New method for ultrasound-guided inferior vena cava filter placement

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ABSTRACT

Objective: Transabdominal ultrasound (TAUS)-guided inferior vena cava filter (IVCF) placement currently uses an inferior vena cava (IVC) longitudinal plane with cross-section of the right renal artery or the transverse plane of the right renal vein (RRV)-IVC intersection. The goal of this study was to introduce a new method for TAUS-guided IVCF placement.

Methods: The study enrolled patients who were at high risk for or had pulmonary embolism from October 22, 2010, to June 30, 2016. The probe was positioned on the right flank to centralize the RRV-IVC junction during imaging and to permit a straight line through the midpoint of the probe on the surface and a parallel line 1.0 cm below the straight line as a marker. The probe was subsequently placed on the abdominal wall with the upper edge at the marker line to show the long axis of the IVC during the process of filter placement. The upper edge of the probe was considered the filter tip position.

Results: A total of 1029 patients were evaluated, and 98 patients (9.5%) were excluded because of poor IVC visualization (n = 14 [1.4%]), IVC or bilateral iliac vein thrombosis (n = 79 [7.7%]), and unsuitable anatomy (n = 5 [0.5%]). The remaining 931 patients (90.5%) were selected for TAUS-guided IVCF placement, and all filters (100%) were successfully placed. There were no procedure-related complications. Suprarenal IVCF was observed in 4 patients (0.4%) by computed tomography, and the filter tip exceeded the upper edge of L2 in 15 patients (1.6%) by plain film radiography; one of them had two RRVs. Severe filter tilting (20.8 degrees) occurred in one patient.

Conclusions: This new method of TAUS-guided IVCF placement was simple, safe, and effective. It may be widely applied for the bedside placement of vena cava filters. (J Vasc Surg: Venous and Lym Dis 2018;■:1-7.)

Key words: Ultrasonography; Inferior vena cava filter; Deep venous thrombosis; Pulmonary embolism

Several techniques for filter placement have been described during the past decades and are still evolving. The purpose of this study was to find a safer, more convenient, less traumatic, and more economical method. Traditionally, percutaneous filter placement is performed either in an interventional unit or in the operating room under fluoroscopic guidance, necessitating mobilization of the patients. However, for critically ill or multitrauma patients, this procedure can be inconvenient and dangerous.[1,2] Other imaging modalities have been used to guide filter placement, such as transabdominal ultrasound (TAUS) and intravascular ultrasound (IVUS).[3-13]

Placement of inferior vena cava filters (IVCFs) using TAUS or IVUS has been shown to be safe, effective, and reliable.[3-13] Both technologies eliminate the risks associated with mobilizing critically ill patients, and radiation exposure and contrast dye are avoided; both are suitable for pregnant women, patients with renal insufficiency, and patients who are allergic to contrast material. The placement of IVUS-guided filters has been shown to be safe and accurate[9-12]; however, this procedure requires specialized equipment and staff, and it is associated with more procedure-related complications compared with fluoroscopic placement.[13] TAUS is simpler than IVUS for filter placement. Moreover, TAUS has some other advantages, including lower cost, no radiation, and bedside operation.[8] Therefore, ultrasound is still favored by patients and surgeons.

Identification of the right renal vein (RRV)-inferior vena cava (IVC) is crucial for infrarenal filter placement. RRV visualization under TAUS is performed through the anterior flank scan and right-side flank scan. In previous studies, some researchers used the RRV-IVC junction, which was visualized transversely as the filter delivery catheter and sheath were slowly pulled back, during which the pullback was stopped when the tip of the filter delivery catheter disappeared from view because the intended deployment position had been reached.[3-6,8,14] The disadvantages of this method are that the catheter tip is difficult to identify and the sheath is pulled back

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too much or too little. Moreover, RRV identification with ultrasound is often affected by bowel gas. The right renal artery (RRA) has been identified as an indirect landmark by other researchers.[7] The IVC is imaged in the longitudinal plane, and the RRA can be seen in cross section crossing posterior to the vena cava. The RRA helps identify the infrarenal location.[7] The longitudinal plane of the IVC provides the best visualization for monitoring of filter implantation, but the RRA cannot always be visualized. Consequently, a strategy to determine the RRV level in the longitudinal plane of the IVC would help avoid such challenges.

