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Retrievable inferior vena cava filters in neurosurgical patients: Retrieval rates and clinical outcomes

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ABSTRACT

Objective: To assess inferior vena cava (IVC) filter retrieval rates and clinical outcomes in neurosurgical patients and to determine patient characteristics associated with filter retrieval.

Patients and methods: This single-center retrospective study included 204 consecutive neurosurgical patients (120 men, 84 women; mean age 60 ± 13 years) who underwent retrievable IVC filter insertion between 1/2011-9/2013. Institutional IVC filter database review was used to identify demographic and clinical data, indication for IVC filtration, and IVC filter type. Patients were followed clinically by the neurosurgical, hematology, and interventional radiology services until removal or conversion to a permanent device. Measured outcomes included filter retrieval rates and parameters associated with device removal.

Results: The majority of filters were placed for venous thromboembolism (200/204, 98%). Of 204 filters, 38(19%) were retrieved at median 186 days post-placement (range 3–665 days), 112(55%) converted to permanent devices, 44(22%) patients were deceased, and 10(5%) patients were lost to follow-up after transfer to an outside healthcare facility. Patients with subarachnoid hemorrhage (18% vs. 35%, p = 0.025) and malignancy (5% vs. 25%, p = 0.009) were less likely to have filters removed. Filter type (p = 0.475), gender (p = 0.221), neurosurgical procedure (p = 0.639), and insurance status (p = 0.207) did not demonstrate a significant association with filter retrieval.

Conclusion: IVC filter retrieval rates in neurosurgical patients are low despite tracking patients clinically in a multidisciplinary setting. Those neurosurgical patients with intracranial hemorrhage or malignancy requiring IVC filters have a lower likelihood of filter retrieval and may benefit from use of permanent devices.

1. Introduction

The management of venous thromboembolism (VTE) in neurosurgical patients can be challenging, given the potentially disastrous complications of systemic anticoagulation in this patient population [1]. The risk for pulmonary embolism (PE) in the general neurosurgical population ranges between 8–25%, with mortality rates between 5–60% [2]. Within this diverse population, patients at highest risk for VTE include those with brain tumors, head trauma, spinal cord injuries, stroke, and subarachnoid hemorrhage [3–5]. Mechanical prophylaxis utilizing inferior vena cava (IVC) filters plays an important role in the management of select neurosurgical patients with VTE [6,7]. Utilization of retrievable IVC filters in patients with contraindications to anticoagulation had continued to increase over the past decade [8], and nationwide retrieval rates remain low despite the introduction of dedicated IVC filter clinics and tracking systems to increase IVC filter retrieval [9]. Data regarding IVC filter retrieval in neurosurgical patients remains particularly limited. Therefore, the purpose of this study was to assess retrieval rates and clinical outcomes in neurosurgical patients treated with retrievable IVC filters and to determine patient characteristics associated with filter retrieval.

2. Material and methods

Institutional review board approval was granted for this Health Insurance Portability and Accountability Act (HIPAA) compliant study,

