

Coronary CT Angiography with reduced radiation dose using the Aquilion ONE ViSION Edition

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A large single center comparison with the Aquilion ONE

Introduction

Coronary CT angiography using the Aquilion ONE with its 320 detector rows and 16cm z-axis coverage has been shown to have good diagnostic accuracy to detect significant coronary stenoses compared to invasive catheter angiography¹⁻². In patients with a heart rate of less than 65 bpm the entire heart can be acquired in a single heartbeat for a low radiation dose³. The use of prospective gating, where only a portion of the heart cycle is

imaged, ^{SURE}Exposure and the novel iterative reconstruction algorithm AIDR 3D all assist in lowering the radiation dose as much as possible. In patients with higher heart rates (>65 bpm) the temporal resolution of 175 ms is not fast enough to freeze cardiac motion, thus multi-segment reconstruction is necessary to improve temporal resolution. As multiple beats need to be scanned, the radiation dose is increased.

In 2012 Toshiba introduced the Aquilion ONE ViSION Edition. In this system the gantry speed is increased from 350 ms to 275 ms and thus the

temporal resolution of a scan acquired in a single heart beat has improved to 137 ms. As a result, this second generation 320-row scanner is expected to allow excellent coronary imaging across a wider range of heart rates as compared to the first generation scanner. To date two papers have been published comparing the two systems⁴⁻⁵. In the study by Chen et al.⁴ coronary CT angiography was performed in 107 consecutive and unselected patients, who were enrolled regardless of heart rate, cardiac rhythm, body size, previous cardiac history (such as coronary bypass grafting) or clinical indication. The only contraindications

	ONE n = 250	ViSION n = 250	P value
BMI – Mean (SD)	24.6 (3.5)	24.6 (3.5)	24.6 (3.5)
Underweight	10 (4)	9 (3.6)	0.815
Normal	157 (62.8)	153 (61.2)	0.712
Overweight	75 (30)	74 (29.6)	0.922
Obese	8 (3.2)	14 (5.6)	0.191
Heart Rate – mean (SD)	62.86 (0.8)	66.75 (1.1)	0.0046*
< 50 bpm	35 (14)	19 (7.6)	0.021
51 – 60 bpm	93 (37.2)	88 (35.2)	0.642
61 – 75 bpm	84 (33.6)	96 (38.4)	0.264
75 – 90 bpm	29 (11.6)	28 (11.2)	0.888
> 91 bpm	9 (3.6)	19 (7.6)	0.052
Arrhythmia			
Yes	8 (3.2)	16 (6.4)	0.094
No	242 (96.8)	234 (93.6)	

Table 1: Selected patient demographics

	ONE n = 250	ViSION n = 250	P value
Number of Beats			
1	155 (62)	195 (78)	<0.001*
2	72 (18.8)	36 (14.4)	<0.001*
3	20 (8)	15 (6)	0.381
4	3 (1.2)	4 (1.6)	1.000
kV			
100	174 (69.6)	224 (89.6)	<0.001*
120	71 (28.4)	26 (10.4)	<0.001*
135	5 (2)	0 (0)	0.061
Radiation Dose – mean (SD)	2.71 (2.47)	2.07 (2.57)	0.0047*
Mean with arrhythmia patients excluded (SD)	2.49 (1.81)	1.69 (1.52)	<0.001*
< 1mSv	34 (13.6)	83 (33.2)	<0.001*
1 mSv	86 (34.4)	97 (38.8)	0.307
2 mSv	61 (24.4)	32 (12.8)	0.001*
3 mSv	21 (8.4)	11 (4.4)	0.068
> 4 mSv	48 (19.2)	27 (3.2)	0.009*

