Case Report

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Anatomical Variations Encountered during Adrenal Venous Sampling: A Report of Three Case Series and Review of Literature

부신정맥채혈술 중 발견된 해부학적 변이들: 3건의 증례 보고 및 문헌 고찰

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Primary aldosteronism is a group of disorders in which the autonomous secretion of aldosterone is associated with hypertension and hypokalemia. It is crucial to determine the laterality of aldosterone hypersecretion because treatment options differ accordingly. Adrenal venous sampling (AVS) is considered the most reliable method for assessing the laterality of primary aldosteronism. This procedure is often technically challenging because of the small size and varied locations of the adrenal veins. A better understanding of anatomical variations and careful review of imaging studies would improve sampling success. This report presents three cases of anatomical variations encountered during AVS.

Index terms Adrenal Glands; Hyperaldosteronism; Blood Specimen Collection; Catheterization; Cone-Beam Computed Tomography

INTRODUCTION

Primary aldosteronism is a group of disorders in which autonomous secretion of aldosterone is associated with hypertension and hypokalemia (1). Primary aldosteronism has two subtypes. The first type is unilateral primary aldosteronism, which is mostly caused by aldosterone-producing adenomas. The second type is bilateral pri-

mary aldosteronism, which is mostly idiopathic hyperaldosteronism. It is important to determine the laterality of aldosterone hypersecretion when planning treatment for primary aldosteronism (2). Adrenal venous sampling (AVS) plays an important role, and is recommended for subtype classification of primary aldosteronism. However, AVS is a technically complicated procedure with success rates ranging between 31%–98% (1). An understanding of venous anatomy is important for the technical success of AVS. Anatomical variations are an important cause of technical failure during AVS.

In this report, we describe three cases of successful AVS in patients with anatomical variations of the adrenal vein. In the first case, the left adrenal vein drained directly into the left inferior vena cava (IVC). In another case, the right adrenal gland drained into the IVC via the two central veins. In the third case, the right adrenal vein formed a common trunk with the accessory hepatic vein.

CASE REPORT

CASE 1

A 35-year-old female with a two-year medical history of hypertension was admitted for evaluation of an incidentally detected left adrenal mass. The absolute adrenal washout value was 74%, which was consistent with that of an adrenal adenoma (Fig. 1). Sodium administration did not suppress serum aldosterone levels. AVS was performed without cosyntropin stimulation. The right adrenal vein was located along the right posterior wall of the IVC. A 5-Fr catheter was unable to cannulate the right adrenal vein because of its small diameter. A coaxial 2.7-Fr microcatheter (Progreat; Terumo, Tokyo, Japan) was used, and cone-beam CT confirmed the correct position. Subsequently, left adrenal vein catheterization was performed. The left adrenal vein drained directly into the preaortic trunk of the IVC due to an anatomical variation known as the left IVC. The selectivity index of the right adrenal vein was 28.1, and that of the left adrenal vein was 32.9. The lateralization index was 11.6 with predominance of the left adrenal gland. In our institution, the cut-off value for the selectivity index is 2.0 without stimulation, and 3.0 with stimulation. The cut-off value for the lateralization index was 2.0 without stimulation and 4.0 with stimulation. The patient underwent left adrenalectomy. Pathological examination confirmed an adrenocortical adenoma.

CASE 2

A 66-year-old male with a four-year history of hypertension was admitted for evaluation of an incidentally detected left adrenal mass. The absolute washout adrenal value was 88%, which was consistent with that of an adrenal adenoma (Fig. 2). Sodium administration did not suppress serum aldosterone levels. The intravenous infusion of cosyntropin was initiated 30 min before AVS. The right adrenal vein was catheterized using a 5-Fr catheter. However, the level of the cannulated right adrenal vein was slightly lower than expected on CT. Further exploration of the upper level of the IVC led to the discovery of another right adrenal vein. Venous sampling from the left adrenal vein was done through the left renal vein. The selectivity indices for the right upper and lower adrenal veins were 22.3 and 18.8, respectively. The selectivity index for the left adrenal vein was 7.8. The lateralization index was 2.10 for the up-

