Received:
12 May 2018

Revised:
10 October 2018

Accepted:
07 November 2018

<https://doi.org/10.1259/bjr.20180429>

Cite this article as:

Liu T, Sun H, Zhang H, Duan J, Hu Y, Xie S. Distinguishing adrenal adenomas from non-adenomas with multidetector CT: evaluation of percentage washout values at a short time delay triphasic enhanced CT. *Br J Radiol* 2019; **91**: 20180429.

FULL PAPER

Distinguishing adrenal adenomas from non-adenomas with multidetector CT: evaluation of percentage washout values at a short time delay triphasic enhanced CT

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Objective: To retrospectively evaluate the diagnostic values of absolute percentage washout ratio (APW) and relative percentage washout ratio (RPW) obtained from a short time delay triphasic enhanced CT in distinguishing adenomas from non-adenomas.

Methods: The study population consisted of 116 patients (58 males and 58 females; mean age, 52 years; age range, 23–89 years) with 116 adrenal masses from 2010 to 2016. Absolute attenuation values in each phase of CT were measured, and then the APW and RPW were calculated. The APW and RPW receiver operating characteristic (ROC) analysis was performed to evaluate the strength of the tests. Sensitivity, specificity, and accuracy were calculated for APW and RPW.

Results: Significant differences were observed in APW and RPW values between the adenoma and non-adenoma groups ($p < 0.001$). Areas under the ROC curve

were 0.822 (95% confidence interval: 0.730, 0.914) and 0.913 (95% confidence interval: 0.851, 0.975) for the APW and RPW tests, respectively. The RPW ($\geq 30\%$) criterion showed the best accuracy (86%), with 85% sensitivity and 90% specificity, followed by the APW ($\geq 32\%$) criterion, with 81% accuracy, 85% sensitivity, and 69% specificity.

Conclusion: The APW and RPW values from a short time delay triphasic enhanced CT were efficient and helpful in differentiating adenomas from non-adenomas, and could provide comparable diagnostic results to the previous reported longer delayed dedicated adrenal CT protocols.

Advances in knowledge: The washout ratio from a short time delay triphasic enhanced CT could help in differentiating adenomas from non-adenomas without the dedicated adrenal CT.

INTRODUCTION

Many of the adrenal masses are discovered incidentally due to the increasing use of multidetector CT for different clinical problems, even in patients without endocrinological symptoms. Radiological studies reported the frequency of incidentalomas varies from 3 to 10% according to the age.^{1,2} Although most of these lesions are non-functioning benign adrenal adenomas, other lesions also exist including hormone-producing adenomas, pheochromocytomas, adrenal carcinomas or metastases.^{3,4} Hence, the differential diagnosis of adrenal lesions is still crucial. The detection of adrenal masses is troubling, particularly for patients with a history of malignant tumor. Assessment of adrenal masses requires an accurate diagnosis to determine appropriate therapeutic approach for the patient.

Dedicated adrenal CT can provide several quantitative CT parameters that contribute to the diagnosis of adrenal lesions, such as lesion size, unenhanced attenuation, level of enhancement at early phase and delayed phase, wash-in attenuation at early phase, percentage washout ratio at delayed phase, and histogram analysis. Various threshold values and the corresponding diagnostic efficiency of these parameters that assist in differentiating between adrenal adenomas and non-adenomas at unenhanced and delayed enhanced CT have been reported.^{5–10}

The purpose of this study is to evaluate the diagnostic values of absolute percentage washout ratio (APW) and relative percentage washout ratio (RPW) obtained from unenhanced and triphasic enhanced CT (200 s delay) in distinguishing adrenal adenomas from non-adenomas,

and to determine the best diagnostic method by using these parameters.

