Bedside carbon dioxide cavagrams for inferior vena cava filters: Preliminary results

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Objective: The objective of this study was to evaluate the feasibility of using carbon dioxide (CO_2) as a contrast agent in performing bedside inferior vena cavagrams before the insertion of vena cava filters. There was a consecutive series of patients undergoing bedside preinsertion cavagrams with inferior vena cava filter insertion. The setting was an 825-bed tertiary care hospital. The subjects were trauma patients undergoing inferior vena cava filter insertion.

Methods: The intervention used was vena cavagrams with CO_2 as the contrast agent. The main outcomes we measured were image quality, adverse reactions, cardiorespiratory changes, and renal failure.

Results: Ten patients underwent CO_2 cavography. All cavagrams were successful, demonstrating opacification of the inferior vena cava with identification of the renal veins and iliac bifurcation. There were no adverse reactions of renal failure.

Conclusions: Carbon dioxide–contrasted vena cavagrams can be safely performed at the bedside, and they give good opacification of the inferior vena cava. (J Vasc Surg 2000;32:144-7.)

Despite routine prophylaxis, venous thromboembolism remains problematic in the trauma population.[1,2] Prophylactic inferior vena cava (IVC) filters have been shown to be safe and effective in reducing morbidity and mortality from pulmonary embolism in high-risk trauma patients.[3-6] A contrast cavagram remains the standard of care before the insertion of a vena cava filter. Although the nonionic iodinated contrast agents have significantly reduced the incidence of pain and adverse reactions, the risk of contrast nephropathy and subsequent renal failure has not diminished.[7] In patients with elevated serum creatinine levels, the risk of contrast nephropathy rises exponentially with the level of the serum creatinine. Duplex ultrasonography scanning has been reported as an acceptable imaging technique for IVC filter insertion, but it is associated with a 10% failure rate for adequate visualization of the IVC.[8] Carbon dioxide (CO_2) used as a contrast agent has no hepatic or renal toxicity and is nonallergenic.[9] We report a consecutive series of successful bedside cavagrams with CO_2 as a contrast agent.

METHODS

Preinsertion cavagrams and IVC filter insertions were performed at the bedside in the intensive care unit (ICU). Our preferred approach was to use the right internal jugular vein to decrease the potential complication of femoral vein thrombosis[10] and the potential for IVC filter tilt when using the Greenfield filter (Boston Scientific, Glen Allen, Va).[11]

Patients were monitored for physiologic changes. All patients had cardiac monitoring and pulse oximetry; seven patients had radial artery catheters; three patients had noninvasive blood pressure monitored every 2 minutes during the procedure; three of the eight mechanically ventilated patients had continuous end-tidal CO_2 ($ETCO_2$) monitors (Hewlett-Packard, Andover, Mass); two patients had indwelling intracranial pressure monitors (with no elevations greater than 18 mm Hg for at least 24 hours) (Camino Laboratories, Exton, Pa); and five patients had a pulmonary artery catheter

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Competition of interest: nil.

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Patient characteristics.

Patient	*Age (y)/sex*	*Injury severity score*	*Creatinine level (mg/dL)*	*Filter type*	*Complications*
1	46/M	16	2.8	BN	Death*
2	46/F	27	1.1	TG	
3	26/M	34	1.6	TG	
4	72/M	33	1.3	VT	Death*
5	38/M	25	0.8	VT	
6	52/M	16	0.7	BN	
7	33/M	38	1.0	BN	
8	39/F	34	0.7	BN	
9	44/F	66	1.5	TG	
10	27/M	27	1.0	BN	

*Death unrelated to the IVC filter insertion.
BN, Bird's Nest filter; *TG,* titanium Greenfield filter; *VT,* Vena Tech filter.

with continuous cardiac output monitoring and continuous mixed venous oxygen saturation measurements (Baxter, Irvine, Calif).

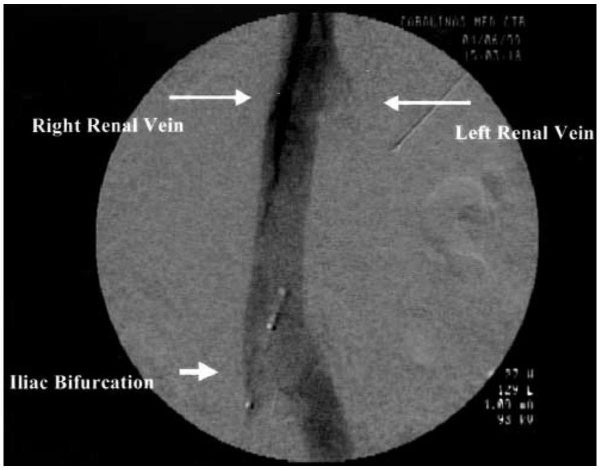
Technique. Patients were prepped and draped with the use of the sterile technique. The patients did not require transfer to a specialized stretcher or unit, because all beds in the ICU are fluoroscopy ready. A portable digital subtraction/fluoroscopy unit (OEC Medical Systems, Salt Lake City, Utah) was used to identify the twelfth thoracic vertebra and lumbar vertebrae. Guidewire placement, insertion of introducer catheters, and deployment of the IVC filters were all fluoroscopically guided. The approach of preference was the right internal jugular vein unless there was a contraindication (eg, existing central venous catheter or injury). With the use of the Seldinger technique, a 9-French introducer catheter was inserted. A 5-French pigtail angiography catheter with radiopaque measuring guides (to correct for the magnification during fluoroscopy) (Pig-Cava; Cook Critical Care Inc, Bloomington, Ind) was advanced into the IVC. Cavagrams were performed with a hand injection system (AngioDynamics, Glen Falls, NY) with digital subtraction enhancement.[12] The pigtail catheter was positioned at the fourth and fifth lumbar vertebral interspace. Injections of 60 cc were repeated with a breath hold if the first cavagram was considered to be suboptimal. If the renal veins were not identified with the first cavagram, a separate cavagram was performed with the catheter positioned at the interspace between the first and second lumbar vertebrae. Images were obtained and saved for the permanent record. Caval size, the location of the iliac bifurcation, and the location of the renal veins were determined. All IVC filters were then inserted into the infrarenal position, and a hard copy plain x-ray film was obtained. The introducer catheter was removed, and direct pressure to the percutaneous insertion site was applied for 10 minutes.