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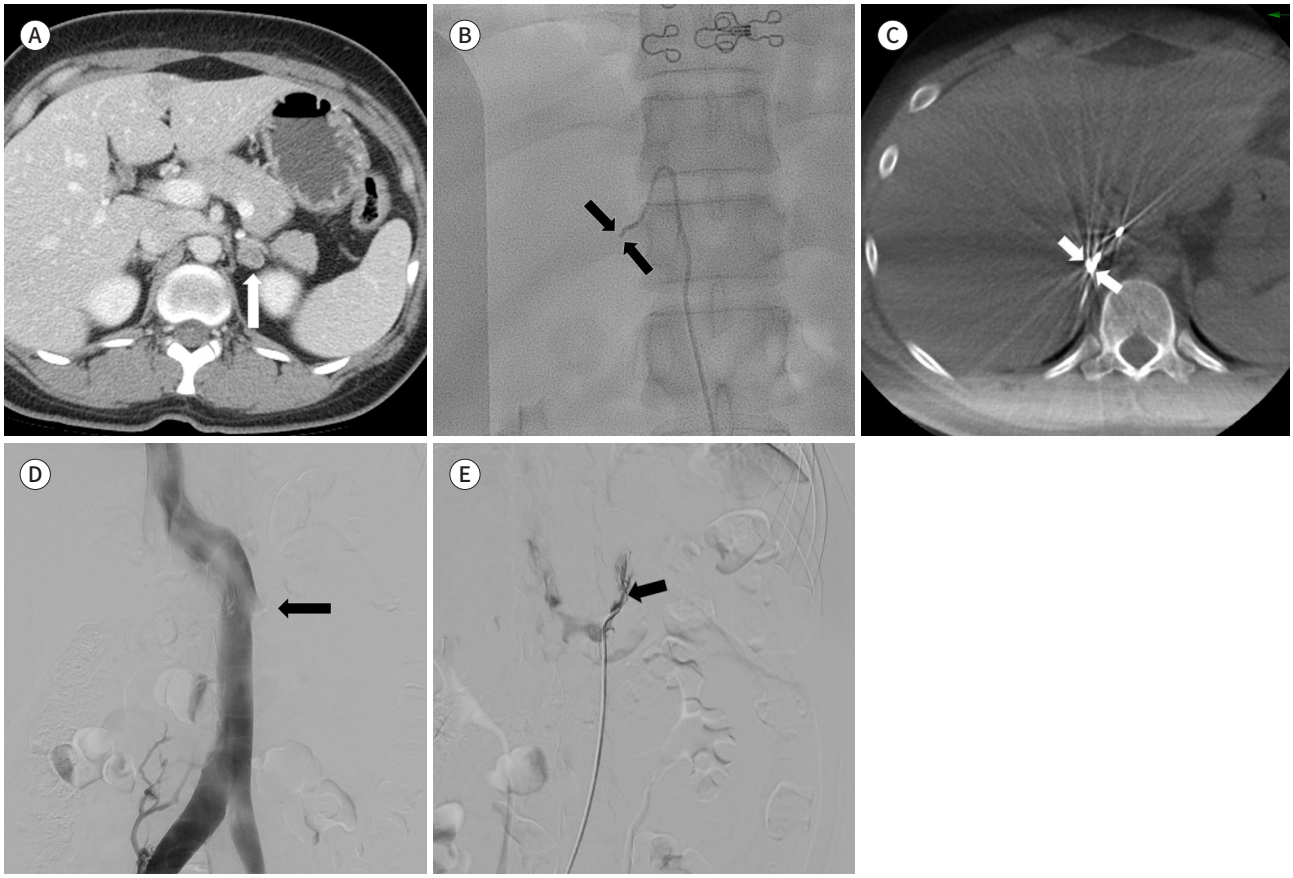
Fig. 1. Case 1. Left adrenal adenoma in a 35-year-old female patient.
A. A well-defined left adrenal mass (arrow) with heterogeneous enhancement on CT.
B, C. A microcatheter (black arrows) advancing into the right adrenal vein. Cone-beam CT confirms the correct position of the microcatheter (white arrows).
D. Inferior vena cavogram shows the left-sided infrarenal segment crossing the spine to join the normal prehepatic segment. Inflow defects from the left renal vein (arrow) are also noted.
E. Fluoroscopic image shows the left adrenal vein (arrow) draining directly into the preaortic trunk of the inferior vena cava.

