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Original Article

Comparative analysis between DSA and color Doppler ultrasound in measurement of kidney and inferior vena cava diameter in adults

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Abstract: Objective: Digital subtraction angiography (DSA) and color Doppler ultrasound of the kidney were utilized to quantitatively measure the diameter of the inferior vena cava and pinpoint the location of the renal vein, aiming to offer evidence and guidance for the selection and placement of inferior vena cava filter. Methods: In total, 325 patients undergoing the placement of inferior vena cava filters between December 2012 and December 2015 were recruited in this study. All participants were diagnosed with deep venous thrombosis of the lower extremity. Among them, 127 cases were male and 198 were female, aged 55.4 years on average. The placement of all filters was evaluated according to the ACCP-8 standards. Prior to the filter placement, the inferior vena cava was assessed by color Doppler ultrasound and DSA. The diameter of the infrarenal inferior vena cava was quantitatively measured by color Doppler ultrasound and DSA equipped with software. The morphology of the position of the renal venous opening of the inferior vena cava was observed. The types of filters were selected based on the above results. Results: The appropriate filter was chosen based on color Doppler ultrasound and DSA findings. All filters were released in the proper position. No renal vein occlusion occurred. The diameter of infrarenal inferior vena cava was measured as 19 ± 5 mm on average by DSA, and 18.4 ± 4 mm detected by color Doppler ultrasound. The diameter of the inferior vena cava was less than 28 mm. Conclusion: No significant difference was observed in terms of the diameter of infrarenal inferior vena cava measured between DSA and color Doppler ultrasound. It provides another option for patients who are ineligible to undergo inferior vena cava angiography under DSA. Furthermore, color Doppler ultrasound plays a pivotal role in determining the precise location of vena cava filter release.

Keywords: Inferior vena cava, vena cava filter, digital subtraction angiography, color Doppler ultrasound

Introduction

Deep venous thrombosis (DVT), also known as deep vein thrombosis, is a common peripheral vascular disease, which results from venous insufficiency. If complicated with pulmonary embolism, it poses severe threats to the affected patients. The placement of the vena cava filter (VCF) is a simple and effective approach to prevent the incidence of fatal pulmonary embolism. According to recent statistics, the incidence rate of pulmonary embolism in Europe and the United States is calculated as approximately 0.5‰, and the mortality rate is alarmingly high up to 25% to 30% if left untreated. Approximately 90% of pulmonary embolism originates from the DVT of the lower extremity. However, the incidence rate of DVT in patients with pulmonary embolism has declined from 30%-60% to 3%-5% after the placement of VCF [1, 2]. At present, the angiography of the inferior vena cava is regarded as the gold standard for guiding the position of deep vein filter placement and the measurement of the diameter of renal inferior vena cava, which are of clinical significance and necessity.

Along with the gradual understanding of DVT, the attendance rate of the affected patients has been significantly enhanced. Color Doppler ultrasound provides an alternative approach for patients who are unable to undergo inferior vena cava angiography due to varying reasons. Therefore, it is of great necessity to deliver preoperative color Doppler ultrasound to measure the diameter and pinpoint the posi-

