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Adrenal venous sampling (AVS): Success of catheterization and concordance of imaging lateralization with AVS lateralization

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Abstract

Aim: Primary hyperaldosteronism (PA) is an important cause of secondary hypertension. One of the most crucial steps in the management of patients with PA is the determination of the laterality of aldosterone production (unilateral or bilateral disease). This study aimed to determine the success rate of adrenal venous sampling (AVS) and the concordance between imaging and AVS laterality.

Materials and Methods: The procedural, radiological, and laboratory data of the patients who underwent AVS were evaluated retrospectively. The Selectivity Index (SI) and Lateralization Index (LI) were used for catheterization success and laterality determination, respectively. The Contralateral Suppression Index (CSI) was used for laterality determination in cases of unilaterally failed AVS. Abdominal CT scans were evaluated for adrenal nodules and hyperplasia.

Results: This study included 36 patients for catheterization success and 28 patients for laterality evaluation. The mean age was 56.08±9.01 years. The overall success rate was 88.9% (32 of 36 patients). The bilateral and unilateral successful catheterization rates were 52.8% and 36.2%, respectively. Unilateral disease was present in 15 (53.6%) patients based on AVS, right-sided in 9 (32.1%), and left-sided in 6 (21.4%) patients. Unilateral disease was present in 18 (64.3%) patients based on imaging, right-sided in 11 (39.3%), and left-sided in 7 (25%) patients. The proportion of agreement between imaging and AVS lateralization was 50% (14 of 28 patients).

Conclusion: The overall success rate of AVS was high when unilateral success was included. In half of the patients with PA in this study, CT showed discordant disease laterality compared to AVS.

Introduction

Primary hyperaldosteronism (PA) is an important cause of secondary hypertension and its prevalence in hypertensive patients in referral centers can be up to 29.8% [1]. One of the important steps in the management of PA is subtyping it (unilateral or bilateral disease). Unilateral disease may benefit from surgical resection, and bilateral disease is mostly treated with medication (mineralocorticoid receptor antagonist). Adrenal venous sampling (AVS) is the recommended method to determine the laterality of aldosterone production [2]. Although there are concerns about the usefulness of AVS in determining the laterality of aldosterone secretion over CT scans in patients with PA [3], multiple publications did not recommend the use of CT scan findings alone in patients older than 35 years to determine the laterality of aldosterone production and surgical decision [4-7]. However, AVS has its drawbacks. AVS can be technically challenging [8], and the interpretation of the results of AVS may vary between centers. Cross-sectional imaging (CT/MRI) and nuclide molecular imaging are other methods used to subtype PA. Radionuclide imaging drawbacks are its inability to detect lesions smaller than 1 cm in diameter [9] and relatively low availability. CT/MRI identified nodules were not always the source of the aldosterone production [10] and subtyping based on CT/MRI findings did not always correlate with subtyping based on AVS. This study aimed to evaluate the success rate of catheterization of adrenal veins and concordance of imaging lateralization with AVS lateralization in a single tertiary care center.

Materials and Methods

Institutional review board approval was obtained before conducting this retrospective study (Research number: GO 23/478 and Decision number: 2023/10-15). This study

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was conducted in patients with PA who underwent AVS without ACTH stimulation in a single center between June 2014 and January 2023. All of the procedures were performed in the morning (between 8 a.m. and 10.30 a.m.) and written informed consents were obtained from all patients before the procedures. The procedures were performed via three operators with 5, 10, and 18 years of experience. Adrenal vein catheterizations were performed in a sequential manner. Peripheral blood was drawn from the femoral vascular sheath simultaneously with each adrenal vein sampling.

All consecutive patients who underwent AVS during the study period and met the inclusion criteria were included in this study. Patients with unilateral or bilateral successful AVS based on cortisol values and without missing aldosterone values were included in the laterality evaluation. Bilateral unsuccessful AVS procedures were excluded from laterality evaluation. For the evaluation of the success of catheterization, patients with missing aldosterone values were also included in the evaluation, if they had cortisol values. Patients with missing both aldosterone and cortisol values and angiographic data were excluded from the study.

