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CT-Guided Interventional Radiology Procedures: Review Article

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ABSTRACT
Background: Interventional radiology guided by computed tomography (CT) uses minimally invasive techniques to perform medical diagnostics and treatments. Because it is widely available and can be conducted using a wide range of equipment, CT is frequently utilized for interventional image guiding.
Objective: This article highlighted for CT-guided interventional radiology procedures, areas and technique.
Methods: Google scholar and PubMed were searched using the following keywords: CT-guided interventional radiology and CT scan. The authors also screened references from the relevant literature including all the identified studies and reviews, only the most recent or complete study was included, between June 2002 and December 2020.
Conclusion: The use of CT-guided interventions radiology may offer a number of advantages. A high accuracy of instrument placement avoids the damage of vulnerable structures adjacent to the target and high accuracy to perform diagnostic and therapeutic medical procedures. In addition, could reduce the need for verification scans or CT fluoroscopy resulting in less radiation exposure.
Keywords: CT-guided interventional radiology, CT scan.

INTRODUCTION
The percentage of people over 60 years of age in the world is expected to nearly double between 2015 and 2050, from 14% to 22% [(1)]. As the world's population ages, so does the health care system. If you've ever had a biopsies or ablations for cancer or osteoporosis, you'll see a big increase in the number of people being diagnosed and treated for these conditions. Diagnosing and treating suspicious lesions become more affordable with image-guided, minimally invasive procedures [(2)]. For percutaneous interventional procedures that require cross-sectional image guidance, CT is one of the most often used imaging modalities. These treatments necessitate the use of specialized technology that simplifies workflows and maximizes patient safety [(2, 3)].

With the advancements in CT technology, the scope and quantity of treatments guided by CT that interventional radiologists conduct has expanded. Wide detector arrays are common in modern CT scanners allowing for more of the patient's anatomy to be scanned in a single rotation. Since the introduction of CT scanners and the increasing use of CT in interventional radiology, CT diagnostic imaging has seen a surge. Interventional radiologists must consider radiation control and monitoring methods while performing treatments guided by CT scans including taking photos of sufficient quality to approach the target safely and accurately [(3, 4)].

Technology developments like iterative reconstruction, large detector arrays and tube current modulation have all contributed to the creation of new CT applications. To reduce overall image noise, CT scanners have improved detectors that are more sensitive to X-rays and have reduced the amount of electronic noise. Manufacturers are now using adaptive shielding technology to minimize overscanning at the beginning and conclusion of the scan range. Various platforms provide iterative image reconstruction techniques, which allow for lower radiation doses while yet keeping a similar level of noise of picture. Many scanner manufacturers provide biopsy-specific settings for picture capture in order to reduce the risk of exposure to patients and any treatment staff still in the scanner suite when images are being taken [(4-5)].

For a range of treatments, CT guidance is frequently used by interventional radiologists, as well as other practitioners [(3-6)]. It's becoming more and more common for angiography to be performed using flat panel (cone beam) CT technology, even while other image guidance modalities, such as high-quality ultrasound (US), are becoming more and more widely available. With the development of new CT systems compatible with magnetic resonance imaging (MRI), CT scans are still an important part of percutaneous therapy imaging [(2)].

CT-Guided Interventional Radiology Areas:
The Society of Interventional Radiology (SIR) has previously produced practice guidelines and standards for fluoroscopically guided operations [(5, 6)], For CT-guided treatments, there are no such criteria. SIR should provide advice on CT-guided procedural best practices at this time. Guidelines for CT-guided interventional procedures developed by the SIR are intended to help physicians develop and maintain a high-quality program using CT guidance while also reviewing the latest technology and strategies for reducing radiation exposure to both patients and operators while also improving the quality of the resulting images [(3)].

Diagnostically, interventional radiology has advanced significantly in the previous two decades and has substituted surgery in several cases. Interventional radiology treatments, which are less intrusive and require less time to recuperate than traditional surgery, are responsible for this development [(7, 8)].

