64-slice CT, SCENARIA
— Outstanding Technological Features and Clinical Impact —
Nippon Medical School Hospital installed SCENARIA into its most frequently used CT examination room, beginning full-scale operations in February, 2011. SCENARIA possesses various hardware and software features which surpass conventional 64-slice CT systems and from a clinical viewpoint is superior in that it allows: (1) 0.35s/rot scanning in any part of the whole body, including for cardiac examinations, (2) low dose examinations using exposure dose optimization while maintaining contrast-to-noise ratio with an adaptive iterative denoising process and (3) high spatial resolution examination capability with a patient table lateral slide mechanism. This paper emphasizes clinical advantages and provides evidence of SCENARIA as a CT scanner that goes beyond conventional 64-slice CT performance by providing case studies demonstrating these advanced features.

1. Introduction

Currently, Nippon Medical School Hospital is utilizing 4 diagnostic CT scanners, with about 34,000 CT scans conducted every year. Among these, about 10,200 (~30%) are contrast enhanced CT scans. 3 of the 4 CT scanners mentioned above are used primarily for outpatient scanning and 1 for inpatient scanning. All requests for emergency CT scans, whether they are outpatient or inpatient requests, are accepted, and scans are performed on the same day of the request followed by interpretation reports for all requested scans.

In our hospital, several interpretation "reading" terminal units are set up in a CT examination room. As a rule, 2 radiologists and 2 radiation technologists are required to operate each CT scanner during the day shift. With this setup, we encourage doctors and technologists to consider changes to achieve the best individual scan based on the purpose of the examination, utilizing shared knowledge and experience. Additionally, our hospital facility includes the first Advanced Emergency Medical Service Center in Japan, which provides emergency medical care 24 hours a day, 365 days a year. Emergency CT examinations, including requests from the Advanced Emergency Medical Service Center, comprise 41% of the total number of CT examinations performed.

Since the basic performance of the 64-slice CT SCENARIA is superior overall compared to conventional 64-slice CT systems, we have installed it in our hospital in the CT examination room that bears the heaviest CT scan burden, which runs 24 hours a day, 365 days a year. Full operation of the unit commenced from February, 2011.

Features of SCENARIA that are superior to conventional 64-slice CT scanners include: (1) 0.35s/rot scanning of any part of the whole body, including for cardiac examinations (2) low dose examinations by using dose optimization together with maintaining a selected noise.

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level (SD mode) or selected contrast-to-noise ratio (CNR mode), with an adaptive iterative denoising process (Intelli IP; iterative noise reduction process) (3) high spatial resolution examinations capabilities with a patient table lateral slide mechanism.

(1) 0.35s/rot scanning on any part of the whole body, including for cardiac examinations

It is well understood that the ability to perform 0.35s/rot scanning on any part of the whole body, including for cardiac examinations, is of great clinical significance. Combining/integrating a number of superior technologies has made high speed scanning possible. In particular, ensuring a rapid view rate that reaches 2,880 view/s, use of a 3 dimensional reconstruction algorithm (CORE method) to achieve reduced artifacts at high pitch scanning and development of a 2 dimensional anti-scatter collimator (2D-ASC) for removal of body axis beam scatter, have contributed greatly to SCENARIA’s success1). SCENARIA has a 0.58, 0.83, 1.08, 1.33, and 1.58 beam pitch, the choice of which can be made depending on the purpose of the examination. If the X-ray tube rotation speed is set at 0.35s/rot and a beam pitch of 1.33 is chosen, then a 70 cm CT examination from the chest region to the pelvis can be completed in 5 seconds. For a 30 cm length chest or abdominal CT examination, about 3 seconds is needed to complete the examination with a beam pitch of 1.08. Shortening the breath holding period not only eases the patient’s cooperation burden, but also leads to an increased number of successful examinations and is therefore desirable for examiners as well as for patients. For contrast scanning, it is important that enough delay is taken for the contrast agent to spread to the target tissue and to monitor the contrast uptake with the Predict Scan feature in order to ensure that the contrast media reaches the target and thereby confirm the scan will not precede the contrast media2).