The procedural, radiological, and laboratory data of the patients were evaluated retrospectively. The success of catheterization was determined based on the Selectivity Index (SI) for each adrenal vein, calculated by the following formula: cortisol adrenal vein/cortisol peripheral. The SI $\geq$2 was considered successful catheterization [11]. In cases where the SI was between 1.5 and 2, the classical angiographic appearance of the adrenal vein (Figures 1 and 2) was sought in addition to the SI for successful catheterization [12, 13]. The SI $<$1.5 was considered a failure regardless of angiographic appearance.

For subtyping (unilateral or bilateral disease) the lateralization index (LI) was used in bilateral successful AVS. LI was calculated as the aldosterone/cortisol ratio between the two adrenal veins (AV). LI $\geq$4 was set as a cut-off for unilateral disease [14]. In cases with LI between 2 and 4, the contralateral suppression index (CSI) (aldosterone/cortisol non-dominant adrenal: aldosterone/cortisol peripheral) was calculated and CSI$<$1 was sought for unilateral disease [15]. CSI is also used to determine the laterality of aldosterone production in unilaterally failed AVS procedures [16, 17]. Cases with a CSI index $\geq$ 5.5 were considered ipsilateral unilateral disease and cases with CSI index $\leq$ 0.5 were considered contralateral unilateral disease [16, 17]. In summary, for the determination of the laterality of aldosterone production, LI $\pm$ CSI was used in patients with bilateral successful catheterization, and CSI was used in patients with unilateral successful catheterization.

Abdominal CT scans were evaluated for adrenal pathology by interventional radiologists during the AVS procedures, which were later reviewed from procedure reports. The longest single diameter was measured for the size measurement of adrenal gland nodules.

Statistical analysis

SPSS 23.0 (IBM Corp, Armonk, NY, USA) was used for statistical analysis. The normality of the quantitative data was analyzed with the use of the Shapiro-Wilk test. Categorical data were presented as percentages and continuous data were presented as mean $\pm$ Standard Deviation (SD). The means of two independent variables were compared with the independent samples t-test. A p-value of less than 0.05 was considered statistical significance.

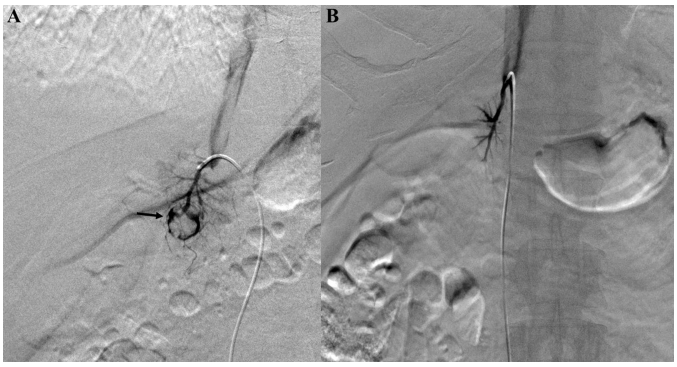

Figure 1. A-B) Classical angiographic appearance of right adrenal veins: a gland-like pattern with a main central trunk and multiple side branches. The arrow in A indicates the adrenal nodule.