Table 2: Selected scan parameters

were pregnancy or poor renal function. This cohort was compared with a similar consecutive cohort imaged with the Aquilion ONE in 2010. The scans performed on the Aquilion ONE did not use AIDR 3D or ^{SURE}Exposure. In this study the mean radiation dose was reduced from 2.67 mSv with Aquilion ONE to 0.93 mSv with the ViSION, representing a 65 % dose reduction. This significant reduction is due to the implementation of many dose saving features such as AIDR 3D and ^{SURE}Exposure in addition to the increased gantry rotation speed. A similar comparison was performed by Tomizawa et al.⁵ In this study however, a more restricted population was investigated where the only variable between the Aquilion ONE and Aquilion ONE ViSION Edition patient cohorts (n = 48 each) was the rotation time. Also in this study, use of the Aquilion ONE ViSION Edition resulted in a substantial reduction

in radiation dose. From a practical perspective, it is important to establish whether these observations, obtained in single academic expert centers, can be generalized to the larger imaging community. The current paper therefore compares the two systems in a radiology department in a private hospital setting with a higher patient throughput and a larger number of patients with arrhythmia than the two published papers.

Patients

We sought to compare the radiation dose reduction for coronary CT angiography between the Aquilion ONE and Aquilion ONE ViSION Edition systems when the only variable was the rotation speed. 500 patients were retrospectively studied, 250 were imaged with Aquilion ONE from September – October 2012 and 250 imaged with the ViSION

Edition from December 2012 – January 2013. Patients presented with atypical chest pain, positive exercise stress test or multiple risk factors for coronary artery disease. Other parameters such as iterative reconstruction and ^{SURE}Exposure settings were the same for both groups. Selected patient demographics are shown in Table 1. The BMI was not significantly different between the two systems. The mean heart rate however was slightly higher with the ViSION Edition. The percentage of patients with a very slow heart rate decreased and the percentage of patients with heart rates between 61 and 75 bpm increased. The number of patients with high heart rates also increased slightly corresponding to an increase in the number of patients with arrhythmia, though this was not statistically significant. Overall the patients in each group were similar. Generally, the cohort studied

