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Case Report

A Strategy for the Safe Removal of Intracardiac IVC Filters

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Abstract

Introduction: Complications arising after placement of an IVC filter are being reported with increasing frequency and have resulted in numerous lawsuits. Intracardiac migration is a known complication that has been reported to have significant rates of morbidity and mortality. Treatment options include anticoagulation alone or removal by endovascular or open techniques. This review presents a strategy for safe and effective management of intracardiac IVC filters in the age of endovascular treatment.

Methods: Five cases of IVC filters that migrated into the heart with three resulting in medical malpractice suits were reviewed to determine the filter's position in the heart and angle of the filter relative to the SVC/IVC axis. The retrieval methods and results were reviewed. Recent medical literature was reviewed. Cases of intracardiac filter migration were included if these factors were described.

Results: Of the five new cases one was in the RA parallel to the IVC and was removed endovascularly. One had struts involving the TC valve and chordae and was successfully removed with open surgery. One was through the PV and TC valve. Endovascular removal tore both valves and required emergency double valve replacement. Two that involved the TC valve tore the valve and RA resulting in cardiac tamponade and death. The majority of cases reported in the literature were isolated cases that described the techniques used to remove filters. Most of the filters removed successfully were in the RA and did not involve the structures of the heart.

Conclusion: In order to safely remove intracardiac IVC filters the axis of the filter must be parallel to IVC/SVC axis and the filter must be in proximity to that plane. In order to retrieve a filter that is not parallel to that axis traction must be placed on the filter to rotate it, swiveling the hooks inside the heart. If on echocardiography the filter is in RA and clear of TC valve and chordae endovascular removal can be attempted if the progress is monitored with echocardiography. Once the IVC filter crosses or involves the TC valve mechanism open removal is recommended to reduce the risk of valvular injury.

Keywords: Intracardiac; IVC filter; Migration; Removal

Introduction

Migration of an IVC filter to the heart is a known, potentially lethal complication. Janjua, et al., have reported that since about 2000 many more of these filters are crossing the TC valve into the RV. They have postulated that the newer materials used in the manufacturing process have contributed to this phenomenon when compared to stainless steel and titanium [1].

IVC filters that migrate to the heart may be asymptomatic and found on imaging that was performed for some other unrelated problem. They can present with chest pain, shortness of breath, palpitations, arrhythmias or sudden death [1]. Since 2000 there has been a higher incidence of major cardiac events and death noted with filter migration. This is believed to be caused by the higher incidence of filter migration further into the heart [1]. Potential complications of not removing the filter include further migration with cardiac perforation or ectopy, filter thrombosis or foreign body infection [2].

Greenfield first described removal of a filter from the heart by an endoluminal approach in 1980 [3]. Since then numerous approaches to managing filters that have migrated have been proposed. Gelbfish and Ascer suggested that anticoagulation alone may be reasonable in high risk patients [4]. Numerous endovascular techniques have been reported, usually as case reports, for removal of intracardiac filters. Owens, et al., illustrated many of the possible endoluminal approaches in a 2009 review [5]. Open surgical removal has been advocated as the safest option or as a backup if endovascular removal fails [2]. Recently Feng, et al., proposed a hybrid technique utilizing off pump right ventriculotomy with direct snare capture of the filter in a patient who was not a candidate for endoluminal extraction and was too hypoxic for cardiopulmonary bypass [6]. There is no consensus about the best approach to managing these filters [3].

The true incidence of intracardiac filter migration is not known. There are many isolated case reports which often focus on a novel approach for retrieving a filter. In 2009 Owens, et al., identified 98 cases of intracardiac migration of IVC filters in 77 publications [2]. There is a tendency to report successful cases. It is not unreasonable to assume that many more cases have gone unreported, unpublished or unrecognized. This article analyzes the literature and five new cases of IVC filters that have migrated to the heart to propose a strategy for the removal of IVC filters that is based upon the location and spatial orientation of the filter and whether any of the hooks or struts are caught on cardiac structures.

