Inferior vena caval diameters were measured in 65 patients with Kimray-Greenfield (KG) inferior vena caval filters. The measurements were made at the distal tips of the filter tines on postplacement radiographs. Magnification corrections were made using the filter tine lengths as references. The overall mean diameter was 20 mm, the range was 13 to 30 mm, and the standard deviation was 3 mm. Two cavae (3%) were more than 28 mm in diameter. A previous in vitro study has shown that in venae cavae of this size there is a significant risk of reduced clot-capturing ability with the KG filter and migration with the Mobin-Uddin filter. Thus it is important to evaluate vena caval diameter by cavigraphy prior to filter placement.

Index terms: (Inferior vena cava, mechanical implant, 982.456) + (Inferior vena cava, normal variation in size, 982.133) + Venae cavae, filters

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MOBIN-UDdin (MU) and Kimray-Greenfield (KG) inferior vena caval (IVC) filters are being used with increasing frequency to treat patients with thromboembolic disease who are at high risk for further pulmonary embolism, but in whom anticoagulation therapy, surgery, and general anesthesia required for caval clipping are contraindicated. Both types of filters are inserted transvenously under local anesthesia via a jugular or femoral vein cutdown, with reported advantages over caval clipping because of less delay, reduced cost, lower morbidity, and lower mortality (1, 2).

A previous in vitro study of intracaval filters has shown that clot-capturing ability and anchoring security in the vena cava varies with caval size. In particular, it appears that if the KG filter expands to a 28-mm or larger diameter within the cavae it may not provide adequate protection against pulmonary embolism; if the MU filter is placed into a 28-mm-diameter or larger cava there is a high risk of filter migration (3, 4). MU filter migration has also been reported and discussed in the clinical literature (5–8). Since these filters function optimally in a limited range of vena caval sizes, it would be helpful to know the distribution of vena caval diameters in the population of patients who receive these devices.

Examining radiographs of patients with KG filters is a simple way of measuring vena caval diameters since the filter serves as both a reference object to determine film magnification and as an internal splint to hold the cava in a symmetrical (roughly circular) cross section. In this study we defined the spectrum of IVC diameters in KG filter patients after filter placement and determined the percentage of filter patients with a 28-mm-diameter or larger vena cava.

MATERIALS AND METHODS

Sixty-five KG filter patients whose postplacement radiographs were available for review were included in this study; 40 had been placed at the Massachusetts General Hospital and 25 at Beth Israel Hospital. Postplacement cavigrams were available for 20/65 of the KG patients. Cava width and filter limb length were measured and the corrected caval width calculated using the equation:

\[
\text{correct cava width} = \frac{\text{actual filter length}}{\text{measured filter length}} \times \text{measured cava width}
\]

The "actual filter length" was determined to be 46 mm by measuring the device itself. Cava width was measured from postplacement cavigrams or, if the cavigram was not available, the maximum distance spanned by the tines was measured. This was always the inside edge of the leftmost hook to the inside edge of the rightmost hook. The KG filter’s long length prevented excessive tilting that could cause the tine-to-tine distance to reflect an inaccurate measure of caval diameter. Cavae were assumed to have a circular cross section.
This uniform filter showed at the site of the filter hooks due to the uniform distending pressure of the filter and contrast medium injection. This assumption was supported by observing that all CT scans obtained on IVC filter patients at both hospitals showed circular cavae at the level of the filter (Fig. 1). Thus, the measured width in any projection represented a measure of caval diameter.

RESULTS

The caval diameter distribution is illustrated in Figure 2. The calculated mean caval diameter was 20 mm, with a standard deviation of 3 mm. The average magnification of the IVC was 28%, i.e., the actual diameter equaled 78% of the measured diameter. Two of the 65 cavae (3%) were more than 28 mm in diameter and appeared to be separated from the rest of the caval measurements, which formed a bell-shaped distribution curve. Since cavae greater than 28 mm in diameter are both risky for filter placement and distinctly different from the normal distribution, they were called “megacavae.” One megacava patient was large in stature, a 6-ft 5-in, 130-kg, 23-year-old man with a tibia fracture and no recurrent pulmonary embolism at 4 months after filter placement (Fig. 3). The other was a 45-year-old man with rheumatic heart disease and elevated right atrial pressure with no documented recurrent pulmonary embolism four years after placement. Severe venous stasis disease developed in this second patient after placement and he is presumed to have an occluded IVC.

The limited resolution of the ruler and radiograph as well as possible deviations from circularity represented the major sources of error in measuring caval diameter. These errors were estimated as follows: (a) film limb length measurement = 50 mm ± 1 mm or 2%; (b) filter limb length measurement = 46 mm ± .5 mm or 1%; (c) caval width measurement = 25 mm ± 1 mm or 4%; and (d) deviation from circularity = 20 mm ± 2 mm or 10%

Some of these errors tended to cancel out so that the combined error was calculated as the square root of the sum of the errors squared as shown in this equation in which total error =

\[ \sqrt{(2)^2 + (1)^2 + (4)^2 + (10)^2} = 11\% \] (2)

Of course, the infrarenal vena caval diameter may be influenced by many additional physiologic variables, such as abdominal pressure, venous flow rate, drugs, posture, central venous pressure, and so on. Given measurement error plus these physiologic variables, the range of caval diameters is probably greater than indicated here. Thus the filter patient population at risk for receiving an undersized filter is probably even greater than 3%.

DISCUSSION

The existence of megacava in 3% of the IVC filter patient population indicates that caval size should be a consideration in the decision to use an IVC filter. Caval size should be evaluated with cavography. If the cava appears larger than 28 mm in diameter in the anteroposterior projection (our magnification correction factor was 0.78), a lateral cavogram must also be obtained since a 28-mm-wide but flat IVC will have a diameter much less than 28 mm when it is made circular by placing a filter. The predicted diameter of a flat cava can be estimated by determining the caval circumference with AP and lateral cavography or computed tomography during a Valsalva maneuver and then dividing by \(2\pi\). One should look for megacava, especially in patients who have a tendency for large cavae, i.e., patients of large stature, with
congestive heart failure, cor pulmonale, tricuspid insufficiency (9), or any other venous system dilating disease state.

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References

One of the two megacavae observed.