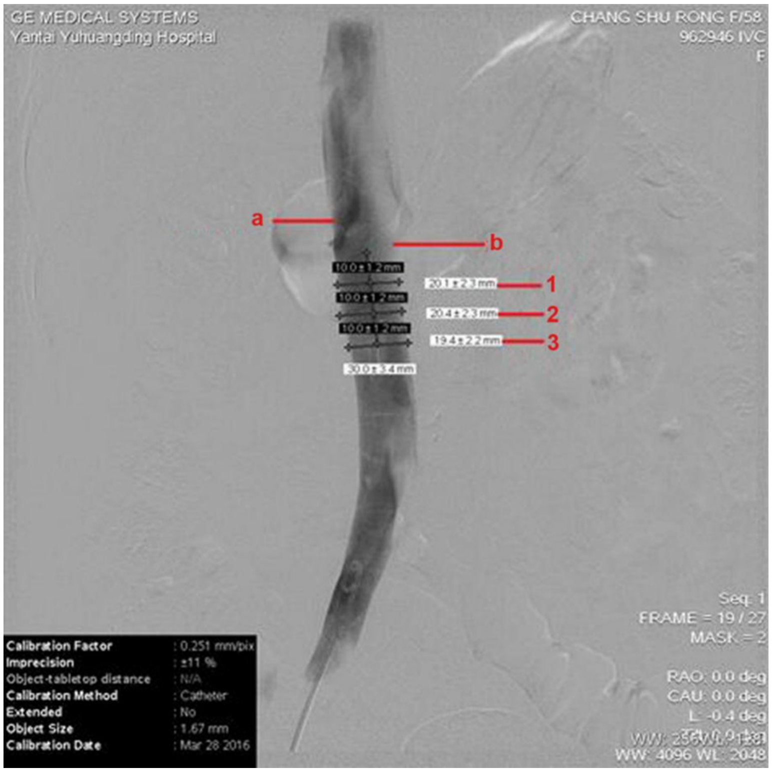

Figure 1. Filter placement before angiography: (a) right renal vein; (b) left renal vein; (1, 2 and 3) three inferior vena cava diameters measured below the renal veins at 1, 2 and 3 cm, respectively.

Figure 2. DSA filter placement after angiography: (a) right renal vein, (b) left renal vein, and (c) vena cava filter.

tion of the inferior vena cava. At the same time, the accurate positioning of the intraoperative renal vein is of clinical significance.

In this investigation, color Doppler ultrasound and digital subtraction angiography (DSA) were adopted to quantitatively measure the diameter and pinpoint the position of renal inferior vena cava in 325 patients diagnosed with DVT of the lower extremity. Relevant clinical experience was summarized as follows.

Materials and methods

Baseline data

A total of 325 patients diagnosed with DVT who underwent the placement of the inferior VCF between December 2012 and December 2015 were recruited in this clinical trial. Among these patients, 127 cases were male and 198 were female, aged 55.4 years on average. Among them, 241 cases were diagnosed with thrombus in the left lower extremity, 74 cases with thrombus in the right lower extremity and 10 with thrombus in bilateral lower extremities. The filters were placed with strict reference to the 8th edition of the American College of Chest Physicians Evidence-Based Medicine Clinical Practice Guidelines (ACCP-8), in which Braun vena tech filters were adopted in 232 cases and Codis Trapease filters were used in the remaining 93 patients.

Preoperative preparation

Preoperatively, patients were placed in the horizontal supine position. After the pa-

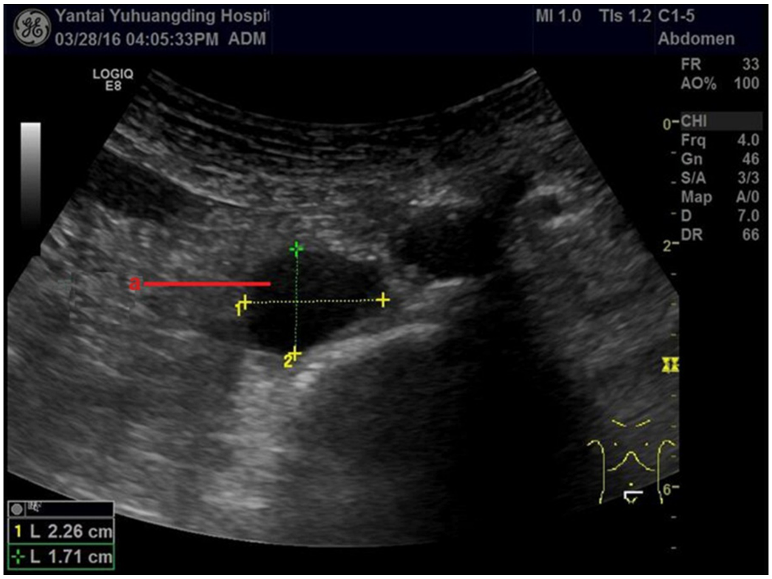

Figure 3. Color Doppler ultrasound of the (a) inferior vena cava: (1) Inferior vena cava transverse diameter; (2) Anteroposterior diameter of the inferior vena cava.