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Patients and Methods

The medical records, imaging and deposition transcripts of five completed medico-legal cases that resulted from the migration of an IVC filter into the heart over a four year period were reviewed. In the United States a patient or their representative can initiate legal action against a health care provider if it is believed that an injury to the patient was caused by a negligent act or omission by the health care provider. In order to prove that medical malpractice occurred it must be determined that there was a violation of the accepted standards of medical care and an injury was caused by the negligence that resulted in significant harm to the patient. The author served as an expert on all of these cases between 2014 and 2017. Informed consent was not required by the Institutional Review Board. Permission to use the patient data was obtained from their lawyers on the condition that the patient remained anonymous. The data is all part of the public record.

The imaging was reviewed to determine the location of the filter within the heart and its orientation with respect to the IVC/SVC axis. If an echocardiogram was performed pre or post removal it was reviewed to determine the exact location of the filter within the heart and whether any of the hooks and/or struts involved the heart wall, a valve or any of the chordate tendineae. The medical records and depositions were reviewed to determine how the treatment plan was decided upon, what consults were done, whether cardiac surgical backup was available, when the diagnosis of a cardiac injury was made, how the complication was treated and the outcome (Table 1).

Patient 1 was a 42 year old man who had a Cook Recovery Tulip (Cook, Inc.) placed one week prior to developing palpitations and refractory cardiac ectopy. On chest x-ray the filter was visualized in the RA in the IVC/SVC axis. No echocardiogram was performed. Interventional Radiology was consulted and successfully removed the filter with a snare and sheath. There was no cardiac surgery backup available at this hospital. He survived without complication.

Patient 2 was a 66 year old woman who had a Greenfield filter (Medi-Tech/Boston Scientific) placed six weeks before developing chest pain and ectopy. On chest x-ray her filter was noted to be perpendicular to the IVC/SVC axis and on echocardiography it was in the RA crossing the TC valve. Struts and hooks were seen to involve the valve. The interventional cardiologist felt that it was not safe to try to remove the filter. The cardiac surgeons removed the filter. She survived and was discharged without complication.

Patient 3 was a 47 year old man who had a TrapEase filter (Cordis, Miami, FL) placed one month before presenting to the ER with chest pain. On chest x-ray the filter was traversing the TC valve from the RA to the RV and was about 70 degrees off the IVC/SVC axis. No echocardiogram was performed. The interventional cardiologist removed the filter and within 30 minutes the patient developed pulse less electrical activity from a cardiac tamponade. A pericardial drain was placed. No cardiac surgery backup was available. The patient developed multiple organ system failure and died.

Patient 4 was a 56 year old man who had an OptEase filter (Cordis) placed three days before developing refractory cardiac ectopy. On chest x-ray the filter was in the RA and was felt to be abutting the TC valve and was lying about 70 degrees off the IVC/SVC axis. No echocardiogram was performed. Interventional radiology removed the filter. No consult was placed pre-procedurally with the cardiac surgeons. Cardiac tamponade developed within thirty minutes. A pericardial drain was placed but the patient died before he could be taken to the OR.

Patient 5 was a 23 year old woman who had a Greenfield filter (Medi-Tech/Boston Scientific) placed months before a chest x-ray that was performed for unrelated symptoms demonstrated that her filter had migrated to the main pulmonary artery. The filter was parallel with the IVC/SVC plane but to the left of that sagittal plane. No echocardiogram was performed. The interventional cardiologist attempted to remove the filter without consulting the cardiac surgeons. The filter was snared but could not fully be engaged in the sheath. It was pulled into the RA/IVC junction before the filter could be totally engaged in the sheath. When the filter was examined there was some tissue in the hooks that was sent for pathology. Within an hour the patient developed florid right heart failure from tricuspid and pulmonic regurgitation. She underwent a double valve replacement and survived. The tissue on her filter was determined to be consistent with heart valves. There is no large reported series of patients with IVC filters that have migrated into the heart. The collective reviews focus upon techniques and outcomes [1,2,5]. The majority of successful endovascular removals have been from the RA with significantly less from the RV and PA. The angle that the filter lies in relation to the IVC/SVC plane has not been included in many of these reports. Anticoagulation either as a primary treatment of after failed endovascular removal has an approximate 50% mortality rate. The lowest mortality rate is after open heart surgery performed either as a primary procedure or after a failed endoluminal attempt. Echocardiographic guidance has not been used in these series.

Discussion

As endovascular equipment and techniques continuously improve there is a tendency to perform endovascular procedures first even when they have not been fully evaluated in unusual situations. Retrieval from the IVC has been shown to be more difficult and have a higher complication rate when there is filter tilt or wall penetration [7-9]. The increasing number of IVC filters that now migrate out of the RA is making their removal more difficult and challenging. The increased risk of a complicated endovascular retrieval needs to be considered and compared to the risk of more conventional surgery [10,11].