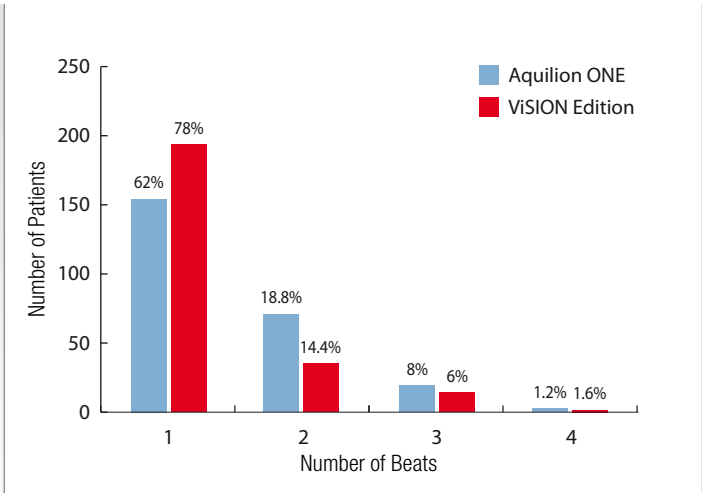


Figure 1: Number of Beats

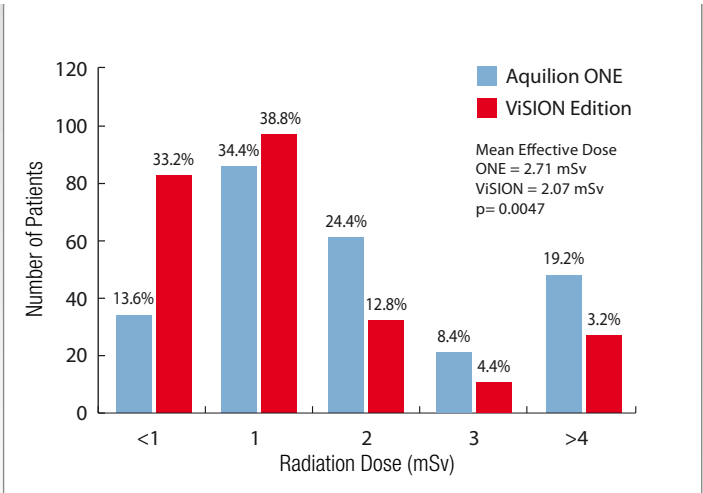


Figure 2: Radiation Dose

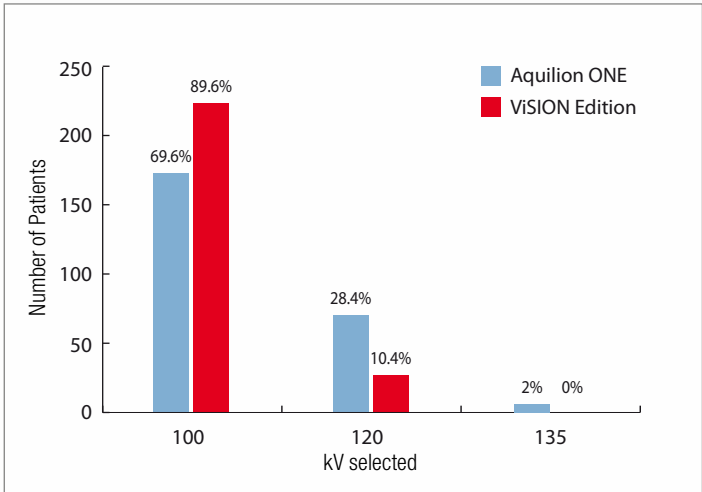


Figure 3: kV selected

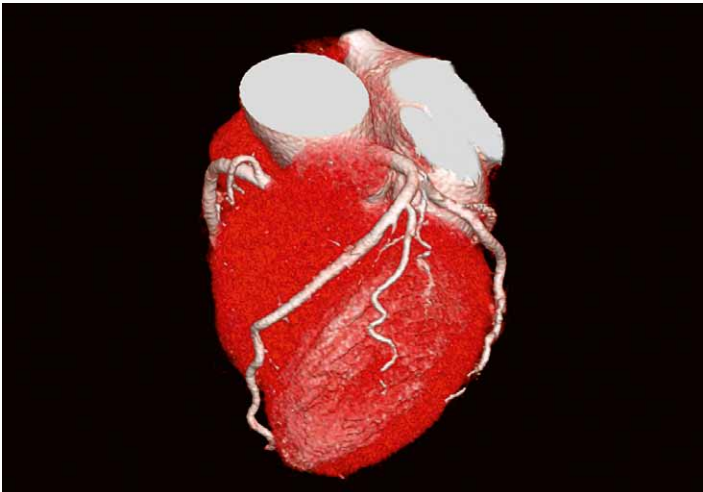


Figure 4a: 3D VR

with the Aquilion ONE ViSION Edition had a higher mean heart rate and an increased prevalence of arrhythmia as compared to standard populations typically studied with coronary CT angiography⁴.

Scan Parameters

On both scanners, coronary CT angiography was performed according to the recommended protocol. Following a breath exercise, ^{SURE}Cardio automatically determined the number of beats and exposure window; however the radiographer was allowed to modify these settings if desired. ^{SURE}Exposure was used to select the mA and kV according to the patient's size. AIDR 3D iterative reconstruction and phaseXact were applied to all reconstructions to ensure the best motion free images at the lowest dose. Selected scan parameters are shown in Table 2.