METHODS AND MATERIALS

Patients

This retrospective study had institutional review board approval; the need for informed consent was waived. Patients with adrenal masses confirmed by either pathological examination or at least 1 year of imaging follow-up at our institution from October 2010 to September 2016 were retrospectively reviewed. Of these, patients who had carried on an unenhanced CT and a short time delay triphasic enhanced CT were selected by using our picture archiving and communication system (Carestream Vue PACS, v. 11.0). A total of 116 patients were obtained in this study (58 males, 58 females), with a mean age of 52 years and the age range was 23–89 years. For males, the mean age was 54 years and the age range was 23–79 years; for females, the mean age was 51 years and the age range was 24–89 years. Six patients had bilateral adrenal lesions, but only one side had been pathologically confirmed and the other side did not undergo surgery or imaging follow-up. Therefore, a total of 116 adrenal masses had been confirmed in this study, consisting of 87 adenomas, 13 pheochromocytomas, and 16 metastatic lesions (lung cancer $n = 5$, colon cancer $n = 3$, lymphoma $n = 3$, breast cancer $n = 1$, hepatocellular carcinoma $n = 1$, cervical carcinoma $n = 1$, pancreatic carcinoma $n = 1$, esophageal carcinoma $n = 1$). Based on the criterion used in the previous report, these 87 adenomas were divided into the lipid-rich (≤ 10 Hounsfield unit (HU)) and lipid-poor (> 10 HU) groups.¹¹ Of the 116 adrenal masses, 56 and 60 arose from the right and left glands, respectively. The clinical data of individual adrenal adenoma, pheochromocytoma, and metastasis groups were shown in Table 1.

Standard of reference

A diagnosis of adenoma or pheochromocytoma was made if the mass was pathologically confirmed by surgery. A diagnosis of metastatic lesion was made if the mass was pathologically confirmed by surgery, or the mass had increased in size or a new lesion had developed during imaging follow-up at least 1 year for patients who had a present or prior history of malignant diseases.

CT protocols

Multidetector CT images were carried out with a 320-slice scanner (Aquilion One, Canon, Japan) or a 128-section scanner (Brilliance iCT, Philips Healthcare, the Netherlands). The helical CT parameters included 5 mm collimation, 5 mm reconstruction intervals, 120 kVp, 250 mA, 1:1 table pitch, rotation time of 0.5 s, and standard reconstruction algorithm. Unenhanced CT scans and enhanced CT scans in three phases of the upper abdomen were obtained by using the same imaging parameters. Dynamic scanning was performed 30 s (arterial phase), 60 s (portal phase), and 200 s (short time delayed phase) after the bolus administration of the i.v. contrast agent (1.5 ml kg^{-1} , iopromide 370, Bayer Schering Pharma AG, Germany) at a rate of 3 ml s^{-1} followed by 10 ml saline with a power injector.

Image and data analysis

The CT images of adrenal masses were reviewed by two experienced radiologists, who had more than 5 years' experience in diagnosis of abdominal diseases. The radiologists who were unaware of the clinical, pathological, and follow-up information interpreted the CT images in consensus on two separate occasions 4 weeks apart. Size of adrenal masses was recorded with the CT distance cursor to measure the largest diameter in the axial plane on the CT scan. For attenuation measurement of adrenal masses, a circular or elliptical region of interest (ROI) was placed centrally in the tumor area showing the strongest enhancement on the portal Phase CT images. The ROI was placed in the same area of the delayed phase and unenhanced CT images. The ROI covered at least one-half to two-thirds of the adrenal mass on the transverse image and did not cover the peripheral area of the lesion in order to avoid a partial volume average. Blood vessels, calcification, hemorrhage, and necrotic or cystic areas within the lesion were excluded from the ROI. The attenuation value of the ROI was measured three times and averaged. The APW and RPW were calculated by means of the following formulas¹²:

$$\text{APW} = (\text{attenuation value at portal Phase CT} - \text{attenuation value at delayed Phase CT}) \times 100\% / (\text{attenuation value at portal Phase CT} - \text{attenuation at unenhanced CT})$$

$$\text{RPW} = (\text{attenuation value at portal Phase CT} - \text{attenuation value at delayed Phase CT}) \times 100\% / \text{attenuation value at portal Phase CT}$$

Table 1. Clinical characteristics of 116 patients with different lesions in adrenal glands