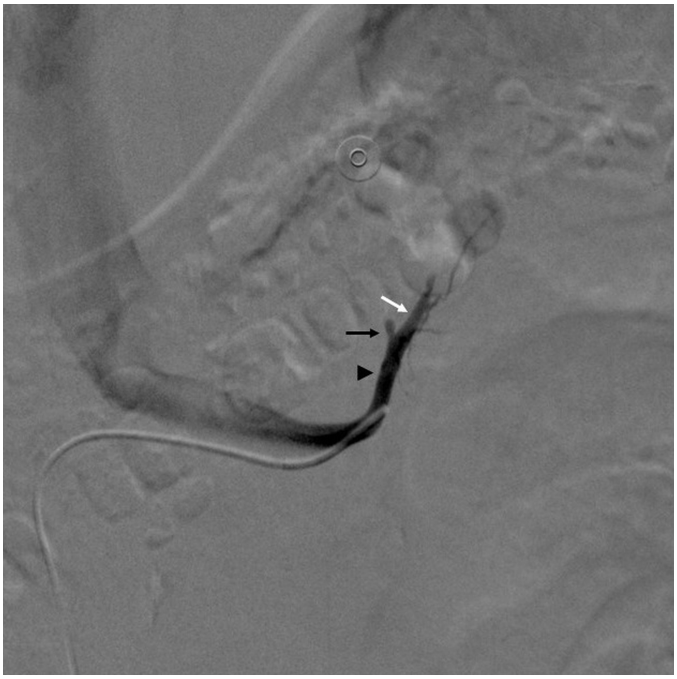

Figure 2. Angiographic appearance of the left adrenal vein (white arrow) merging with the inferior phrenic vein (black arrow) to form a common trunk (arrowhead) that drains into the left renal vein

Results

In this study period, 43 patients underwent AVS for PA. Seven patients were excluded from the study because of the lack of laboratory and/or angiographic data. In total, 36 patients were included in the evaluation of the success of catheterization. Four patients were only excluded from the evaluation of the laterality of aldosterone secretion because of the lack of aldosterone values. Of the 32 patients

for whom all laboratory and angiographic data were available for laterality evaluation, 28 were included in laterality assessment, while the remaining 4 patients were excluded due to bilateral unsuccessful catheterization.

Success of catheterization

Thirty-six patients (22 (61.1%) males, and 14 (38.9%) females) were included in the analysis of catheterization success. The mean age was 56.08±9.01 years. The overall success rate was 88.9% (32 of 36 patients). There was no statistically significant difference between operators in terms of success rate. Table 1 shows the number of successful catheterizations based on the criteria used for successful catheterization. The bilateral successful catheterization rate was 52.8% (19 of 36 patients). The unilateral successful catheterization rate was 36.2% (13 of 36 patients, 11 left side and 2 right side). In 5 (13.9%) patients, a second AVS procedure was performed to achieve bilateral successful catheterization.

Laterality of aldosterone production

Twenty-eight patients (18 (64.3%) males, and 10 (35.7%) females) were included in the laterality analysis. The mean age was 56.39±8.39 years. Unilateral disease was present in 15 (53.6%) patients based on AVS results, right-sided in 9 (32.1%), and left-sided in 6 (21.4%) patients. Table 2 shows the CT findings of patients who were included in the laterality assessment. The sizes of the adrenal nodules ranged from 0.7 to 3.4 cm. The mean age of the patients with nodular hyperplasia was significantly higher than patients with adrenal nodules (the mean ages were 61.86±8.12 and 54.57±8.37, respectively, p=0.045). The proportion of agreement between imaging and AVS lateralization was 50% (14 of 28 patients) (Table 3).

Table 1. Number of successful catheterizations based on criteria used.

Criteria used for successful catheterization	Left Side[a]	Right Side[b]
SI $\geq$ 2	26 (86.7%)	16 (76.2%)
SI between 1.5 and 2 plus the classical angiographic appearance of the adrenal vein	4 (13.3%)	5 (23.8%)

[a]: in a total of 30 left-side successful catheterization, [b]: in a total of 21 right-side successful catheterization, SI: Selectivity Index

Table 2. CT findings of patients included in the laterality assessment.

Findings	Number of the patients (%)
Nodule	
Right	11 (39.3)
Left	7 (25)
Bilateral	3 (10.7)
Bilateral nodular hyperplasia	7 (25)

Table 3. The proportion of agreement of imaging lateralization with AVS lateralization (%).

		Imaging Lateralization			
		Right	Left	Bilateral	Total
AVS Lateralization	Right	6* (66.7)	1 (11.1)	2 (22.2)	9
	Left	.	3* (50)	3 (50)	6
	Bilateral	5 (38.5)	3 (23.1)	5* (38.5)	13
	Total	11	7	10	28

*: Agreement, AVS: Adrenal venous sampling. There was no statistical significance agreement between the two methods according to the Kappa statistics (Kappa value: 0.23, p-value: 0.077).