RRV visualization by ultrasound scan at the right flank was less disturbed by bowel gas than from the anterior flank as the liver is an ultrasonic medium in this location. In this study, we used this RRV visualization method for TAUS-guided filter placement and assessed feasibility and safety.

ARTICLE HIGHLIGHTS

- **Type of Research**: Single-center retrospective study
- **Take Home Message:** In 931 patients who underwent ultrasound-guided inferior vena cava (IVC) filter placement, the probe was positioned on the right flank to identify the right renal vein-IVC junction. There were no complications, and technical success was 100%. Suprarenal filter placement occurred in 0.4%.
- **Recommendation:** The authors recommend placement of the ultrasound probe on the right flank to identify the right renal vein-IVC junction as a landmark for IVC filter placement.

METHODS

Population of patients. A retrospective review of hospital medical records was conducted of all consecutive patients who underwent IVCF placement at Wuhan Union Hospital between October 22, 2010, and June 30, 2016. A total of 1029 inpatients from the vascular surgery department of Wuhan Union Hospital were screened for appropriate indications and eligibility for IVCF placement. In October 2010, a new method of ultrasound-guided IVCF placement was used at our institution. Data were collected for all consecutive patients who underwent filter placement with this method. This study was approved by the Medical Ethics Committee at Tongji Medical College of Huazhong University of Science and Technology, and the need for consent of individual patients was waived because of the retrospective study design. This study was conducted in accordance with the Declaration of Helsinki.

Equipment. Duplex ultrasound imaging systems and filters were commercially available, including GE Logiq E9 and C6-1 probe (GE Healthcare, Wauwatosa, Wisc), Philips iU22 and C5-2 probe (Philips Healthcare, Andover, Mass), VenaTech-LGM filters and kit (B. Braun Medical, Bethlehem, Pa), and Aegisy filters (Xianjian; Lifetech Medical, Shenzhen, China).

Preprocedure imaging. TAUS was performed to determine the feasibility of bedside filter placement, including the deep veins of the lower extremities, femoral vein, iliac vein, IVC, and renal veins. All patients were required to fast or to receive simethicone (2 mL of liquid simethicone each time, three times a day) 1 day before and at least 30 minutes before undergoing ultrasound examination.[15]

Inclusion criteria for bedside IVCF placement were as follows: patency was confirmed of the femoral vein and iliac vein on one side and of the IVC; largest diameter of IVC on cross section at a position distal to the renal vein <2.8 cm; IVC visualization by TAUS; and RRV visualization in the coronal plane.

Exclusion criteria were as follows: thrombosis in bilateral femoral veins or iliac veins; thrombosis in the IVC; IVC malformation, such as bilateral IVC; largest diameter of IVC ≥2.8 cm; and IVC cannot be visualized in patients with fasting or medical treatment with silicone oil.

TAUS-guided filter placement. The usual target landing zone for the IVCF is the infrarenal IVC, close to the level of the renal veins.[16] Therefore, identification of the lowest renal vein is crucial. We considered the RRV as an example because it usually represents the lowest renal vein.

During IVCF insertion, the patient was placed in the supine position or on the right side slightly elevated without contraindications to more exposure of the flank area. The ultrasonographer was positioned on the right side of the patient with unobstructed access to the anterior flank. First, the probe was positioned on the right flank to show the long-axis section of the RRV and the RRV-IVC junction, with the intersection being centralized in the image. Subsequently, a straight line was drawn through the midpoint of the probe surface, and then a parallel line was drawn 1.0 cm below the straight line as a marker (Fig 1).

The probe was placed on the abdominal wall with the upper edge level with the marker line level to show the long axis of the IVC (Fig 2). The sheath of the filter was later inserted into the femoral vein under local anesthesia, which was delivered until visualization. Forward and backward movement of the sheath permitted the determination of its position. The injection of contrast agents (solution of 2 mL of SonoVue [Bracco, Milan, Italy] and 8 mL of normal saline) into the sheath could help confirm the catheter tip and avoid a "pseudotip" appearance. By measuring the distance of the end of the sheath to the marker line, the sheath could be pushed to the