Characteristic	Adenoma ($N = 87$)	Non-adenoma ($N = 29$)		Overall
		Pheochromocytoma ($N = 13$)	Metastasis ($N = 16$)	
Mean age (years)	51 ± 13 (23 ~ 79)	50 ± 15 (24 ~ 72)	61 ± 11 (43 ~ 89)	52 ± 13 (23 ~ 89)
Gender (female: male)	39:48	7:6	12:4	58:58
Location (right: left gland)	42:45	8:5	6:10	56:60
Diagnosis criterion				
Pathological results	87	13	6	106
Clinical findings + imaging follow-up	0	0	10	10

Table 2. Quantitative CT parameters of adrenal adenoma and non-adenoma groups

CT parameter	Adrenal adenoma (N = 87)			Non-adenoma (N = 29)			<i>p</i> ^a
	Lipid-rich (N = 53)	Lipid-poor (N = 34)	Total (N = 87)	Pheochromocytoma (N = 13)	Metastasis (N = 16)	Total (N = 29)	
Size (mm)	21.09 (14.42)	29.17 (14.30)	24.44 (13.98)	50.70 (22.41)	31.64 (41.64)	45.62 (32.83)	<0.001
Unenhanced attenuation (HU)	0 (14.5)	24.0 (17.3)	7.0 (22.0)	39.0 (10.5)	32.0 (12.3)	36.0 (10.0)	<0.001
APW (%)	45.0 (19.4)	49.1 (21.6)	47.0 (19.4)	41.8 (22.1)	12.6 (73.6)	23.5 (35.5)	<0.001
RPW (%)	46.2 (18.3)	34.6 (17.0)	40.8 (18.0)	23.3 (17.2)	3.5 (27.3)	10.6 (22.1)	<0.001

APW, absolute percentage washout ratio; HU, Hounsfield unit; RPW, relative percentage washout ratio.

Data are presented as median (interquartile range).

^aThe *p* value levels are for comparisons between total adrenal adenoma and total non-adenoma groups by using Mann-Whitney U test.

Statistical analysis

Data were analyzed by using statistical software (SPSS v. 11.0.1, Chicago, IL). The size, unenhanced attenuation, APW, and RPW values of adrenal adenomas, pheochromocytomas, and metastatic lesions were calculated and presented as median (interquartile range). The differences in the values of quantitative CT parameters including size, unenhanced attenuation, APW, and RPW between the three groups were examined by using the Kruskal-Wallis test, followed by the Mann-Whitney U test for comparison between the adenoma and non-adenoma groups. A value of $p < 0.05$ was considered statistically significant. The receiver operating characteristic (ROC) analysis of size, APW, and RPW were performed to evaluate the strength of the tests. The optimal threshold values of size, APW, and RPW,

determined by the maximum value of Youden's index (sensitivity + specificity – 1), were selected when a significant difference was present between the adenoma and non-adenoma groups. Then, the corresponding sensitivity, specificity and accuracy were calculated for size, APW, and RPW.

RESULTS

The data of quantitative CT parameters of adrenal adenoma and non-adenoma groups and the statistical results of multiple comparisons were shown in Table 2. The median (interquartile range) size of adenomas, pheochromocytomas, and metastatic lesions were 24.44 mm (13.98 mm), 50.70 mm (22.41 mm), and 31.64 mm (41.64 mm), respectively. The median (interquartile range) unenhanced attenuations of the three groups were 7.0 HU (22.0 HU), 39.0 HU (10.5 HU), and 32.0 HU (12.3 HU), respectively. The median (interquartile range) APW values of the three groups were 47.0% (19.4%), 41.8% (22.1%), and 12.6% (73.6%), respectively (Figure 1). The median (interquartile range) RPW values of the three groups were 40.8% (18.0%), 23.3% (17.2%), and 3.5% (27.3%), respectively (Figure 2). A significant difference was found between adenomas and pheochromocytomas as well as between adenomas and metastatic lesions in size ($p < 0.001$), unenhanced attenuation ($p < 0.001$), APW ($p < 0.001$), and RPW ($p < 0.001$) values (Figures 1 and 2). There was no significant difference between pheochromocytomas and metastatic lesion in terms of size ($p > 0.05$), unenhanced attenuation ($p > 0.05$), APW ($p > 0.05$), and RPW ($p > 0.05$) (Figures 1 and 2). Significant differences were observed in quantitative CT parameters including size, unenhanced attenuation, APW, and RPW values between the adenoma and non-adenoma groups ($p < 0.001$) (Figures 3 and 4).