Discussion

In this study, the overall success rate was 88.9% (32 of 36 patients). The bilateral and unilateral successful catheterization rates were 52.8% and 36.2%, respectively. The proportion of agreement of cross-sectional imaging lateralization with AVS lateralization was 50%. In a Spanish multicenter study, the proportion of agreement between cross-sectional imaging and AVS lateralization was 54.4% [18], which was consistent with our results. These findings suggest that imaging lateralization was inaccurate compared to AVS in nearly half of the patients who underwent AVS. Magill, et al. reported that CT imaging was either inaccurate or provided no additional information in 68% of the patients with PA, compared with AVS [19]. Campbell, et al. concluded that discordance about lateralization between cross-sectional imaging and AVS was high and that many patients avoided a potentially non-curative operation due to AVS [4].

Although AVS is considered the gold standard method for subtyping PA, AVS can be a technically challenging procedure. In this study, successful catheterization rates of the left and right adrenal veins were 83.3% and 58.3%, respectively. Although all left adrenal veins were angiographically documented during the AVS procedures in this study, a 100% success rate was not achieved according to SI. This may be because when sampling the common trunk of the left adrenal and inferior phrenic vein, the blood of the left adrenal vein could be diluted with blood from the inferior phrenic vein, superselective catheterization of the left adrenal vein with a microcatheter may solve this problem [20]. What makes AVS technically challenging is mostly the right adrenal vein because of its small size and anatomical variations [21]. The rate of successful catheterization for the right adrenal vein was 58.3%, and it was below the left adrenal vein. To improve the rate of successful right adrenal vein catheterization, intra-procedural CT imaging techniques or rapid cortisol assays can be used [22]. Additionally, performing a second AVS procedure may be considered when the first attempt fails. The second AVS procedure is usually successful when the first attempt fails [23].

The limitations of this study were retrospective data collection and the exclusion of some patients because of a lack of data. These factors made the study open to selection bias. In conclusion, the overall successful catheterization rate was 88.9%. In this study, the proportion of agreement of AVS lateralization with imaging lateralization was 50%, meaning that imaging can show inconsistent findings with AVS in subtyping PA.

Ethical approval

This retrospective study was approved by the Health Sciences Research Ethics Committee of Hacettepe University (Research number: GO 23/478 and Decision number: 2023/10-15).