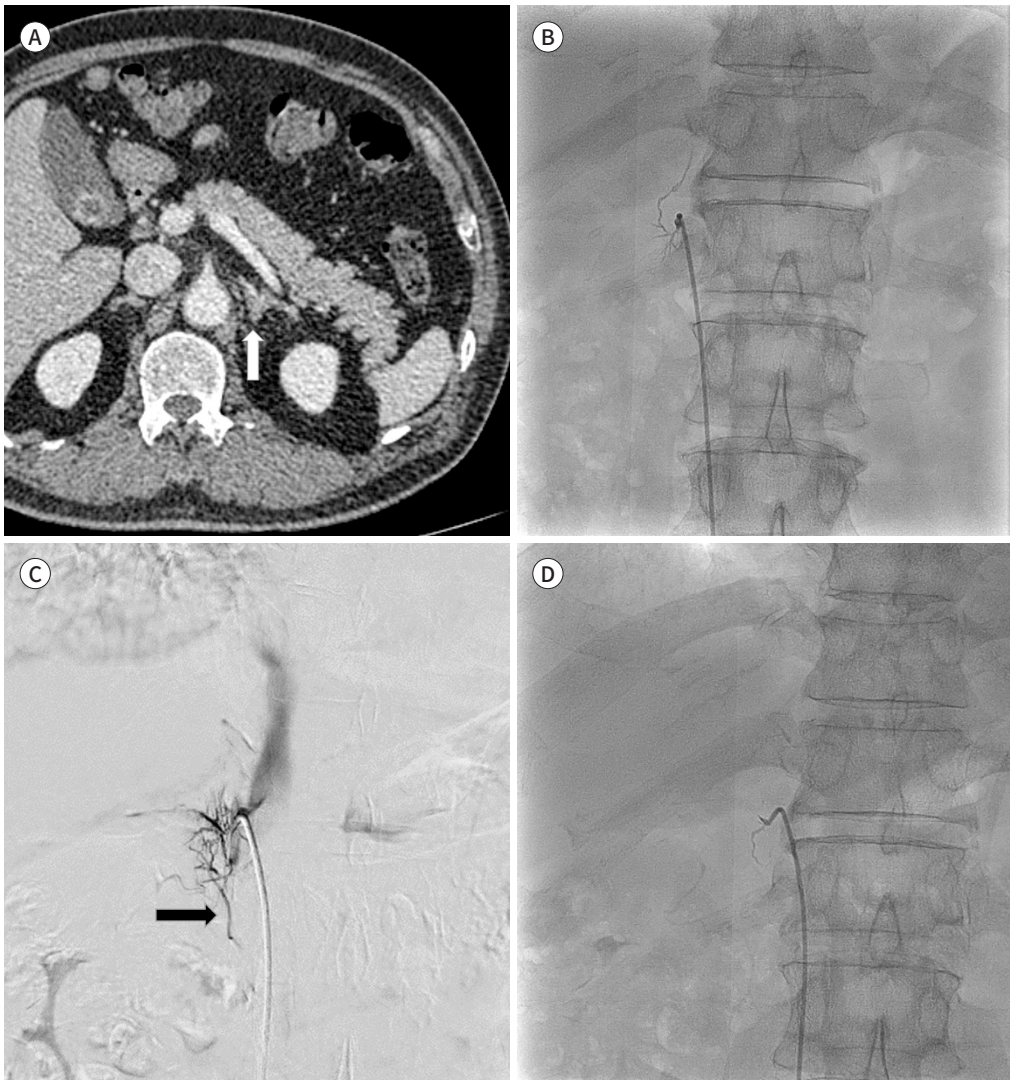


per right adrenal vein, and 1.88 for the lower right adrenal vein with predominance of the right adrenal gland. The patient was prescribed antihypertensive medications.