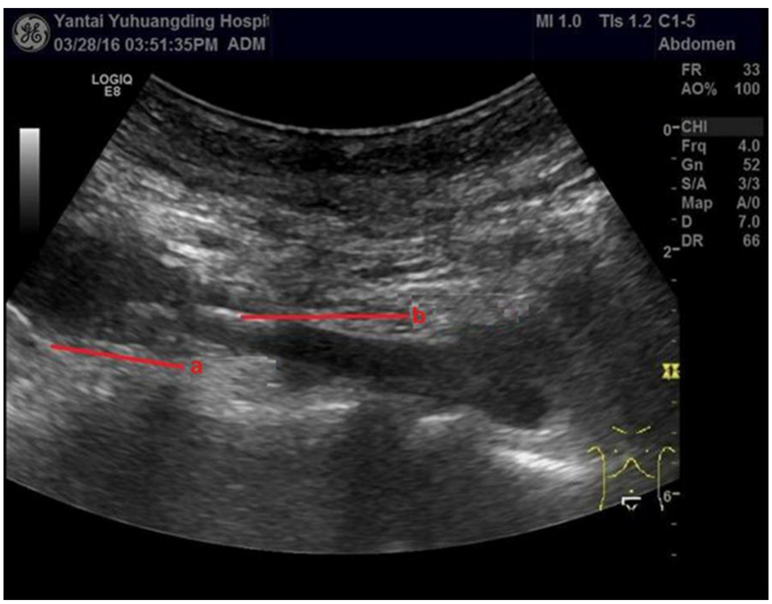

Figure 4. Color Doppler ultrasound: (a) left renal vein opening; (b) vena cava filter.

tients were successfully prepared, the towels were draped for local anesthesia. A puncture was placed using a 5F pigtail catheter. During the angiography, patients were asked to hold their breath when the Valsalva maneuver was performed. The contrast range was ranged from the contralateral iliac vein to the renal vein area. The software equipped in the DSA was adopted to quantitatively determine the position of the lower margin of the renal vein. The diameter of the inferior vena cava was measured as 1, 2 and 3 cm and averaged (**Figure 1**). In addition, the inferior vena cava thrombosis, the location of the renal venous opening, and the position of the bilateral internal iliac vein junction were pinpointed and validated. The renal vein was located at approximately 0.5-1.0 cm below the disposition of the placed filters. Postoperative DSA of the renal vein was repeatedly performed to determine its anatomical relationship with the filters (**Figure 2**).

Imaging procedures

The patients were placed in the supine position to expose the abdomen and groin. For color Doppler ultrasound of the inferior vena cava during the Valsalva maneuver and equipped software, the inferior vena cava diameter at the lower side of the lower edge of the renal vein was measured as 1, 2 and 3 cm and the average value was calculated, as illustrated in **Figure 3**. According to the location of the left renal vein, the vena cava filter was accurately released (**Figure 4**). To determine whether the blood vessels were not complicated with deformity, variability and thrombosis, the entrance levels of bilateral renal veins were quantitatively determined and an *in vitro* mark was established. When the filters were cast, all operations must be monitored by color Doppler ultrasound to determine whether the renal veins sank below the entrance level of approximately 1 cm of where the filter was placed.

Statistical analysis

SPSS 19.0 statistical software was used for data analysis (SPSS Inc., Chicago, IL, U.S.).

Table 1. Comparison of the renal inferior vena cava diameter and length between two genders

Gender	Diameter by DSA (mm)	Diameter by ultrasound (mm)	*P* value
Male	19.0 ± 5.4	18.4 ± 2.5	0.776
Female	18.0 ± 4.6	18.0 ± 2.8	0.158

Measurement data were expressed as mean ± standard deviation (SD). Gender, as well as renal inferior vena cava diameter and length were statistically compared using independent sample *t*-test. $P < 0.05$ was considered as statistically significant.