Patient	Location	Angle Relative to IVC/SVC Axis	Pre-operative Echocardiogram	Procedure	Result
1	RA	0°	-	Endovascular	Successful Removal
2	RA Crossing TCV	90°	+	Open Surgery	Successful Removal
3	RA crossing TCV into RV	70°	-	Endovascular	Cardiac Tamponade Death
4	RA Abutting TCV	70°	-	Endovascular	Cardiac Tamponade Death
5	Main PA	0° - Not In-line with IVC	-	Endovascular	Injury to PV and TCV - CHF

Table 1: Patients medical records.

Abbreviations: RA = Right Atrium; TCV = Tricuspid Valve; PV = Pulmonic Valve; RV = Right Ventricle; PA = Pulmonary Artery

In order to remove an IVC filter the lateral force of the struts must be overcome so that the filter will collapse into the inflexible, coaxial sheath. When the filter is in line with the sheath this is not complicated. However, when there is filter tilt the chance of complications increases because the filter must be rotated into the same axis as the sheath in order to be captured. This is even more important when the IVC filter has migrated into the heart because there are more structures within the heart that can be damaged and a perforation can easily lead to cardiac tamponade and death. The traction on the snare and advancement of the sheath can make it difficult to appreciate any increased resistance that might be felt if a heart valve or the wall of the RA is engaged by a filter hook [12]. Following the progress of retrieval with 2-D fluoroscopy cannot warn the operator that a complication is about to happen.

Most operators will probably never encounter an IVC filter that has migrated into the heart. It is important to have an algorithm to follow when dealing with this unusual complication. When an IVC filter has migrated into the heart it is essential to perform an echocardiogram to exactly localize the filter's position in the heart, the relationship of the filter to the valve structures and the wall of the heart. It is imperative to have a multidiscipline team which includes an interventionalist, an echocardiologist and a cardiac surgeon. The interventionalist must have considerable experience removing IVC filters. They should all be involved in the planning of which procedure should be done and the surgeon should be readily available if an endovascular procedure is undertaken. The endovascular procedure should be performed with echocardiographic and fluoroscopic guidance. If any of these conditions are not met the patient should be transferred to another hospital that can provide those services.

If the filter is in the RA and free of the valve and heart wall endovascular retrieval should be the chosen. When the filter is in the IVC/SVC plane the retrieval should be straight forward and uncomplicated. Rotation of a filter that is at an angle that is not parallel to that plane is possible but must be performed with dynamic echocardiography to insure that it is performed safely. The procedure must be stopped immediately if the hooks engage any cardiac structure and before significant damage is done. If the filter cannot be retrieved consideration should be given to removing it by open heart surgery if the patient is able to tolerate the procedure.

When the filter is across or past the TC valve echocardiography is needed to determine if the filter is free of attachments. If it is free of attachments then the multidisciplinary team needs to determine if the filter can be engaged and captured in the sheath without damaging the heart structures remembering that it will require torque inside of the heart to get it into the sheath. If the decision is made to proceed with endovascular retrieval and the patient accepts the increased risk, the procedure must be performed with dynamic echocardiographic guidance. If a hook becomes engaged with a heart structure the procedure must be aborted and a decision made about whether or not to proceed with open surgery.

When the filter is across or past the TC valve and found to be involving the valve structures or heart wall open surgery for removal is the best option if the patient can tolerate the procedure. If endovascular retrieval is not possible or has been unsuccessful and the patient cannot tolerate cardiac bypass for retrieval then consideration should be given to either a hybrid procedure or anticoagulation. The patient should be informed to the significant mortality associated with anticoagulation alone as a treatment for the migrated filter.

Conclusion

The exact incidence of IVC filter migration into the heart is unknown. Newer filter designs and construction materials have led to a higher incidence of these filters leaving the RA when they migrate to the heart. Crossing the TC valve makes retrieval much more difficult because of the proximity of the valvular structures and heart wall and the need to apply torque to the filter to engage it in the retrieval sheath. Using dynamic echocardiography and following an algorithm for treatment options should increase the likelihood of successful filter retrieval and reduce the risks of major complications and death.

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