Despite the fact that specialised angiographic units are used for the majority of interventional radiology

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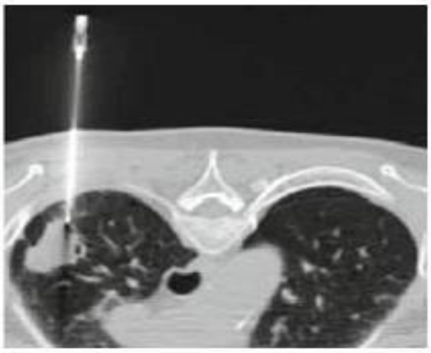
treatments, CT units (with and without the CT fluoroscopy option) are also utilised because of the exceptional anatomic visibility they provide. CT fluoroscopy may provide diagnostic and therapeutic benefits, but it also comes with the disadvantage of exposing medical staff to radiation, which units without CT fluoroscopy avoid. Any diagnostic or therapeutic technique using X-rays has the inherent weakness that the patient will be exposed, and the related radiation danger should always be a worry. Radiation's stochastic and non-stochastic (deterministic) effects are the subject of this issue [(7)].

Technique of CT-Guided Interventions Radiology:

Procedures such as biopsy, drainage, catheter insertion and RF ablation can all benefit from CT guidance. Similarly, knee arthroplasty and other orthopaedic procedures can also benefit from CT guidance. The 64-channel multidetector row helical CT scanner is commonly utilised for the majority of treatments, however a 4-channel or 16-channel scanner is more than sufficient for many operations [(7, 8)].

In all CT-guided operations, a needle or probe is advanced iteratively and incrementally. An operator in the control room scans and the patient on the CT bed. Introducing and positioning interventional access equipment (e.g. a needle, RF ablation probe, or drainage catheter) requires a CT scan. A CT scan is used to confirm the location of a specific place on the body (Figure 1) [(7)].



(A) (B) (C)

Figure (1): CT-guided interventional procedure's overall setup. Case is placed on the CT table in the proper posture (A). Radiation shielded control room was used to scan (B). An alignment of the probe is made with regard to the lesion (C), the probe is advanced with CT guiding [(7)].

Four phases can be used to organise any CT-guided procedure (such as a biopsy or RF ablation) as shown in figure (2). Prior imaging, current scans are used to determine the best path for the instrument in the trajectory planning stage. The patient is then pricked with a needle or probe. Orientation and insertion of the needle/probe are completed in the third phase. In the end, a sample is taken; the lesion is sampled or ablated, or a catheter is introduced, depending on the procedure being carried out [(7, 8)].

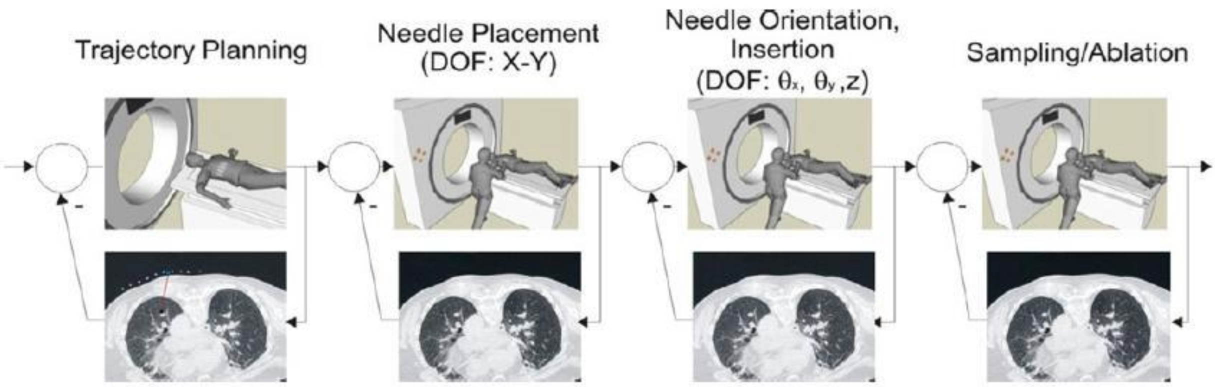


Figure (2): CT-guided procedure steps [(7)].