Single beat imaging

The improved temporal resolution on the ViSION Edition has important implications for the number of patients that can be imaged in a single heart beat. Whereas the previous generation scanner allowed single-heartbeat scanning with heart rates of up to approximately 65 bpm, with the ViSION Edition patients with heart rates up to 75 bpm can be imaged in a single heart beat. At this site, there was a statistically significant increase in the number of one beat scans performed on the ViSION Edition (78 % compared with 62 %), and a corresponding decrease in the number of 2 beat scans (Figure 1). As expected, the number of three and four beat scans did not change as the number of patients with arrhythmia was similar between the two groups; generally only patients experiencing arrhythmia during

the acquisition have more than 2 beats imaged. Overall 92.4 % of patients were imaged with either a one or two beat scan on the ViSION Edition compared to 80.8 % with the Aquilion ONE.

Dose reduction

A radiation dose of less than 1 mSv was achieved in significantly more patients, 33.2 % on the ViSION Edition compared with 13.6 % on the Aquilion ONE. On the other hand, a general reduction in the number of patients receiving over 2 mSv was seen as well (Figure 2). Patients with heart rates between 65 and 75 bpm benefit most from the increased gantry rotation speed on the ViSION Edition as they are now imaged with one beat rather than two beats. The improved temporal resolution has also allowed the exposure window to be narrowed to a single gantry rotation in patients with heart rates

Clinical Case History

This 68 year old woman with BMI 24.2 presented with a history of smoking, dyslipidemia and hypertension. The heart rate at the time of scan was 70 bpm. A one beat scan was performed with 100 kV. The DLP was 39.0 and the effective dose was 0.5 mSv ($k=0.014$). No significant coronary artery disease was demonstrated in this scan.



Figure 4b: LAD

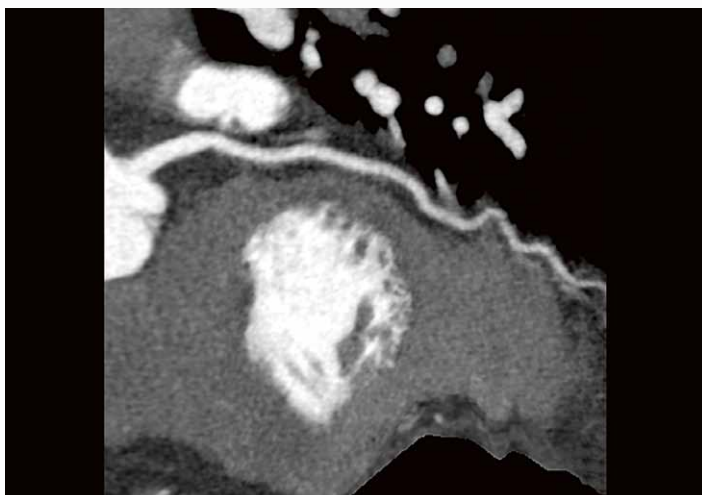


Figure 4c: LCx



Figure 4d: RCA

less than 55 bpm. Accordingly, the radiation dose has been further reduced for these patients too. The mean radiation dose decreased with the ViSION Edition (2.07 mSv compared to 2.71 mSv, $p=0.0047$). The overall reduction in dose between the Aquilion ONE and ViSION Edition was 23 %. When the patients with arrhythmia are excluded from the analysis, similar to the Tomizawa study⁵, the dose reduction was 32 %.

The ViSION Edition system is equipped with a 90 kW generator to provide sufficient exposure required for the 275 ms gantry rotation speed. The larger generator enables larger patients to be scanned at 100 kV. In this study 89.6 % of patients were imaged at 100 kV with an average patient BMI of 25 (Figure 3). Importantly, all these patients had diagnostic image quality (Figure 4).

Conclusion

Aquilion ONE has proved to be an exceptionally robust scanner for performing cardiac CT examinations on a wide range of patients with varying heart rates and rhythms. The ViSION Edition further extends this strength by allowing single beat coronary imaging in patients with heart rates up to 75 bpm. This study has shown that significant radiation dose reduction of 23 % can be achieved in a large patient population, echoing similar findings in the two published papers^{4,5}. Importantly, even in unselected populations, the majority of patients can now be scanned within a single heart beat, providing important advantages both for patients and imaging providers.

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