RESULTS

Ten patients underwent preinsertion CO_2 cavagrams (Table). Three titanium Greenfield filters (Boston Scientific), two LGM Vena Tech filters (B. Braun, Evanston, Ill), and five Bird's Nest filters were inserted. Vena Tech filters were inserted into two patients who were scheduled to have magnetic resonance imaging (MRI) within 4 weeks of filter insertion; only the Simon Nitinol (Bard, Salt Lake City, Utah) and the Vena Tech (Braun) filters are safe for magnetic resonance imaging immediately after insertion. Six IVC filters were inserted through the femoral route, and four were inserted through the internal jugular vein. Femoral access was used because two patients had indwelling right internal jugular catheters, two patients had cervical immobilization, and two patients had both.

Three injections of contrast were needed in seven patients, two were needed in two patients, and one was needed in one patient. The iliac bifurcation and the location of the renal veins were identified in all patients (Figure). All caval measurements were less than 28 mm in diameter.

No physiologic changes, including blood pressure, cardiac outputs, mixed venous saturations, pulse oximetry, or intracranial pressures, occurred within 10 minutes of the cavagram as a result of the CO_2 injections. In two patients, $ETCO_2$ increased (8 mm Hg and 10 mm Hg) after a 6-second breath hold to decrease venous return and enhance the image quality. In these patients, the $ETCO_2$ increase was the same, and the increase occurred at the same time after the breath hold (6 seconds and 10 sec-



Carbon dioxide cavagram. Renal veins and iliac bifurcation are clearly identified. The right renal vein is demonstrated by noncontrasted blood entering the contrast column, and the left renal vein is opacified by contrast.

onds) as in the trial breath holds before the CO_2 injections. There were no complaints of pain during injections in awake patients. Four patients had elevated serum creatinine levels (>1.2 mg/dL) at the time of their cavagrams. There were no increases in creatinine levels over the next 96 hours.

DISCUSSION

Carbon dioxide was first used as a contrast agent in the early 1950s to identify pericardial effusions. In the 1960s and 1970s it was used in both venous and arterial angiography.[9] The advantages of CO_2 are its lack of side effects, including the absence of renal or hepatic toxicity, and the ability to be given in repeated injections without a cumulative effect.[9,13] Pain has been reported with CO_2 injections into peripheral veins, but it does not occur with IVC injections.[13] The major disadvantage of CO_2 is the requirement for digital subtraction. However, digital subtraction image quality has rapidly improved over the past decade, and this technology is now portable to the bedside. The insertion of IVC filters in the ICU can be performed with safety and cost-effectiveness while avoiding the risk of transporting critically ill patients.[8,14] Although none of the patients were hemodynamically unstable, each had devices at risk for dislodgment during transport from the ICU: eight patients had endotracheal tubes, which required mechanical ventilation; five had indwelling pulmonary artery catheters; two patients had intracranial pressure monitors; and four had orthopedic or spinal traction devices.

Carbon dioxide is rapidly dissolved in blood, and boluses of 100 cc or less are cleared by the lungs in one pass and cause no changes in arterial pH, pO_2, or pCO_2.[13] We observed no hemodynamic or respiratory changes during the injections of CO_2 or for 10 minutes thereafter. In addition, we demonstrated that small boluses of 60 cc did not alter $ETCO_2$ or affect intracranial pressure (patients with normal intracranial pressures).

Sullivan and colleagues[13] described two patients in whom poor opacification with CO_2 underestimated the cava diameter. We were satisfied with the opacification for all of our cavagrams. Several patients required repeated injections for an optimum image; however, repeated CO_2 injections are of no consequence. The location of the renal veins, the cava diameter, and the location of the iliac bifurcation were easily identified by bedside CO_2 cavography in all patients. We are currently initiating a prospective comparison of CO_2 and iodinated contrast in determining caval diameter.

In summary, a CO_2-contrasted preinsertion cavagram for bedside IVC filter insertions produced excellent opacification of the IVC, demonstrating the locations of both the renal veins and the iliac bifurcation. In patients with elevated serum creatinine levels, CO_2 contrast is preferable to other contrast materials to avoid contrast nephropathy and renal failure. Because there are few adverse reactions, CO_2 contrast may become the contrast of choice for the evaluation of the vena cava before the insertion of IVC filters. Further study is needed to determine the accuracy of CO_2 in measuring caval diameter.

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