Statistical results for CT parameters according to group comparisons were shown in Table 3. There were significant differences in all parameters between lipid-rich adenomas and non-adenomas, as well as between lipid-poor adenomas and non-adenomas. The APW and RPW values of lipid-poor adenoma group were significantly higher than that of non-adenoma group ($p < 0.001$) (Figures 5–8). Significant differences between the lipid-rich and lipid-poor adenoma groups were observed in size, unenhanced attenuation, and RPW parameters. For differentiation of the 87 adenomas from the 29 non-adenomas, the ROC and

Figure 1. The APW values of adenoma, pheochromocytoma, and metastasis groups at a short time delay triphasic enhanced CT are shown in a boxplot. The APW value of adenoma group is significantly higher than that of pheochromocytoma or metastasis group ($p < 0.05$ and $p < 0.001$, respectively). The APW values of pheochromocytoma and metastasis groups have no statistical differences. The transverse lines within the boxes indicate the median APW values. The APW values of adenoma group have two outliers indicated by the circle. APW, absolute percentage washout ratio.

Figure 2. The RPW values of adenoma, pheochromocytoma, and metastasis groups at a short time delay triphasic enhanced CT are shown in a boxplot. The RPW value of adenoma group is significantly higher than that of pheochromocytoma or metastasis group ($p < 0.001$). The RPW values of pheochromocytoma and metastasis groups have no statistical differences. The transverse lines within the boxes indicate the median RPW values. The RPW values of adenoma group have five outliers indicated by the circle. RPW, relative percentage washout ratio.

Figure 3. The APW values of adenoma and non-adenoma groups at a short time delay triphasic enhanced CT are shown in a boxplot. The APW value of adenoma group is significantly higher than that of non-adenoma group ($p < 0.001$). The transverse lines within the boxes indicate the median APW values. The APW values of adenoma group have two outliers indicated by the circle. The APW values of non-adenoma group have four outliers indicated by the circle or asterisk. APW, absolute percentage washout ratio.

best diagnostic values of individual quantitative CT parameters were shown in Table 4. Areas under the ROC curve were 0.835 (95% confidence interval: 0.744, 0.925), 0.822 (95% confidence interval: 0.730, 0.914), and 0.913 (95% confidence interval: 0.851,

Figure 4. The RPW values of adenoma and non-adenoma groups at a short time delay triphasic enhanced CT are shown in a boxplot. The RPW value of adenoma group is significantly higher than that of non-adenoma group ($p < 0.001$). The transverse lines within the boxes indicate the median RPW values. The RPW values of adenoma group have five outliers indicated by the circle. The RPW values of non-adenoma group have one outlier indicated by the circle. RPW, relative percentage washout ratio.

0.975) for the size, APW, and RPW tests (Figure 9), respectively, to detect adenomatous disease. For differentiation of adenomas from non-adenomas, the RPW criterion ($\geq 30\%$) showed the best accuracy (86%), with 85% sensitivity and 90% specificity, followed by the APW criterion ($\geq 32\%$), with 81% accuracy, 85% sensitivity, and 69% specificity. The sensitivity, specificity, and accuracy of the size criterion (≤ 37 mm) were 66%, 91%, and 72%, respectively.