CT-guided Dosimetry:

CT-guided interventions benefit from ionization effects concentrated in a few slices. (e.g., a little portion of thorax for biopsy of lung). Therefore, it is critical to take into account both the stochastic and deterministic consequences of this delivery method. Radiation exposure's stochastic risk has been documented in the past (like genetic impact on tumour induction) does not have a threshold for the development of cancer: as a patient's dose rises, so does their risk. To avoid radiation-induced damage to the body, deterministic effects (damage to organs or tissue) must be over a certain threshold; for example, 2 Gy or greater is required to cause skin damage (acute skin reactions as erythema and epilation) [9, 10].

Since all radiosensitive organs are weighted according to their individual radiosensitivity, the effective dose can be used to determine a stochastic dosage. Measuring skin exposure with ESD provides an accurate picture of how much radiation is reaching the patient's skin [11].

The latest trends and the most advanced applications:

The use of C-Arm CT in Interventional procedures

The three primary interventional guiding modalities are radiography and fluoroscopy (R & F), C-arm angiography, and computed tomography (CT) in the past have been performed in different interventional suites, and they have remained thus. An "omniscanning" system that combines three separate modalities could be made practical by recently announced digital flat-panel detectors. For typical neuro-interventions. Early results show that C-arm CT using an area detector installed on a C-gantry can offer the picture quality required for intraoperative workup of arterial and musculoskeletal problems [12]. As this novel modality's therapeutic value grows, so does its clinical utility and the related procedures for its use.

Flat-panel detector-based C-arm CT can be beneficial in image-guided procedures. An overview of the technology and its integration with the C-arm gantry will be followed by a discussion of specific examples of how the flat-panel detector can be utilized to solve intraoperative problems during surgery [7].

Applications in vascular surgeries

Vascular surgeries frequently make use of C-arms. A new range of applications is possible because of the integration of several modalities into a single system. A catheter can be advanced with fluoroscopic guidance. For example, a high-resolution computed tomography scan can subsequently be used to confirm the catheter's tip location. If the catheter tip is found to be in the correct place during dynamic CT scanning, it is possible to inject contrast, embolic agents, or medicines. Aneurysm sac form can now be better visualized during surgery with the help of C-arm CT intra-operative 3D vascular imaging and 3D surface mapping [13]. The metal artefact profile of C-arm CT is superior to that of conventional CT. Intravascular stent deployment is much easier with this technique.

Intraoperative application

C-arm imagers are commonly seen in the operating rooms of neurosurgeons and orthopaedic surgeons to aid in the evaluation of the instruments' relative position in relation to the patient's anatomy. Additional information obtained from CT imaging might be incredibly helpful in some cases even though fluoroscopic guidance is sufficient in most cases. Thus, the modern C-arm system's capacity to omniscan can greatly improve the procedure's accuracy and efficiency. When orthopedic screws are being placed transpedicularly, the C-arm CT scanner is employed. Intraoperative tomographic imaging is already possible thanks to dedicated instruments like the O-arm (Medtronic Inc., St. Paul, MN) [7, 14].

MSK applications

With the aid of fluoroscopes, surgeries like vertebroplasty and kyphoplasty have traditionally been performed. Percutaneous access to the desired vertebral body can be acquired using a transpedicular or parapedicular technique. This can be done with one pedicle or both. The osteoporotic or fractured vertebral body is then reinforced with bone cement, which is applied precisely where it is needed. C-arm CT has made it possible to use tomographic imaging in addition to normal fluoroscopic projections to verify the precise location of the needle tip [7].

More Procedures

Interactional techniques such as TIPS and chemoembolization of malignancies should benefit from the use of R & F and angiography-CT scanning modes in combination. It will be easier to perform percutaneous biopsies with this method as well. Even while fluoroscopy is a viable option for many interventions, the integrated mode offers greater adaptability. Patients who require cross-sectional imaging during surgery can get access to it immediately [7].

CONCLUSION

The use of CT-guided interventions radiology may offer a number of advantages. A high accuracy of instrument placement avoids the damage of vulnerable structures adjacent to the target and high accuracy to perform diagnostic and therapeutic medical procedures. In addition, could reduce the need for verification scans or CT fluoroscopy resulting in less radiation exposure.

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