techniques are required.

Patient movement and respiration

A limiting problem in some interventional techniques is organ movement due to respiration. High power robotic systems can avoid this problem.

Uses of Robotic arm

vertebral bone biopsy , retrocrural lesion biopsy. Applications like, mediastinal mass biopsy , FNAC of lung nodule , pelvic mass biopsy , liver biopsy of in giving therapeutic blocks , in selective nerve root block,canstop for aborting the procedure .{7}
,facet joint block{8} , sympathetic ganglion block , radiofrequency ablation procedures .In Diagnostic procedures .

Merits :- The key requirement for successful therapeutic block is to ensure optimal distribution of local anesthetic and steroid around nerve or plexus and this goal is most effectively achieved under CT guided visualization . Complications such as intraneural or intra arterial injections can be avoided. The potential advantage is :-

- 1. Direct visualization of nerves
- 2. Direct visualization of anatomical structures (blood vessels, muscles, bones, tendons etc.
- under image guidance continue to increase in numbers and importance, as they have been in the past several years, there will be more demand for technological assistance. In this role, image-guided robots may have a place and this place needs to be demonstrated in randomized clinical trials. Ten years ago image-guided procedures largely consisted of biopsies. Over the past decade interventional techniques have blossomed and include procedures to ablate tissue with energies such as radiofrequency, heat, cold, and laser. 3. Direct and indirect visualization of speed of injection of local anesthetic during injection.
- 4. Avoidance of s ide effects like intraneuronal injection , inadvertent intravascular injection
- 5. Improved quality of block .
- 6. Easy anesthetic drug delivery and fewer needle punctures.
- 7. Consistent accuracy because of navigation through slices and as it executes complex trajectory.

- 8.Safety acess , smaller and difficult to reach target s , for target areas affected by breath movement , the robot uses medspira interactive breath hold control system (IBC) to help the patient maintain a constant breath hold position during the procedure .
- 9. It comes with patient immobilizer to minimize patient movement during the procedure .
- 1o. Faster procedure time .

The success rate for blocks is almost100% as compared with other methods . Demerits:- 1. Major demerit is high radiation exposure to the patient and the pain physician or the radiologist

2. Cost of the equipment and the procedure.

III. Discussion:-

s percutaneous procedures with cannulae and probes Reconstructive procedures have also developed. An example is vertebroplasty and kyphoplasty in which methymethacrylate is injected into vertebra under X-ray image guidance to increase stability and to reduce pain.

Robots have some potential advantages over the human operator in certain applications. Examples include working in hazardous environments such as imaging rooms where radiation is used. During fluoroscopic or CT guided procedures the operator frequently advances the cannula with the imaging beam off and then acquires additional images to identify the current position of the tip. Options to overcome the limitation of intermittent imaging include stand-off devices to keep the operator's hands out of the direct x-ray beam. These devices are clumsy, and still force the operator to be too close to the radiation.

During percutaneous radiotherapy procedures radioactive seeds or probes are inserted into the patient. These are dangerous to have close to the operator. Other potential uses are to integrate robots with image guidance, including multimodality integration, and the integration of tracking technologies such as optical or mechanical trackers. The robots can perform active guidance in procedures where path planning and execution are difficult or provide a zone of constraint to keep the operator out of dangerous areas. A robot can also be integrated with active control to compensate for motion such as respiration. By compensating for patient motion the target can be made to appear static.

To be accepted in clinical practice, however, a robot must be intuitive and require minimal operator training. It must also be quick and easy to set up and not significantly increase the length of procedures. Robots must also be cost effective. The possibility of performing procedures that the human cannot perform but that are clinically necessary remains an ultimate goal for medical robotics. Engineers and physicians should work together to create and validate these systems for the benefits of patients everywhere.

IV. Conclusion:-

In general medical imaging plays a five key roles in image guided therapy and interventions .These roles are (1) Pre procedure planning (2) Intra procedural targeting (3) intra procedural monitoring (4) Intra procedural control and(5) post procedural assessment . As research and development in medical imaging focuses on interventional needs, it is likely that the role of medical imaging in interventions will become more integral and more widely applied .Medical imaging the sine qua non of all interventional procedures ,begin with x-ray fluoroscopy used predominantly to visualize bone and contrast material filled blood vessels and now includes cross sectional imaging techniques of ultra sonograph ,computed tomography, and magnetic resonance imaging and nuclear medicine techniques of positron emission tomography combined with CT(PET/CT) and single photon emission computed tomography combined with CT(SPECT/CT) each can be used to guide and monitor therapies .Further growth and development of medical imaging devices have allowed more interventional procedures to be performed and more patients to benefit from them .In general diagnostic and therapeutic radiology requires the highest quality images for perfection ,This high quality imaging may require more imaging time and more radiation dose .Because of robotic arms imaging can be restricted to the region of interest {9,10}. Computed tomography provides a very good representation of the skeletal structures and are therefore first choice of mapping of skeletal injuries in conjunction with severe trauma or for detailing skeletal structures . It is still a golden method of imaging for oncology patients {11} .3D reconstruction of CT scan is useful advance in the understanding of anatomy of the body and its pathologies .and robotic arm attachment further makes the procedure more precise . Robots are now helpful in orthopedic surgery also.(12,13) The Pain physician needs to develop a thorough understanding of the anatomical structure involved and need to acquire both solid grounding in technology and the practical skills to visualize a nerve structure .

Conflicts of interest

The authors confirm that there are no conflicts of interest related to this article.

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