

Multi Slice Computed Tomography (MSCT)

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Introduction

Since the dawn of true medicine, physician based their observation on cadaver dissection to understand organ function, normal appearance and their response to disease. Medical Imaging (MI) started with Roentgen in the end of the 19th century with the introduction of X-ray. However this technique was a projection on a plan surface of the imaged structure like the chest or the skull where the brain was not directly seen.

It was a major breakthrough when the first CT image of the brain was done in 1972, showing the brain of a living human without the need to open the skull to see what is in there. However one slice needed 270 seconds or 4minuts 30 seconds to be done with a low resolution (96 pixels). The whole brain was scanned in almost one hour there where a constant effort provided by physician to improve the speed and the amount of information in a axial image.

The CT image is the product of one X-ray beam hitting a detector after going thru an anatomic structure. The amount of X-ray arriving to the detector is translated into an image. For each axial image this process needed, in the early years of 1980, seconds to be done and the late 1990, sub second. However this was not fast enough to cover for example the abdomen or the chest in one breath hold, making overlooking small lesion a real issue if the patient is not holding his breath correctly or dyspneic patient difficult to examine. Speed of the mechanical rotation of the X-ray source and detector was less than the physiologic motion like breathing, intestinal bowel movement and specially blood circulation in the vessels, leading whether to image artifacts (abdomen and lungs) or non evaluation of artery, veins and above all the heart.



MSCT:

In the mid 1990 a new technology emerged the dual detector allowing the collection of 2 axial images from one single X-ray beam at less than one second. Practically an organ was scanned in half the regular time.

When a multi detector array (4, 8, 16, 32, 40 and now 64) was positioned in front of the X-ray, an equivalent number of images (4, 8, 16, 32, 40 and 64 slices) where acquired in one rotation of the X-ray tube// detectors couple usually in the order of 0.2 to 0.35 seconds.

Scanning more than 16 slices at the same time was like covering a volume rather in one step and axial image can be reconstructed and displayed in a slice thickness equal to the geometrical thickness of the detector (0.5 to 0.625 mm). The lungs are now scanned in one breath hold that is no longer than very few seconds (3 seconds for the MSCT 64) without the risk of skipping small lesion. Large coverage or even total body scans can be achieved in less than 30 seconds. More important was the fast scan matching physiologic motion like blood circulation allowing imaging arteries and veins when contrast materiel injected intravenously was still in the vascular bed and following contrast progression in

specific organs like the liver, pancreas lungs, brain thus studying the perfusion of those organs same as tumor vascular supply.

So the major achievement of multi detector technology was the ability to get Multi Slices in a sub second, increasing the Speed, the Coverage (volume) the Resolution (thin detector=thin images 0.5 to 0.625 mm).

MSCT applications:

- a- Total Body Scan: The dream of every physician and probably every patient is to know what is in his body; this virtual in vivo dissection is now achievable. However due to the amount of X-ray radiation deposited in the organ covered by the Scan, hole body MSCT should be reserved only when screening for disease like staging a cancer to look for lymph nodes or metastasis, searching for an infectious process in Fever from unknown origin, fracture or hemorrhage in a poly trauma patient specially if his unconscious. There are many other clinical setting where hole body scan is the imaging first line exam where radiation protection should be weighted with the benefit of such procedure.
- b- Organ Perfusion: assessing blood pool of an organ gives an idea of its function and viability. Patient presenting with Stroke benefit from a Brain CT Perfusion to see which territory is lacking blood supply and if the patient will recover if revascularization is promptly achieved. Hyper-active zone need more blood supply like in epilepsy and this can also be seen. In other organ like the lungs, liver pancreas, uterus, ovaries, prostate etc.. Knowing how blood pool is dispersed gives an idea of the tissue characteristics. Tumors

needs more vessels to develop and enlarge, by visualizing this amount of vessels by contrast enhancement we can screen, diagnosed tumors and follow their progression under treatment, the less contrast they show after treatment means less blood supply to their tissue and more tissue death.

