Computed tomography evaluation of inferior vena cava
Bard G2 filters

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Purpose: Evaluate the G2 Bard Recovery filter for inferior vena cava (IVC) and retroperitoneal complications.

Materials and Methods: This is a retrospective analysis of consecutive patients (pts) who received the G2 Bard Recovery filter. The images of all pts who had follow up contrast enhanced computed tomography (CT) of the abdomen were assessed for filter tilting, migration, caval wall penetration, thrombus within the filter, filter fracture, caval injury and retroperitoneal complications. Mean implantation time, filter and retrieval success rate were evaluated.

Results: 154 G2 filters were deployed in 154 pts, 100 males and 54 females, mean age 48.8, (range 13-88). The access site was right common femoral vein in 93 pts, right internal jugular vein in 51 pts and left common femoral vein in 10 pts. 151 filters were deployed in the IVC below the renal veins and 3 filters in the supraparenal IVC. Follow up CT of the abdomen (mean, 105 days; range, 1-773) in 63 pts demonstrated tilting of the filter (>15°) in 27 (42%) of 63 pts, legs or arms extending into inferior vena cava tributaries in 14 (22%) of 63 pts, (lumbar veins in 11 (17%) pts, right ovarian vein in 2 (3%) pts, and duplicated renal vein in 1 (1%) pt), 25 legs or arms perforation was noted in 15 (23%) of 63 pts (1 to 4 legs or arms per filter), IVC thrombus >25% in 3 (4%) of 63 pts, and 2 (3%) of 63 pts showed inferior migration of the filter. No filter fractures were noted. One perforation was extending into the duodenum and one into the wall of the aorta. No retroperitoneal hematoma was observed. After a mean period of 153 days (range, 9-354 d), 15 attempts at G2 filter removal were made in 15 pts. Filter removal was successful in all 15 attempts (100%) without complications.

Conclusion: Filter tilting, extension of filter’s legs or arms into IVC tributaries, and caval perforation are prevalent findings in IVC G2 Bard Recovery filter.

Complications of the Bard Recovery filter and their effect on attempted retrieval in 107 patients

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Purpose: This study reviews a large series of Recovery filters for fractures, leg penetration, tilt and migration and whether this prevented retrieval.

Materials and Methods: Post-placement and pre-retrieval images of the filter were acquired from the electronic database and the hard-copy film archive and digitized. All digitized images of the filter were assessed for migration (judged by dividing the vertebral body into upper, middle and lower thirds), tilt (by comparing the angulation on the post-placement and pre-retrieval images), penetration (by reviewing any intercurrent CT scans) and for fracture.

Results: 363 Recovery filters were placed at our institution. 107 patients were recalled for retrieval and 98 filters (91.5%) were retrieved and 9 filters remain in situ. In the 9 unsuccessful retrievals, 6 patients had severe tilt or leg migration into renal veins and 3 patients had thrombus at the filter. (112 patients died before retrieval and 144 patients still have their filters in situ). Retrieval occurred between 2 and 551 days with a mean retrieval period of 121 days. Paired post-placement and pre-retrieval scout images were collected in 81 of the 107 cases (76%). Fractures were seen in 5 filters (6%) with one case demonstrating distal migration of a filter limb into a middle lobe pulmonary artery. 11 patients had an intercurrent CT scan, 7 (64%) of which demonstrated limb penetration outside the cava into the retroperitoneum including into the renal vein and duodenum. Tilt of more than 20 degrees was seen in 6 (7%) cases. There were no cases of distal migration of the entire filter. Local migration (as judged to by change in cranio-caudal position by more than 1/3 of a vertebral body) occurred in both cranial and caudal directions in 14 patients (17%).

Conclusion: 1. Fracture, leg penetration, tilt and migration are common in the Bard recovery filter, but the majority of these are clinically insignificant. 2. Severe tilt or migration into the renal veins are significant complications of this filter, because this prevents retrieval as seen in 5.5% of our cases. 3. The potentially significant complication of complete fracture with distal migration was seen in only 1 out of 107 patients.
removed due to the presence of residual thrombus (n=3), occlusion of the IVC (n=3) but also because of severe tilt or migration (n=17). 279 patients with filters died due to co-morbidities, the majority due to cancer. 375 patients still have their filters in situ.

**Conclusion:** The majority of filters had an absolute indication. Complications after filter placement were frequent (35.4%) but there was a low rate of breakthrough PE and the majority of the complications are clinically insignificant. Our retrieval rate was 83.0%. This may be lower than expected because of higher rates of severe tilt and local migration.