CASE 3

A 28-year-old female with a two-year medical history of hypertension and on medication was admitted for evaluation of secondary hypertension. Suppression of serum aldosterone level was borderline. Contrast-enhanced adrenal CT showed no evidence of a mass in either adrenal gland. An anatomical variation of the right adrenal vein was noted. It formed the common trunk with the right accessory hepatic vein (Fig. 3). An AVS was performed without cosyntropin stimulation. The right accessory hepatic vein was catheterized based on the CT findings. Hepatic venography using a 5-Fr catheter revealed right adrenal vein opacification. A coaxial 2.7-Fr microcatheter was advanced into the right central vein, and a blood sample was obtained. Venous sampling from the left adrenal vein was performed through the left renal vein. The selectivity index of the right adrenal vein was 83.9, and that of the left adrenal

Fig. 2. Case 2. Left adrenal incidentaloma in a 66-year-old male patient.
A. The left adrenal gland shows a nodular thickening (arrow) of a medial limb on CT.
B. Fluoroscopic image shows glandlike pattern of injection into the right adrenal vein (the level of superior border of T12 body).
C, D. Another right adrenal vein is located at the level of the inferior border of the T11 body. A communication channel (arrow) between the two adrenal veins is also noted.



vein was 84.6. The lateralization index was 1.02 with predominance of the right adrenal gland. The patient was prescribed antihypertensive medications.

This study was approved by the Institutional Review Board of our institution (IRB No. 2023-01-041), and the requirement for informed consent was waived.

DISCUSSION

The venous drainage of the adrenal glands typically involves a single central vein that drains each adrenal gland. The left adrenal vein usually follows a caudal or downward path into the superior margin of the left renal vein. It forms a common trunk with the inferior

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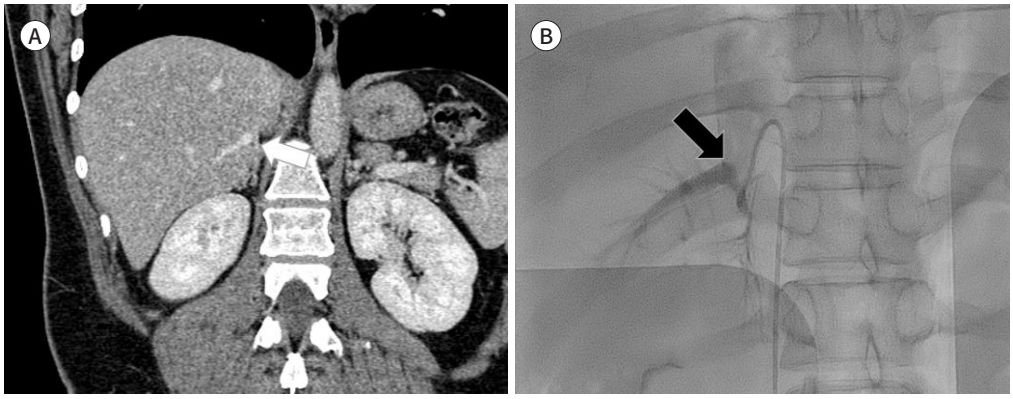
Fig. 3. Case 3. Twenty-eight-year-old female patient with a two-year medical history of hypertension.
A. Contrast-enhanced adrenal CT shows the right adrenal vein (arrow) merging with an accessory right hepatic vein.
B. Venogram of right adrenal vein shows spidery pattern, and the right adrenal vein forms a common trunk with an accessory hepatic vein (arrow).



phrenic vein before entering the left renal vein. The course of the left adrenal vein is extremely constant, and catheterization of the left adrenal vein is technically feasible. Cannulating the right adrenal vein is technically more challenging than the left adrenal vein because the vein is small and short, and it drains directly into the posterior wall of the IVC. The orifice is typically located between the T10 and L1 vertebrae (3).

Mapping of the right adrenal vein using CT is helpful for successful AVS, and appropriate image acquisition timing is essential. Timing of the arterial phase is too early for visualizing the right adrenal vein, whereas the portal phase is too late (4). Optimal visualization of the right adrenal vein is possible between the arterial and portal phases, known as the late arterial or adrenal venous phase (13 s after the completion of the first scan or with a fixed delay of 45–55 s). According to previous studies, the right adrenal vein can be visualized in the late arterial phase in 95% of patients with primary aldosteronism (3). Thin-slice (1 mm slice thickness) axial and multiplanar images can provide better anatomical detection.