Results

VCF placement

Imaging examination revealed that the filter positions were properly placed with no filter tilt or displacement. No alternative adverse events were observed in a majority of cases. Slight filter tilt and insufficient opening of the inferior vena cava were noted in 7 patients, which were probably correlated with the small diameter of the inferior vena cava.

Diameter of the inferior vena cava

With the use of DSA and equipped software, the mean diameter of the inferior vena cava was quantitatively measured as (19 ± 5) mm. By employing the color Doppler ultrasound, the average diameter of the infrarenal inferior vena cava was (18.4 ± 4) mm. During quiet breathing, the cross-sectional inferior vena cava was seen in the oval shape during Valsalva maneuver, probably due to the congestion that resulted in a nearly circular cross-section and reduced the measurement error. No significant difference was observed in terms of the diameter of the renal inferior vena cava between men and women (t=0.294, P=0.776; t=1.613, P=0.158, **Table 1**).

Discussion

In this study, color Doppler ultrasound and DSA were adopted to quantitatively measure the diameter of the renal inferior vena cava in patients with DVT, iodide ion allergies, severe renal impairment or even a particular pregnant woman, which provides a novel option for the filter release. In addition, it is necessary to determine the inferior vena cava diameter and accurately release the filter through accurate measurement.

By color Doppler ultrasound, the success rate of measuring the inferior vena cava diameter is estimated between 90-98.5% [2, 3]. We utilized the special material of the guide wire catheter for the entire process of the filter placement. Consequently, the success rate of color Doppler ultrasound in the measurement of the diameter of the inferior vena cava filter was even higher compared with that of DSA. At present, the release of vena cava filters is essentially imported in China. These products are designed and manufactured based on the physiological characteristics of Caucasian race. In accordance with the European and American standards, the diameter of renal inferior vena cava > 28 mm is considered an enormous inferior vena cava [4]. In the present study, no patient presented with a diameter of renal inferior vena cava > 28 mm. Prince *et al*. [5] quantitatively measured the diameter of the inferior vena cava after filter placement in 65 patients, ranging from 13 to 30 mm, 20 ± 3 mm on average, which probably resulted from the ethnic difference. Two methods are mainly adopted to measure the diameter of the inferior vena cava. In this study, the diameter of the renal inferior vena cava measured in Chinese patients was shorter compared with that of the Caucasian counterparts. However, the inferior vena cava diameters of these patients did not exceed the current diameter range required for the filter placement. For patients with the right heart failure may have a significant expansion of the inferior vena cava. Consequently, special attention should be given during the filter placement. The diameter of the inferior vena cava < 10 mm is not recommended in patients with vena cava filter placement because an exceedingly small inferior vena cava filter is likely to lead to opening insufficiency, postoperative blood clots, *etc*. [6].

Vena cava filter placement by color Doppler ultrasound has the following advantages. First, it yields high femoral vein puncture success rate. By color Doppler ultrasound, femoral vein puncture can be directly viewed, which not only improves the success rate of the puncture, but also reduces the risk of complications. Second, it achieves wide range of applications. The vena cava filter placement by color Doppler ultrasound does not require contrast agents. It is especially suitable for patients with iodine allergy and severe renal insufficiency, improving their chances of surgical treatment. Third, both physicians and patients can avoid X-ray irradiation. Long-term X-ray irradiation can cause a certain degree of body damage. Furthermore, it may cause permanent damage especially during pregnancy or female patients who are having children. However, excessive accumulation of intestinal gas in the abdomen of patients can cause interference during observation and measurement.

To better guide the precise placement of the filters and allow more patients to benefit from vena cava filter placement, we included more patients in current investigation on the basis of previous studies. Color Doppler ultrasound and DSA adopted to quantitatively measure the diameter of infrarenal inferior vena cava. No statistical significance was observed in the diameter of the inferior vena cava measured by color Doppler ultrasound or DSA. In addition, precise filter placement provides vital reference as reflected by different methods of adult patients with renal inferior vena cava in the Shandong peninsula. Besides color Doppler ultrasound-guided vena cava filter placement, DSA is an appropriate supplement to monitor the filter placement.

Disclosure of conflict of interest

None.

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