For differentiation of 34 lipid-poor adenomas from 29 non-adenomas, the ROC and the best diagnostic values of individual quantitative CT parameters were shown in Table 5. Areas under the ROC curve were 0.785 (95% confidence interval: 0.667, 0.903), 0.839 (95% confidence interval: 0.740, 0.939), and 0.850 (95% confidence interval: 0.751, 0.949) for the size, APW, and RPW tests (Figure 10), respectively, to detect lipid-poor adenomas. For differentiation of lipid-poor adenomas from non-adenomas, the RPW criterion ($\geq 30\%$) showed the best accuracy (79%), with 71% sensitivity and 90% specificity, followed by the APW criterion ($\geq 33\%$), with 78% accuracy, 85% sensitivity, and 69% specificity. The sensitivity, specificity, and accuracy of the size criterion (≤ 39 mm) were 91%, 62%, and 78%, respectively.

DISCUSSION

The detection of adrenal lesions during CT examination has become common in recent years. The differential diagnosis between adenomas and non-adenomas with imaging techniques is particularly important for an adequate prognosis and appropriate therapy, thus to avoid invasive procedures such as biopsy or surgery, or unnecessary prolonged follow-up. In this retrospective study, we examined several quantitative CT parameters

Table 3. Statistical results for CT parameters according to group comparisons

CT parameter	Lipid-rich adenomas vs non-adenomas	Lipid-poor adenomas vs non-adenomas	Lipid-rich adenomas vs lipid-poor adenomas
Size (mm)	<0.001	<0.001	0.005
Unenhanced attenuation (HU)	<0.001	<0.001	<0.001
APW (%)	<0.001	<0.001	0.354
RPW (%)	<0.001	<0.001	<0.001

APW, absolute percentage washout ratio; HU, Hounsfield unit; RPW, relative percentage washout ratio. The *p* value levels are for group comparisons by using Mann-Whitney U test.

Figure 5. The APW values of lipid-poor adenoma and non-adenoma groups at a short time delay triphasic enhanced CT are shown in a boxplot. The APW value of lipid-poor adenoma group is significantly higher than that of non-adenoma group ($p < 0.001$). The transverse lines within the boxes indicate the median APW values. The APW values of lipid-poor adenoma group have one outlier indicated by the circle. The APW values of non-adenoma group have four outliers indicated by the circle or asterisk. APW, absolute percentage washout ratio.

Figure 6. The RPW values of lipid-poor adenoma and non-adenoma groups at a short time delay triphasic enhanced CT are shown in a boxplot. The RPW value of lipid-poor adenoma group is significantly higher than that of non-adenoma group ($p < 0.001$). The transverse lines within the boxes indicate the median RPW values. The RPW values of adenoma group have one outlier indicated by the circle. The RPW values of metastases have one outlier indicated by the circle. RPW, relative percentage washout ratio.

derived from the unenhanced and a short time delay triphasic enhanced CT for differentiation of adrenal adenomas from non-adenomas. We found that there were significant differences

Figure 7. A lipid-poor adenoma in a 43-year-old male. (a) Axial unenhanced CT image shows a well-defined 2.7 cm, right adrenal mass. The attenuation in the ROI is 41 HU. (b) Axial enhanced CT image (portal phase) shows that the attenuation in the same ROI is 105 HU. (c) Axial enhanced CT image (short time delayed phase) shows that the attenuation in the same ROI is 68 HU. The APW and RPW of this lesion are 57.8 and 35.2%, respectively. APW, absolute percentage washout ratio; HU, Hounsfield unit; ROI, region of interest; RPW, relative percentage washout ratio.

Figure 8. An adrenal metastasis in a 56-year-old male, who had a history of colon cancer. (a) Axial unenhanced CT image shows a well-defined 2.8 cm, left adrenal mass. The attenuation in the ROI is 14 HU. (b) Axial enhanced CT image (portal phase) shows that the attenuation in the same ROI is 21 HU. (c) Axial enhanced CT image (short time delayed phase) shows that the attenuation in the same ROI is 26 HU. The APW and RPW of this lesion are -71.4% and -23.8%, respectively. APW, absolute percentage washout ratio; HU, Hounsfield unit; ROI, region of interest; RPW, relative percentage washout ratio.