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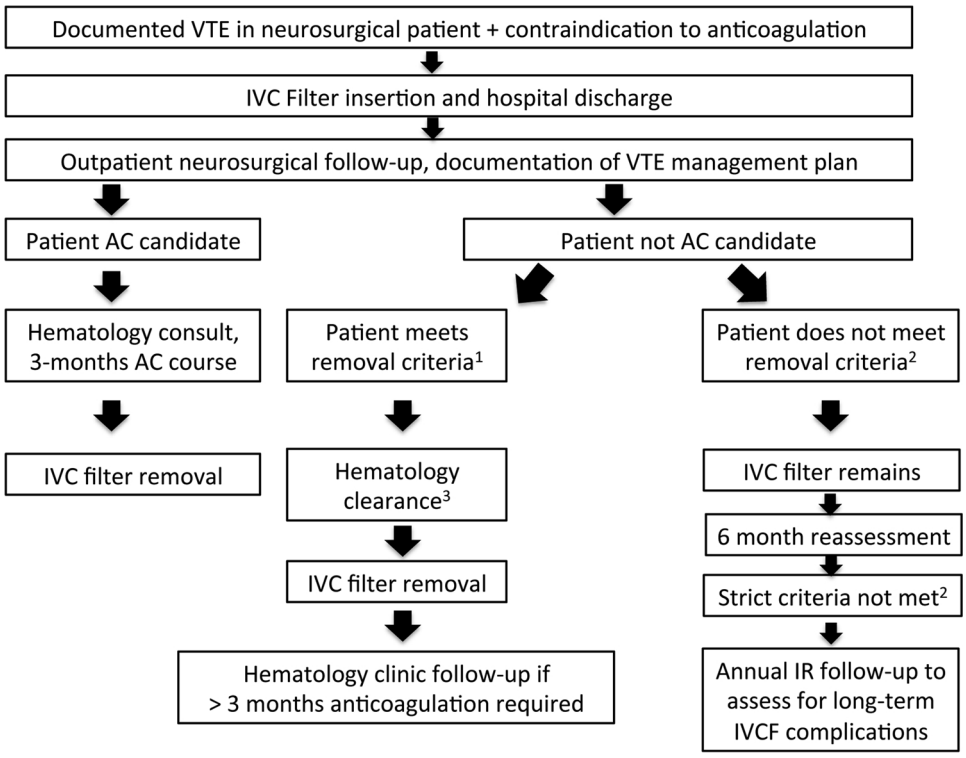

Fig. 1. Multi-disciplinary IVC filter tracking and retrieval algorithm for neurosurgical patients. [1.] = removal criteria: single transient venous thromboembolism (VTE) event, patient asymptomatic, 3-month Doppler US documented VTE clearance, no persistent VTE risk factors (e.g. immobility, hemiparesis, hypercoagulable state, cancer). [2.] = non-removal criteria: plan for future intracranial surgery, persistent or recurrent VTE (US or clinically), persistent VTE risk factors, elderly age (> 75 years), patient death or loss to follow-up. [3.] = Hematology clearance: three months post IVC filter insertion. IVCF = IVC filter, AC = anticoagulation.

with the requirement for consent for study inclusion waived. Written informed consent was obtained for the insertion and retrieval of IVC filters. All filters were placed with the intent of future filter retrieval.

2.1. Clinical setting, study design, and patient cohort

This retrospective study included 204 consecutive neurosurgical patients who underwent insertion of a retrievable IVC filter at an urban, academic tertiary care medical center between January 2011 and September 2013. This 2-year period was selected given close clinical monitoring via a multidisciplinary (Neurosurgery, Hematology, and Interventional Radiology) institutional protocol for placement and retrieval of IVC filters in neurosurgical patients during this time frame (Fig. 1). Patients were identified through review of an institutional IVC filter database, and demographic data (age, gender), clinical history (central nervous system pathology, malignancy), indication for IVC filtration (proven VTE or prophylaxis), and IVC filter types were recorded [10]. The hospital electronic medical record was further reviewed for length of hospital stay, patient disposition at discharge, and insurance status. Patients were followed clinically until IVC filter removal or conversion into a permanent device, and the IVC filter dwell time was recorded.