(2) Low dose examinations by using exposure dose optimization along with maintaining a selected noise level (SD mode) or selected contrast-to-noise ratio (CNR mode), with an adaptive iterative denoising process

It is necessary for doctors and technologists who perform CT examinations to pay particular attention to reducing medical X-ray exposure. Currently, most CT scanners employ a method that uses a selected noise level as a barometer to modulate mA and thereby optimize the X-ray dose (SD mode). With this method, it is possible to maintain a consistent level of image noise and obtain clear images regardless the scan regions. We have been using this method since it enables us to perform examinations while maintaining a balance of image quality and exposure. In addition to SD mode, SCENARIA possesses a CNR mode, which is based on maintaining a selected contrast-to-noise ratio, using a tissue comparison contrast database that considers the readers discrimination ability. Since the contrast between tissues is higher in patients with small body size such as infants or elderly women, or when the tube voltage is reduced in order to reduce exposure dose, using CNR mode allows a greater reduction of exposure dose than in SD mode, in which noise level is used as the barometer. In a phantom experiment using agar, CNR mode yielded an equal contrast-to-noise ratio (CNR) at both 120 kV and 100 kV tube voltages. By using the 100 kV tube voltage, therefore, exposure dose can be reduced by 47%3) (Fig. 1). Using low kV as a technique to reduce exposure dose during CT examinations has been

![Fig. 1: Comparison of exposure dose between SD mode and CNR mode during low tube voltage-scanning](image_url)

A φ260 agar phantom was created and diluted contrast media was added. By employing the CNR mode, an almost equal CNR was obtained while using a different tube voltage. In this experiment, using a 100 kV tube voltage resulted in a 47% reduction in exposure dose. (The experiment was conducted through collaboration between Kumamoto University, School of Health Sciences, Department of Radiology Kumamoto University Hospital and Hitachi Medical Corporation)
attracting much attention, and this technique also has great potential to maintain superior contrast.

Adaptive iterative denoising is an arithmetic processing method that has attracted much attention recently. Intelli IP, which is an embedded function in SCENARIA, performs iterative adaptive processing for both projection and image data based on the reliability of statistical data, and it enables CT examinations with minimum X-ray dose by utilizing perspectives and techniques that are different than previous dose control and optimization methods (Fig. 2).

(3) High spatial resolution examinations capabilities with a patient table lateral slide mechanism

When conducting CT examinations, it is desirable to position the patient as best as possible at the center of rotation. However due to anatomical or mechanical constraints of the CT patient table, this is sometimes difficult to achieve, and has been a significant problem for us as well. Furthermore, new clinical challenges have arisen recently that require examination of smaller sized targets, such as in cardiac CT examinations, while maintaining as much as possible a high spatial resolution. To facilitate such examinations, SCENARIA possesses a patient table lateral slide mechanism (IntelliCenter) that can position the patient at the center of rotation by allowing movement of the CT patient table to a maximum of 80 mm laterally. In basic experiments performed at our hospital, (spatial resolution and MTF), applying IntelliCenter in examinations resulted in a 10% increase in spatial resolution at a point 80 mm away from the rotation center (Fig. 3). In addition, SCENARIA possesses a Cardiac (Small) Bow-tie Filter, which functions as a cardiac radiation compensating filter. Combining this Bow-tie filter feature with IntelliCenter can result in a 1/4 decrease in radiation exposure dose in the entire scanning area, and a 1/3 decrease even outside the region of interest. This reduction is of great benefit to clinical practice.

![Fig. 2: Dose Reduction effect and image SD change by Intelli IP](image1)

Compared to Intelli IP OFF (original image), the SD value was reduced 18% with Intelli IP ON (level D), corresponding to a 33% reduction in exposure dose. Furthermore, SD value was reduced by 23% with Intelli IP ON (level E), corresponding to a 41% reduction in exposure dose.