Table 4. ROC of quantitative CT parameters for diagnosis of adrenal adenomas

CT parameter	AUC	95% CI	Criterion	Sensitivity (%)	Specificity (%)	Accuracy (%)
Size (mm)	0.835	0.744 ~ 0.925	≤ 37	66	91	72
APW (%)	0.822	0.730 ~ 0.914	≥ 32	85	69	81
RPW (%)	0.913	0.851 ~ 0.975	≥ 30	85	90	86

APW, absolute percentage washout ratio; AUC, area under the curve; ROC, receiver operating characteristic; RPW, relative percentage washout ratio.

87 adrenal adenomas and 29 non-adenomas were evaluated. The criterion value was determined by the maximum value of Youden's index (sensitivity + specificity - 1).

between the adenoma and non-adenoma groups in tumor size, unenhanced attenuation, APW, and RPW values.

Previous studies revealed that there is considerable overlap for size as a criterion in distinguishing benign from malignant lesions, and should be combined with other criteria for diagnosis.^{13,14} Park et al reported that when the lesion size was 3 cm or larger, a substantial number of large adenomas were misdiagnosed as non-adenomas because CT sensitivity for adenoma markedly decreased.¹⁵ Choyke et al suggested that most small (less than 3 cm) incidentally discovered adrenal masses are benign in patients without a history of malignant disease.¹⁶ For the incidentalomas from 3 to 5 cm in size, other imaging methods or pathological examination should be considered. Lesions larger than 5 cm should be removed because of the

high risk of malignancy. For patients with histories of malignant disease, even smaller adrenal lesions are suspected for metastases. In our study, the size criterion (≤ 37 mm) for adenoma yielded a specificity of 91%, while the 66% sensitivity and 72% accuracy were not desirable as a diagnostic criterion, especially for adrenal metastases.

Adrenal adenomas demonstrate low attenuation on unenhanced CT images because the majority of adenomas contain intracellular lipid at the microscopical level, but generally do not contain massive mature adipocytes. In our study, the unenhanced attenuation of adenomas (median, 7.0 HU) was significantly lower than that of the non-adenomas (median, 36.0 HU). Many investigators use a threshold value of less than 10 HU to diagnose an adenoma, and obtain an optimal high specificity and sensitivity from this

Table 5. Receiver operator characteristic of quantitative CT parameters for diagnosis of adrenal lipid-poor adenomas

CT parameter	AUC	95% CI	Criterion	Sensitivity (%)	Specificity (%)	Accuracy (%)
Size (mm)	0.785	0.667 ~ 0.903	≤ 39	91	62	78
APW (%)	0.839	0.740 ~ 0.939	≥ 33	85	69	78
RPW (%)	0.850	0.751 ~ 0.949	≥ 30	71	90	79

APW, absolute percentage washout ratio; AUC, area under the curve; RPW, relative percentage washout ratio.

Note—34 adrenal lipid-poor adenomas and 29 non-adenomas were evaluated. The criterion value was determined by the maximum value of Youden's index (sensitivity + specificity - 1).

criterion, especially for lipid-rich adenomas.^{17,18} In addition, unenhanced CT attenuation of less than 10 HU excludes malignancy even in high-risk population.¹⁹ Kamiyama et al reported that a threshold of 10 HU yielded 100% accuracy for lipid-rich adenomas but 57% sensitivity for total adenomas because of the lipid-poor adenomas.⁶ Thus, unenhanced CT attenuation could not be used to sufficiently differentiate adenomas from non-adenomas, especially for lipid-poor adenomas. Therefore, we will not go into detail on the diagnostic value of unenhanced attenuation in this article.