- c- Vascular imaging : with fast and large coverage, imaging the vascular tree by MSCT is now the gold standard, replacing the invasive catheter procedure that needed hospital admission, cost and its not negligible amount of complication. Today doing an Angio CT is an ambulatory exam that needs no further preparation than a regular CT. The high sensitivity and specificity of this tool made the catheterization a therapeutic procedure only for all the systemic vasculature. When a diseased vessel is diagnosed by MSCT, patient might benefit from interventional catheterization or operation.
- d- Volume imaging: 3D volume reconstruction is feasible with the MSCT technology since a volume is covered in one step by very thin and high resolution images. Rendering an organ in its three dimensions will show its relation to other organs, display it in a Multiplan orientation (sagittal, coronal or oblique). Joints and bones can be seen from all angles, the complexity of a fracture is reduced by seeing each fragment, vertebral bodies are also displayed in their entire axis with all kind of fractures or deformities (scoliosis) studied.
- e- Cardiac Imaging: this is the field where the MSCT and specially the 64 MSCT proved to be invaluable. By gaining the ability of scanning a volume of 64 slices of 0.625 slices in 200 milliseconds, we can image 4 cm of the heart in one diastolic phase if the heart rate is 65 beat per minute. So in 5 to 6 heart beats we can cover the whole heart cavities and its

vessels mainly the coronary arteries.

- f- Coronary CT Angio (CCTA): knowing that the most common cause of cardiac arrest is Coronary Artery Disease (CAD) mainly due to atheroma plaque, and less likely to anomalous origin of the coronary artery, a screening tool for high risk patient was needed. Since the CT is still a cross sectional imaging, the vessel wall was visible so was any plaque deposition on it, and the origin of the vessel can be seen.

The high negative predictive value (98%) of CCTA is now used to rule out vessel wall disease in high risk patient. Patient suffering from atypical chest pain with normal ECG or enzyme level can benefit from this exam that do not need hospital admission and is done in an out-patient setting, allowing at the same time to rule out other chest pain origin like pulmonary emboli or thoracic aortic dissection. This triple rule out exam will save extremely valuable time for critical patient and save live as well. Patient showing significant atheroma plaque with luminal narrowing will have to proceed to other tests like stress test or coronary catheterization to study the hemodynamic implication of the wall disease and if needed an angioplasty can be performed at the same time.

Those where some of the major advances in medical imaging that MSCT was behind, a large area is still uncovered and waiting to be developed. The future will see the application of MSCT in dynamic imaging where scanning real time heart motion or bowel loop peristaltic motion, thus covering the anatomy, tissue characterization, function, viability and dynamic of the body.

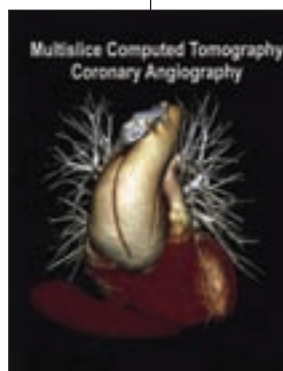
Disadvantage of MSCT: the only real disadvantage of MSCT

is the amount of radiation delivered to the body during the exam. This technology needing power and speed an increase in the X-ray tube and generator capacity was mandatory, getting a sharp X-ray beam to get thin slices was addressed by increasing the parameters (mAs, Kv..) .Bringing all this technology to work properly and in a safe environment is very expensive (1.3 Millions US\$)

In fact site preparation is different from the usual CT scan, power consumption is higher, personal training is different, more hardware and software are needed to handle the enormous amount of data and images generated by one exam (1000 images for an abdomen). A very sophisticated work station is a must to do all the post -processing and viewing (3D volume rendering, vascular imaging, perfusion assessment, virtual colonoscopy...etc...). A multi Terra bites archiving system to save most of the images is necessary to comply with all health organization commissions inquiries.

MSCT in Lebanon:

The Lebanese Radiologist training and continuous education and the commitment of hospital owners and administrators to better serve our patients and people from neighboring countries, keeping our country in the leap of the major medical advances, led to the fact that almost 10 MSCT where installed since 2006 in Lebanon, making our country one of the first among the Arab countries to have this platform. A state policy should be applied to encourage, support and implement with all safety measurement such development. A reimbursement plan must be established and honored by all users and beneficial once guidelines for MSCT exam and special procedure are well evaluated.





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