In this report, we described three cases of successful AVS in patients with anatomical variations of the adrenal vein. An incidence rate of left IVC of up to 3% was observed in approximately 0.04%–0.5% of a population (5). The IVC can show multiple anatomical variations, such as double and left IVC (2). Anatomical variations of the adrenal vein can also be accompanied by IVC variations. According to previous reports, right adrenal vein constantly drains directly into the IVC. However, in patients with double or left IVC, the left adrenal vein may drain directly into the preaortic trunk of the IVC (2, 6). To our knowledge, there have been only a few reports on AVS in patients with left IVC (2). The location of the left adrenal vein in our patient was similar to that of a previously reported case.

In recent years, cone-beam CT has emerged as an important tool for AVS. This method is especially useful when confirmation of the proper selection of the adrenal vein is difficult. In this study, cone-beam CT was used to determine the location of the catheter tip without contrast injection. Meyrignac et al. (7) reported that cone-beam CT angiography allows for better evaluation of the selectivity of adrenal vein catheterization and increases the success rate of AVS. Cone-beam CT angiography during AVS is not associated with significant complications

or additional radiation exposure in previous studies (7, 8). Optimization of the scan parameters is crucial for significant dose reduction when acquiring cone-beam CT images.

Several anatomical variations of the right adrenal vein, such as duplication and triplication, have been previously reported (9). In a previous study, 14 of 432 patients (3.2%) were diagnosed with duplicate right adrenal vein during AVS (1). In 12 of 14 patients, apparent communication between the two adrenal veins was observed on venography. Based on the drainage area, the two adrenal veins are classified as main or accessory veins. When performing AVS in patients with duplicate right adrenal vein, additional sampling of the accessory right adrenal vein may be desirable (1). The results from each right adrenal vein can be contradictory, greatly influencing treatment decision-making (e.g., change from surgery to medication).

The common trunk of the accessory hepatic and right adrenal veins is the most common anatomical variation of the right adrenal vein, with a prevalence 8%–24% (10). In patients with a common trunk of an accessory hepatic vein and right adrenal vein, the study results may be compromised by blood dilution resulting from the accessory venous flow. Superselective catheterization of the right adrenal vein is recommended to determine the lateralization of aldosterone production (10). The orifice of the accessory hepatic vein may be located near the right adrenal vein without forming a common trunk (3). In these patients, there is a potential risk that the nearby accessory hepatic vein may be mistaken as the right adrenal vein.

In conclusion, three cases of anatomical variations encountered during AVS were presented. A better understanding of anatomical variations and careful review of imaging studies would improve the success of AVS.

Author Contributions

Conceptualization, all authors; supervision, all authors; writing—original draft, P.J.; and writing—review & editing, all authors.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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부신정맥채혈술 중 발견된 해부학적 변이들: 3건의 증례 보고 및 문헌 고찰

박주영[1] · 이형남[1]* · 김명섭[2] · 박혜림[1]

원발성 알도스테론증은 자율신경계에 의한 알도스테론 분비조절의 장애로 고혈압 및 저칼륨혈증과 관련이 있다. 원발성 알도스테론증에서 편측성을 결정하는 것이 매우 중요한 이유는 그에 따라 치료 방법이 달라지기 때문이다. 부신정맥채혈술은 원발성 알도스테론증에서 편측성을 평가하는 가장 신뢰성 있는 방법으로 알려져 있다. 부신정맥채혈술은 부신 정맥이 크기가 매우 작으며 그 해부학적 위치가 다양하기 때문에 기술적으로 어려운 시술이다. 따라서 성공적인 시술을 위해서는 해부학적 변이를 잘 이해하고 시술 전 영상 검사를 면밀히 검토하는 것이 중요하다. 부신정맥채혈술 중에 발견된 세 가지 해부학적 변이를 보고하고자 한다.

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