![Fig. 3: Increase in spatial resolution by IntelliCenter: Comparison with Iso-, Off-center](image2)

Spatial resolution sections of Catphan phantom were positioned at the rotation center of the X-ray tube and a point 80mm away from the rotation center. Both images were obtained under identical scan conditions and reconstructed by the same abdominal kernel. By scanning at the rotation center, spatial resolution increased by about 10%.
According to the 2009 Cardiovascular Diseases Clinical Investigation from the Japanese Circulation Society, the number of cardiac CT examinations (coronary artery) increased rapidly; 150,309 in 2007, 218,053 in 2008, and 273,370 in 2009. However, if retrospective ECG gating is conducted with a 64-slice CT, the cardiac CT examination exposure dose will be in the range of 8 ~ 25mSv, which is somewhat higher than other CT examinations. To achieve as low an exposure dose as possible while maintaining a high spatial resolution, combining IntelliCenter and the Cardiac (Small) Bow-tie Filter will become the new standard. In addition to reducing tube voltage and tube current, prospective ECG gating has become an indispensable examination method to reduce exposure during cardiac CT examinations. Prospective ECG gating is also an embedded function in SCENARIA. Prospectively ECG gated cardiac CT examinations, allow an even lower exposure dose by combining IntelliCenter and Cardiac (Small) Bow-tie Filter, under appropriate heart rate control with β-blockers, represents a great improvement over previous options. In addition to its use in cardiac CT scans at our hospital, IntelliCenter is being applied to the orthopedics field in shoulder joint or upper limb examinations. This has reduced the difficulties we have faced in positioning patients compared to the previous method; this system has been a wonderful addition to our hospital.

2. Practical utilization of SCENARIA’s features

1. Case 1 Female, age 79 (Fig. 4)

For detailed examination of a previous cerebral infarction, a craniocervical CT Angiography was conducted. At the center of the VR image (B), calcification of the right internal carotid artery (blue arrow), 2 stenoses immediately after the origin of the left common carotid artery (yellow arrow), and occlusion of the left internal carotid artery (red arrow), can be observed. In curved planar reconstruction image (A), running along the right common carotid artery to the internal carotid artery, a hard plaque and small soft plaque can be seen in the right internal carotid artery bifurcation. Additionally, circumferential hard plaque can be observed in the intracranial right internal carotid artery wall (green arrow).

On the other hand, in curved planar reconstruction image (C), running along the left common carotid artery to the internal carotid artery from a different angle, 2 stenoses immediately after the origin of the left common carotid artery (yellow arrow) and occlusion of the left internal carotid artery (red arrow) can be clearly seen.

2. Case 2 Female, age 78 (Fig. 5)

In follow-up of an aortic arch graft replacement, aortic CT examination was conducted. By applying a 0.35s/rot X-ray tube rotation speed and a beam pitch of 1.33, total scanning time was 5 seconds. From the VR image (A), motion artifacts due to heartbeat were very small and the ascending aorta could be adequately assessed. The abdominal major branch can also be clearly seen. From curved planar reconstruction image (B: natural view) running along the aortic arch to the right external iliac artery, it is clear that the contrast of the lumen is substantially uniform from along the aortic arch to the right external iliac artery. Stenosis can be observed at the beginning of the left common iliac artery (yellow arrow).

From curved planar reconstruction image (C: straight view), a small stenosis was seen at the distal graft anastomosis (red arrow). Additionally, hard and soft plaques can be found in some areas in the aorta.
3. Case 3 Male, age 57 (Fig. 6)

For preoperative examination of colon cancer at a splenic flexure, images of the arterial phase (examination beginning 30 seconds after injection of the contrast media) and the portal phase (80 seconds after injection of the contrast media) were taken and the intraperitoneal artery, portal and venous system were assessed.

The celiac and superior mesenteric artery and their branches are shown in red and the inferior mesenteric artery and its branches are shown in blue in the artery phase VR image (A). Splenic flexure colon cancer is shown in purple. The artery running down from the peripheral splenic artery to the interperitoneal can be seen (yellow arrow). From the VR image looking down from the head (B), main feeder of the cancer is considered to be comprised of the left colic artery (blue arrow) and the middle colic artery (red arrow), dominated mainly by the former. Additionally, localized and varicose gastric artery branching from the splenic artery can be seen (green arrow).

