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● *Original Contribution*

ASSESSMENT OF THE SAFETY AND EFFICACY OF BEDSIDE ULTRASOUND GUIDANCE FOR INFERIOR VENA CAVA FILTER PLACEMENT IN CRITICALLY ILL INTENSIVE CARE UNIT PATIENTS

Ying Liu,* Hong Zhou,* ChangYu Chen,* Chi Cui,† XiPin Liu,‡ Qinwen Liu,‡ Ming Ye,* and Jing Wang*

* Ultrasound Department, Third People's Hospital of Chengdu and Second Affiliated Hospital of Chengdu, Chongqing Medical University, Chengdu City, Sichuan Province, People's Republic of China; † Department of Vascular Surgery, Third People's Hospital of Chengdu and Second Affiliated Hospital of Chengdu, Chongqing Medical University, Chengdu City, Sichuan Province, People's Republic of China; and ‡ Radiology Department, Third People's Hospital of Chengdu and Second Affiliated Hospital of Chengdu, Chongqing Medical University, Chengdu City, Sichuan Province, People's Republic of China

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Abstract—Inferior vena cava filters (IVCFs) have been used clinically for approximately 45 y, but only a few studies of these devices have involved intensive care unit (ICU) patients who were critically ill and had multiple-organ dysfunction or were otherwise too unstable for transport. The purpose of this research was to assess the tolerability and efficacy of bedside ultrasound-guided IVCF placement in ICU patients. A retrospective analysis of both bedside ultrasound-guided and X-ray-guided ICVF placement was performed from November of 2011 to August of 2013. The total success rate for ultrasound-guided IVCF placement was 93.4%, which included a 96.0% success rate in 25 ICU patients with an average age of 69.46 y. Six-month follow-up studies revealed no significant differences in long-term complications between the ultrasound- and X-ray-guided groups. IVCFs may be safely implanted under ultrasound guidance in a monitored ICU environment. Our conclusion is that patients should be fasting and should receive an enema and that pre-operative surface marking and dynamic monitoring should be employed. Further research is needed to develop specific ultrasound guidelines. (E-mail: 445716102@qq.com) © 2015 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Inferior vena cava filters, Intensive care unit, Ultrasound, Safety, Efficacy.**

INTRODUCTION

In situations where standard anticoagulation therapy (OAT) is contraindicated or has recently failed, the curative effects of inferior vena cava filters (IVCFs), which are placed to prevent pulmonary emboli (PE), have been confirmed in both the short term and the intermediate term (Decousus et al. 1998; Haut et al. 2014; Helling et al. 2009). Previous studies have revealed that bedridden patients hospitalized in intensive care units (ICUs) may develop lower limb deep venous thrombosis (DVT) and calf muscular venous thrombosis (Aronow 2004; Liu et al. 2012). PE occur secondary to DVT. Lower limb DVT is responsible for more than 90% of PE (Hong et al. 2012), which frequently lead to death. In China, the mortality rate for PE is lower than only the mortality rates for tumors and acute myocardial infarction. Consequences of PE depend on the size and number of emboli: a small embolus may block a small artery in the lungs, causing a small pulmonary infarction, whereas a large pulmonary embolus may block nearly all of the blood traveling from the heart to the lungs, quickly causing death. In a patient with a DVT, the placement of an IVCF, which is made of a durable and non-corrosive biocompatible material, is the most commonly used method of trapping most, if not all, thrombi to prevent new or recurrent PE.

As IVCFs have been used in clinical practice for approximately 45 y, the majority of placement procedures have been performed with the assistance of either contrast venography or fluoroscopic guidance (Wellons et al. 2003). However, this technology is associated with several drawbacks, including iodine allergy, X-ray exposure, contra-indications to the injection of iodinated

Address correspondence to: Ying Liu, No. 82 QingLong Street, QingYang District, Chengdu City, Sichuan Province, People's Republic of China. E-mail: 445716102@qq.com

contrast medium in cases of renal insufficiency and unavailability of equipment for bedside examination (Uhl et al. 2002).

