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Clinical Usage of Ultrasonography in Vascular access

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Introduction
In ESRD patients who continue hemodialysis treatment, vascular access is so precious that it can be called a lifeline, and maintaining a necessary dialysis dose by securing an appropriate blood flow for a long period of time is very important in maintaining a good prognosis and quality of life for patients. The ideal vascular access is to maintain an appropriate blood flow rate (600-800 mL/min) during hemodialysis to increase the efficiency of dialysis within a fixed time, and to minimize complications related to vascular access such as stenosis, obstruction, thrombosis, infection, aneurysm, and hemorrhage. Doppler is very useful when performing vascular mapping in patients with a high risk of vascular access failure or when evaluating vascular access that is clinically problematic. Doppler ultrasound has the advantage of being able to measure the blood flow of the vascular access and at the same time morphologically observe the presence or absence of stenosis, find the stenosis area, and measure the diameter of the area to determine the degree of stenosis. Because of the coverage of the health insurance in Korea, the condition of the vascular access can be simply evaluated at an economical inspection cost.
In this lecture, using Doppler ultrasound, 1) mapping of dialysis vessels and 2) methods of evaluating the condition of AVF and AVG are covered.

Main text
1. Mapping of the vascular access
Patients with stage 4 CKD who are scheduled for renal replacement therapy with hemodialysis should establish vascular access. The reason for performing ultrasound before surgery is to select an appropriate location that is convenient for needling, has a high success rate of surgery, and can be used for a long time. The arteries that should be checked in the upper limb are the brachial artery, radial artery, and ulnar artery, and the status of the cephalic vein needs to be evaluated. The median antecubital vein near the crease that diverges from the cephalic vein is also commonly used in AVG. In addition, if the cephalic vein is not suitable in the vascular access composition, the condition of the basilic vein or brachial vein should be checked. The principle of a blood vessel that can be used as a dialysis access is as follows. 1) The upper limb is better than the lower limb. 2) Consider the non-dominant arm first. 3) The arterial blood flow should be good and arteriosclerosis should be low. 4) The minimum diameter of arteries and veins required for arteriovenous fistula surgery is not clear, but the growth potential and quality of blood vessels under 2 mm need to be evaluated. 4) The needling site must be located within 6mm depth. 5) Even if the size of the vein is less than 2mm, it can be selected if the expandability is good when using a tourniquet. Also, in the case of AVG, when using tourniquet, it should be about 3mm to make it easier to connect the graft. 6) Check for respiratory variations to confirm central venous stenosis.
2. Evaluation of established vascular access
Evaluation of low blood flow during dialysis, difficulty in puncture, difficulty in hemostasis, excessive blood flow, vascular pain, increase in venous pressure, aneurysm and pseudoaneurysm, evaluation of thrombosis in aneurysm, seroma, stenosis, bleeding, infection, thrombosis, obstruction are possible through Doppler ultrasound.
1) Assessment of AVF
AVF of the upper extremity includes radio-cephalic, brachio-cephalic, and transposed basilic AVF. We can observe brachial artery flow, resistive index, wall condition, depth, diameter, diameter of surgical anastomsis, hematoma, fibrosis, edema, calcification, aneurysm, stenosis, collateral vein, and

thrombosis through Doppler.
2) Evaluation of AVG
AVG of the upper limb is composed of a looped or curved configuration in the forearm or upper arm. There are brachio-antecubital, brachio-basilic, and brachio-axillary AVG. In addition to the items observed in AVF, AVG-vein anastomosis, AVG-artery anastomosis, pseudoanurysm, seroma, graft and skin depth were observed.
3. Things to note when performing Doppler ultrasound
1) Enough jelly should be applied so that the blood vessels are not compressed by the probe.
2) Scan in the order of inflow – anastomosis – conduit – outflow. The appropriate blood flow rate of the brachial artery is 500-600 ml/min for AVF and 600-800 ml/min for AVG.
3) Region of interest is placed in the center of the screen whenever possible.
4) In B mode scan, depth, focus, gain, and dynamic range are adjusted to obtain an image in which the vessel wall and other structures are clearly distinguished.
5) In B mode scan, the diameter of the blood vessel is measured in the transverse plane (short axis view).
6) Blood flow is measured in laminar flow whenever possible.
7) The angle of the ultrasonic beam; The blood vessel wall is scanned perpendicularly, and that of color Doppler or pulsed wave Doppler is oblique (less than 60 degrees).
8) In pulsed Doppler flow, the brachial artery should be monophasic and an RI less than 0.6 is good.
9) Significant stenosis is a stenosis rate of 50% or more in the diameter of short axis view with clinical indicators.
10) A thrombus appears as a finding in which high-density is observed in the lumen in the B mode scan and is not pressed even when pressed by the probe, and no color signal is detected in the area with a thrombus in the color Doppler scan.

Conclusion
Doppler ultrasound is very useful for the establishment and management of vascular access and evaluation of complications. It is a strategy that can maximize the efficiency of dialysis at a fixed time by maintaining proper blood flow in hemodialysis patients, reducing patient discomfort and improving quality of life. Therefore, the ability of nephrologists to learn and perform Doppler ultrasound directly on patients is required.