**10:36 AM Abstract No. 4**

**Retrieval of permanently-embedded IVC filters and description of the laser-assisted sheath technique: Radiographic-histopathologic correlation**

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**Purpose:** To evaluate the safety and effectiveness of removing permanently-embedded IVC filters. To describe the laser-assisted sheath technique. To elucidate the pathophysiology of chronic filter implantation via histologic analysis of retrieved specimens.

**Materials and Methods:** An IRB-approved retrospective study was performed on all patients who underwent filter retrieval from 10/2008 to 10/2009 in our department. Inclusion criteria were patients diagnosed with a permanently-embedded filter (adhered to the IVC and refractory to standard retrieval methods), no longer requiring filtration, who underwent attempted filter removal using alternative methods. All specimens were sent for histology including Elastic Van Gieson (EVG) staining.

**Results:** Ten consecutive patients with embedded filters underwent attempted retrieval. There were 6 men and 4 women (mean age 47.6 y, range 28-84). Indications for retrieval were symptomatic chronic IVC occlusion with associated edema, caval and aortic penetration, and/or acute PE from caval thrombosis. Retrieval was also performed to reduce risk of complications from long-term filter implantation and to eliminate the need for lifelong anticoagulation. Filter implantation times were as follows: 1 Venatech (1495 d), 1 Simon-Nitinol (1485 d), 1 Optepe (70 d), 1 G2 (416 d), 5 Günther Tulip (GTF) (mean 606 d, range 154-1010) and 1 Celect (124 d). Aggressive traction with snares or wire-loop methods was used with sheath and/or forceps dissection under fluoroscopy. An excimer laser-tipped sheath was used adjunctively in 2 GTF cases. Retrieval was successful in 10/10 (100%). There were no procedural or clinical complications (mean t/u 129 d, range 21-354). EVG stains revealed vessel wall component in 9/10 (90%): scant intima on 8 filters and abundant intima on 1 Venatech. Histologically, all specimens demonstrated a predominance of dense fibrosis; and evidence of tissue ablation was confirmed in the laser-treated specimens.

**Conclusion:** Retrieval of permanently-embedded filters is technically feasible using alternative methods. The laser-assisted sheath technique appears useful for ablation of dense fibrotic tissue—a major histologically confirmed sequela of chronic filter implantation.

10:48 AM Abstract No. 5

**Removal of retrievable IVC filters with CT findings indicating filter strut perforation**


**Purpose:** The struts of IVC filters are known to perforate the IVC wall. This study examines the feasibility and safety of removing IVC filters with struts that perforate the IVC wall on CT imaging.

**Materials and Methods:** This IRB approved, retrospective study included 64 attempted IVC filter retrievals from 62 patients over a 5 year period. Pre-retrieval CT was used to describe the various imaging characteristics of filter struts as they appeared to perforate the IVC wall. Filter struts were graded using the following CT-based grading system: Grade 0 = no perforation, Grade 1 = struts external but immediately adjacent to the IVC lumen, Grade 2 = struts completely outside the lumen as demonstrated by a halo of retroperitoneal fat, Grade 3 = struts that contact adjacent organs/retroperitoneal structures. Patient medical records were evaluated for filter type, results of filter removal, and complications.

**Results:** Grade 1 strut perforations were seen in 45 cases (70.3%), Grade 2 perforations were seen in 38 (59.4%) cases, and Grade 3 perforations were seen in 26 cases (40.6%). Nine patients (14%) had no strut perforations. Patients in this study had the following filters: Recovery (n=23), G2 (n=20), Günther Tulip (n=8), and Optease (n=3). Average filter dwell time was 172 days (range 13-490 days). Fifty-seven of the 64 filters (89.1%) were removed successfully. Seven (10.1%) filters could not be removed because of incorporation of filter struts or tip of filter into the IVC wall. Seven (100%) of the failed retrievals and 48 (84.2%) of the successfully retrieved filters demonstrated some degree of strut perforation (p<NS). Prior to retrieval attempt, filter fracture was detected in 8 cases (12.5%) and IVC stenosis was present in 3 cases (4.7%). No major complications occurred during any retrieval or retrieval attempt. There were 2 cases complicated by immediate post-procedure abdominal pain. Both clinically resolved and no abnormality was detected on CT performed within 2 hours of the procedure.

**Conclusion:** IVC filter struts perforating the IVC wall is a common finding on CT. IVC filters with strut perforation can be removed safely and this should not necessarily be a contraindication for IVC filter retrieval.

11:00 AM Abstract No. 6

**An in vitro study of clot-trapping efficiency of retrievable IVC filters**

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**Purpose:** To evaluate the clot-trapping efficiency of current retrievable inferior vena cava (IVC) filters using an in-vitro model.