The values of APW and RPW vary according to the timing of early and delayed scan. There is still controversy over the optimal scan delay to evaluate these parameters.^{5,6,20–22} Most of the previous studies about washout ratio for distinguishing adenomas from non-adenomas are based on a dedicated adrenal CT, which requires a relatively longer time delayed enhanced attenuation for calculating APW and RPW. The timing of delayed acquisitions ranges from 5 to 15 min after the start of the injection. Park et al reported that a washout rate of 15-min-delayed CT was most useful in the diagnosis of adrenal adenomas due to

the early inflow and outflow of contrast media in the tissues of adrenal adenomas, regardless of various CT machines and protocols.²¹ They evaluated the 15-min-washout rate with a threshold of 55%, and results showed a sensitivity of 93.9%, and a specificity of 95.8%. Angelelli et al revealed that the washout values in CT scans performed at 5 min, 10 min, and 15 min provided comparable diagnostic results.²² CT scans performed at 5 min were to be preferred, since they reduced the examination time and patient discomfort.

In this study, we used a short time (200 s) delayed triphasic enhanced CT to calculate the washout ratio. For multiple comparisons of the three groups, the APW and RPW of adenomas were significantly higher than that of the pheochromocytomas or metastatic lesions, but no difference was observed between pheochromocytomas and metastatic lesions. The APW and RPW were significantly lower in non-adenomas than in adenomas. The APW criterion ($\geq 32\%$) for adenoma yielded 85% sensitivity, which was the same as that of RPW at the criterion of 30%. However, the 69% specificity and 81% accuracy of APW were lower than the 90% specificity and 86% accuracy of RPW.

Figure 9. The inner line demonstrates ROC curve for APW values (area under the curve = 0.822; 95% confidence interval: 0.730, 0.914) for detecting adrenal adenomas. The outer line demonstrates ROC curve for RPW values (area under the curve = 0.913; 95% confidence interval: 0.851, 0.975) for detecting adrenal adenomas. APW, absolute percentage washout ratio; ROC, receiver operating characteristic; RPW, relative percentage washout ratio.

Figure 10. The inner line demonstrates ROC curve for APW values (area under the curve = 0.839; 95% confidence interval: 0.740, 0.939) for detecting adrenal lipid-poor adenomas. The outer line demonstrates ROC curve for RPW values (area under the curve = 0.850; 95% confidence interval: 0.751, 0.949) for detecting adrenal lipid-poor adenomas. APW, absolute percentage washout ratio; ROC, receiver operating characteristic; RPW, relative percentage washout ratio.

In previous studies, the accuracy of RPW was higher than that of APW, which was similar to our study.^{6,20} Meanwhile, RPW is especially useful when the unenhanced attenuation of an adrenal lesion is not existent. Therefore, RPW may be the most useful quantitative CT parameter to differentiate adrenal adenomas from non-adenomas.

There was no significant difference in APW between lipid-rich (median, 45.0%) and lipid-poor (median, 49.1%) adenomas in our study. The APW criterion ($\geq 33\%$) for lipid-poor adenomas yielded 85% sensitivity, 69% specificity, and 78% accuracy. For lipid-poor adenomas, the diagnostic efficiency of the APW was very close to that of total adenomas (85% sensitivity, 69% specificity, and 81% accuracy). The RPW value of lipid-rich adenoma (median, 46.2%) was significantly higher than that of the lipid-poor adenomas (median, 34.6%), which was similar to the previous study.⁶ The RPW criterion ($\geq 30\%$) for lipid-poor adenomas yielded 71% sensitivity and 79% accuracy, which was lower than that of total adenomas (85% sensitivity and 86%

accuracy). Meanwhile, the specificity of RPW for lipid-poor adenomas was 90%, just the same as that of total adenomas. Hence, RPW for lipid-poor adenomas could still meet the requirement for diagnosis.

Our research still has limitations, such as the relatively smaller number of non-adenomas than that of adenomas. Most cases of adenomas carried out both unenhanced and enhanced CT scans, because they were discovered incidentally or because they had hormonal function. Patients with a history of malignant disease do not follow this adrenal CT protocol, since imaging follow-up is often taken with unenhanced CT.

CONCLUSION

Our study showed that the APW and RPW values from a short time delay triphasic enhanced CT were efficient and helpful in differentiating adenomas from non-adenomas, and could provide comparable diagnostic results to the previous reported longer delayed dedicated adrenal CT protocols.

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