References

1. Käyser SC, Dekkers T, Groenewoud HJ, et al. Study Heterogeneity and Estimation of Prevalence of Primary Aldosteronism: A Systematic Review and Meta-Regression Analysis. J Clin Endocrinol Metab. 2016;101(7):2826-35.
2. Funder JW, Carey RM, Mantero F, et al. The Management of Primary Aldosteronism: Case Detection, Diagnosis, and Treatment: An Endocrine Society Clinical Practice Guideline. J Clin Endocrinol Metab. 2016;101(5):1889-916.
3. Dekkers T, Prejbisz A, Kool LJS, et al. Adrenal vein sampling versus CT scan to determine treatment in primary aldosteronism: an outcome-based randomised diagnostic trial. Lancet Diabetes Endocrinol. 2016;4(9):739-46.
4. Campbell RA, Young DS, Shaver CN, et al. Influence of Adrenal Venous Sampling on Management in Patients with Primary Aldosteronism Independent of Lateralization on Cross-Sectional Imaging. J Am Coll Surg. 2019;229(1):116-24.
5. Kempers MJ, Lenders JW, van Outheusden L, et al. Systematic review: diagnostic procedures to differentiate unilateral from bilateral adrenal abnormality in primary aldosteronism. Ann Intern Med. 2009;151(5):329-37.
6. Lim V, Guo Q, Grant CS, et al. Accuracy of adrenal imaging and adrenal venous sampling in predicting surgical cure of primary aldosteronism. J Clin Endocrinol Metab. 2014;99(8):2712-9.
7. Ladurner R, Sommerey S, Buechner S, et al. Accuracy of adrenal imaging and adrenal venous sampling in diagnosing unilateral primary aldosteronism. Eur J Clin Invest. 2017;47(5):372-7.
8. Kumasaka S, Tokue H, Tsushima Y. Difficulty factors of adrenal venous sampling based on patient characteristics and imaging findings. Acta Radiol. 2022;63(9):1276-82.
9. Ren X, Cheng G, Wang Z. Advances in the molecular imaging of primary aldosteronism. Ann Nucl Med. 2023;37(8):433-41.
10. Nanba AT, Nanba K, Byrd JB, et al. Discordance between imaging and immunohistochemistry in unilateral primary aldosteronism. Clin Endocrinol (Oxf). 2017;87(6):665-72.
11. Rossi GP, Auchus RJ, Brown M, et al. An expert consensus statement on use of adrenal vein sampling for the subtyping of primary aldosteronism. Hypertension. 2014;63(1):151-60.
12. Rossi GP, Pitter G, Bernante P, et al. Adrenal vein sampling for primary aldosteronism: the assessment of selectivity and lateralization of aldosterone excess baseline and after adrenocorticotropic hormone (ACTH) stimulation. J Hypertens. 2008;26(5):989-97.
13. Rossi GP, Sacchetto A, Chiesura-Corona M, et al. Identification of the etiology of primary aldosteronism with adrenal vein sampling in patients with equivocal computed tomography and magnetic resonance findings: results in 104 consecutive cases. J Clin Endocrinol Metab. 2001;86(3):1083-90.
14. Bardet S, Chamontin B, Douillard C, et al. SFE/SFHTA/AFCE consensus on primary aldosteronism, part 4: Subtype diagnosis. Ann Endocrinol (Paris). 2016;77(3):208-13.
15. Williams TA, Lenders JWM, Mulatero P, et al. Outcomes after adrenalectomy for unilateral primary aldosteronism: an international consensus on outcome measures and analysis of remission rates in an international cohort. Lancet Diabetes Endocrinol. 2017;5(9):689-99.
16. Strajina V, Al-Hilli Z, Andrews JC, et al. Primary aldosteronism: making sense of partial data sets from failed adrenal venous sampling-suppression of adrenal aldosterone production can be used in clinical decision making. Surgery. 2018;163(4):801-6.
17. Pasternak JD, Epelboym I, Seiser N, et al. Diagnostic utility of data from adrenal venous sampling for primary aldosteronism despite failed cannulation of the right adrenal vein. Surgery. 2016;159(1):267-73.
18. Araujo-Castro M, Paja Fano M, González Boillos M, et al. Adrenal venous sampling in primary aldosteronism: Experience of a Spanish multicentric study (Results from the SPAIN-ALDO Register). Endocrine. 2022;78(2):363-72.
19. Magill SB, Raff H, Shaker JL, et al. Comparison of adrenal vein sampling and computed tomography in the differentiation of primary aldosteronism. J Clin Endocrinol Metab. 2001;86(3):1066-71.
20. Noda Y, Goshima S, Nagata S, et al. Utility of microcatheter in adrenal venous sampling for primary aldosteronism. Br J Radiol. 2020;93(1109):20190636.
21. Omura K, Ota H, Takahashi Y, et al. Anatomical Variations of the Right Adrenal Vein: Concordance Between Multidetector Computed Tomography and Catheter Venography. Hypertension. 2017;69(3):428-34.
22. Wolley M, Thuzar M, Stowasser M. Controversies and advances in adrenal venous sampling in the diagnostic workup of primary aldosteronism. Best Pract Res Clin Endocrinol Metab. 2020;34(3):101400.
23. Kline GA, Leung AA, Sam D, et al. Repeat Adrenal Vein Sampling in Aldosteronism: Reproducibility and Interpretation of Persistently Discordant Results. J Clin Endocrinol Metab. 2021;106(3):e1170-e8.