A superimposed (fusion) image of the colon (semitransparent) with vascular system of arterial and portal phase is shown in the VR images (C: from the front, D: left anterior oblique position). The superior mesenteric vein, splenic vein, and portal vein are shown in yellow green. The left colic vein and the superior rectal vein joining the inferior mesenteric vein are shown in purple. The drainage vein of the splenic flexure colon cancer was found to be the left colic vein (red arrow).

4. Case 4 Male, age 61 (Fig. 7)

An abnormality was found in an exercise electrocardiog-
raphy, and a cardiac CT examination was conducted for the purpose of close examination.

In VR image (A), the left anterior descending artery (LAD) was found to be very small and its entire image cannot be seen clearly. Additionally, the myocardial wall of the anterior wall ~ apex is thinning and the contrast media in the left ventricular cavity is visible. In the VR vessel tree image (B) in which only the coronary artery and the aorta were selected, LAD cannot be seen clearly compared to the right coronary artery (RCA), the left circumflex artery (LCX), and the high lateral branch (LB).

In CPR image (C) along the LAD, the diffuse and severe stenosis can be observed at the LAD (1). In short axis view (D) at the same level, low attenuation value soft plaque on the intimal side was observed. At the middle of the LAD (2) highly severe stenosis was observed and the lumen was almost impossible to observe. In the lumen of the distal part of the LAD (3), a contrast effect can be seen, however the attenuation value is low.

In angiographic view (E), a stenosis was observed at the origin of RCA, while other stenoses were observed in the area distal to the RCA (blue arrow) and the posterior descending branch (yellow arrow). In CPR image (F) running along the RCA, a stenosis due to soft plaque with positive remodeling was observed (red arrow) at the origin of RCA. The lumen, plaque and outer membrane were traced and displayed in 5 different colors depending on CT values in straight view (G), which displays the RCA linearly. Measurement of plaque volume was possible. Additionally, in the short axis view of the same lesion (H), the plaque CT value was about 52HU, and is likely to be a fibro-fatty plaque.

5. Case 5 Male, age 57 (Fig. 8)

Due to suspicious of re-dissociation at the ascending aorta after an ascending aortic arch replacement operation for Stanford type A aortic dissection, an emergency electrocardiography (ECG) gated cardiac CT and thoracic aorta CT examination was conducted.

The whole image of the thoracic aorta and coronary artery can be seen in VR image (A). The graft replacement of the ascending aortic arch can be observed (blue arrow). Dissection in the descending thoracic aorta was still remaining (T: true lumen, F: false lumen). In coronal MPR image (B), a new re-dissected lumen (yellow arrow) was observed at the proximal side of the graft-replaced ascending aorta (blue arrow). In para-sagittal MPR image (C), the intimal flap just distal to the descending aorta of the elephant trunk seen beyond the graft distal anastomotic part was observed (red arrow). T shows the true lumen and F shows the false lumen.

At the aortic root VR image (D) and the same level MPR image (E), spread re-dissection in the left main trunk (LMT) was observed (blue arrow). Narrowing of the LMT Ostia was observed (red arrow). Furthermore, the small intima tear in the ascending aortic root can be recognized (yellow arrow). RCA is the right coronary artery and LAD is the left anterior descending coronary artery.

On the other hand, in VR image (F) and aortic root MPR image (G) that were displayed as if looking up the aorta, re-dissection also occurred in the right wall of the aortic root and a large re-dissected lumen was created (red arrow). The dissection was spreading also in the right coronary artery (RCA) root and stricture of Ostia and intima tear (yellow arrow) could be observed.
3. Conclusion

Although this report comes only shortly after full operation of the 64-slice CT SCENARIA, we have been surprised by its demonstrated high potential. Recent improvements in diagnostic imaging have been very rapid. Especially, improvements in CT have been remarkable. Multislice CT has developed with the aim of faster, longer, and better performance compared to single slice helical CT. Since the introduction of the 64-slice CT, CT scanners that go beyond 64ch capability with various additional functions have been introduced. As described above, the SCENARIA 64-slice CT scanner possesses various important functions beyond the conventional 64-slice CT, and is therefore truly considered to be a "Brand-new Beyond 64-slice CT Scanner".

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References