Ultrasound is a tolerable, non-invasive, accurate and cost-effective means of examining both the vascular cavity and the surrounding tissues and is the imaging modality of choice for diagnosing lower limb DVT (Mangeni et al. 2006). As it allows for real-time dynamic observation of IVCF implantation, ultrasonographic evaluation of the inferior vena cava (IVC) provides information on the circumferential engagement of filter struts in the IVC wall. As a result of these findings, multiple research studies have focused on ultrasound-guided IVCF placement in small samples of patients (Benjamin et al. 1999; Garrett et al. 2004). A few of these studies have involved critically ill patients hospitalized in an ICU—patients whose hospital courses were complicated by multiple-organ dysfunction and coagulation abnormalities that rendered them too unstable for transport (Benjamin et al. 1999; Conners et al. 2002). Therefore, there have been no adequate, well-controlled studies examining the options available for image-guided procedures. The purpose of this research was to assess the tolerability and efficacy of beside ultrasound-guided IVCF placement in ICU patients with organ dysfunction.

METHODS

From November 2011 to August 2013, 81 patients diagnosed with unilateral lower limb DVT were enrolled in a retrospective analysis of both beside ultrasound-guided (n = 46) and X-ray-guided (n = 35) placement of Aegisy filters, which are designed to allow retrievability (Xian Jian Polytron Technologies, Shenzhen City, Guangdong Province, China). Ethical approval was given by the medical ethics committee of the Third People's Hospital of Chengdu, and all study patients signed an informed consent. All filters were placed by the same registered vascular technologist.

During the IVCF implantation procedure, transabdominal duplex ultrasound guidance (New MSK M7 Portable Ultrasound with 7- to 3-MHz convex array probe and 5- to 10-MHz linear probe, Mindray, Shenzhen City, Guangdong Province, China) was performed on 46 patients (including 25 ICU patients) by two experienced ultrasound physicians. The remaining 35 IVCFs were placed *via* X-ray guidance (Allura Xper FD20, Philips Medical Systems Nederland, Veenpluis, The Netherlands) by two experienced radiologists. Therefore, we divided the patients into two groups: an ultrasound group and an X-ray group.

All patients met the study's inclusion criteria. The sonographic diagnosis confirmed the presence of an acute unilateral lower limb DVT in each patient, and the diameter of the IVC was <3 cm and without any mutation or thrombosis. It is worth noting that contrast-enhanced chest computed tomography confirmed the presence of small branch PE in two patients before their operations.

Ultrasound group

All patients fasted and received an enema before surgery. Operations on all 25 ICU patients were completed in a monitored ICU environment, and the remaining 21 cases were completed in the operating room. Patients first underwent ultrasound to verify visualization of the renal vein–IVC junction. The superior mesenteric artery and abdominal aorta were visualized, and the left renal vein, which runs between the two vessels, was found to confirm both the left and contralateral renal vein–IVC junctions; the distal junction of the two was marked on the outer body surface of each patient. Under sonographic real-time monitoring, percutaneous common femoral vein access was obtained *via* placement of a sheath using a local anesthetic. Right femoral venous access was preferred, as it provides a more direct path to the IVC, but the left common femoral vein was used if a thrombus was present on the right side. A sheath was advanced into the IVC (Fig. 1a). A guidewire was then advanced through the sheath (Fig. 1b). Visualized *via* ultrasound, the filter apex was advanced over the wire to a position approximately 1 cm below the renal vein–IVC junction, where the filter was subsequently deployed, so that when the filter was completely opened (Fig. 1c, d), its petal-shaped proximal basket (Fig. 1e, f) did not block the renal vein–IVC junction. This action can prevent kidney congestion and enlargement, which are due to poor venous return. For post-deployment imaging, an accurate distance was calculated between the filter apex position and the renal vein–IVC junction (Fig. 1g) again by ultrasonography, to ensure that the filter apex was placed in an infrarenal location. After the procedure, reduced-radiation abdominal radiographs were obtained to confirm that all devices were placed accurately without any filter shift or filter tilt.

X-ray group

Placement was performed in 35 patients in the angiography suite. Using the Seldinger (1953) technique, a vascular technologist punctured the contralateral femoral vein and injected contrast. Under fluoroscopic guidance, the position of the renal vein–IVC junction was confirmed and marked on the outer body surface. Insertion of the guidewire and introduction of the sheath over the guidewire, as well as insertion of the filter, were completed in a manner similar to that used in the ultrasound group: The filter was subsequently advanced