2.2. Patient demographics and filter indications

The study cohort consisted of 204 patients, spanning 120 (59%) men and 84 (41%) women, with a mean age of 60 ± 13 years. The predominant central nervous system abnormality was intracranial hemorrhage in 121/204 (59%) patients secondary to trauma, aneurysm rupture, or arteriovenous malformation. A neurosurgical operation was performed in 140/204 (69%) patients, of which 33 (16%) patients underwent spine surgery. Forty-four (22%) patients had an underlying malignancy, and 21 (10%) patients had an underlying central nervous system (CNS) malignancy. Venous thromboembolism with contraindication to anticoagulation was the predominant indication for IVC filtration in 200 (98%) patients, including 49 (24%) patients with documented pulmonary embolism. A total of 106 (52%) patients were diagnosed with above the knee deep venous thrombosis, 48 (24%) patients had a known DVT not otherwise classified, 38 (19%) patients with superficial venous thrombosis with concern for propagation into the deep venous system, and 8 (4%) patients had below the knee deep venous thrombosis. Prophylactic filters due to high-risk surgery were placed in 4 patients (2%). Patient demographics are summarized in Table 1.

2.3. IVC filter insertion

IVC filter insertion and retrieval procedures were performed by four Certificate of Added Qualification-licensed Interventional Radiologists with 1–15 years of clinical experience. All filters were placed in the Interventional Radiology suite. Routine ultrasound-guided venous access was gained via the internal jugular or common femoral vein under local anesthesia with placement of a 5-French sheath. Cavography was performed using a 5-French pigtail catheter positioned in the lower IVC just above the iliac vein confluence, and IVC patency, anatomy, and caliber was assessed. The 5-French accessed was upsized to accept manufacturer specific IVC filter deployment sheaths, and IVC filters were deployed in the infrarenal vena cava, typically at the L2-L3 level within a straight segment of IVC under fluoroscopic observation. Specific device selection was at the discretion of the operating Interventional Radiologist based on IVC caliber, anatomy, patency, and operator preference; IVC filters employed included 68 (33%) Celect Vena Cava Filter (Cook Medical, IN) and Günther Tulip Vena Cava Filter (Cook Medical, IN), 102 (50%) Eclipse Vena Cava Filter (Bard Peripheral Vascular, Inc., AZ, Market withdrawal), Express Vena Cava Filter (Bard Peripheral Vascular, Inc., AZ, Market withdrawal), Meridian Vena Cava Filter (Bard Peripheral Vascular, Inc., AZ, Market withdrawal) and Denali Vena Cava Filter (Bard Peripheral Vascular, Inc., AZ) and 34 (17%) Option Elite Inferior Vena Cava Filter System (Argon Medical Devices, TX).

2.4. IVC filter retrieval

Discontinuation of vena cava filtration was performed according

Table 1
Patient demographics and disease characteristics in 204 neurosurgical patients.

Measure	All IVC Filter Insertions
Gender male/female	120/84
Age (years)	60 ± 13
Intracranial hemorrhage	121 (59%)
Neurosurgical operation	140 (69%)
Systemic malignancy	44 (22%)
Intracranial lesion	21 (10%)
Deceased at follow-up	40 (20%)
Indication for IVC Filtration	
- Venous thromboembolism	200 (98%)
- Prophylaxis	4 (2%)
Pulmonary Embolism	49 (24%)
DVT chronicity	
- Acute	177 (87%)
- Subacute	6 (3%)
- Chronic	17 (8%)
Location	
- Above knee	106 (52%)
- Superficial	38 (19%)
- Known DVT, not otherwise characterized	48 (24%)
- Infrapopliteal	8 (4%)
IVC Filter retrieval	38/204 (19%)
Converted to permanent filter	112 (55%)
Length of stay (days)	22 ± 15
IVC Filter manufacturer	
● Cook Medical Gunther-Tulip, Celect	68 (33%)
● Bard Eclipse, Express, Meridian, Denali	102 (50%)
● Argon Option Elite	34 (17%)
Insurance	
- Medicare/Medicaid	87 (43%)
- Health Maintenance Organization (HMO)	47 (23%)
- Preferred Provider Organization (PPO)	45 (22%)
- Veterans Affairs (VA)	4 (2%)
- No insurance	19 (9%)
- State insurance	2 (1%)

when patients became eligible for removal based on the institutional IVC filter removal algorithm which mirrored the Society of Interventional Radiology (SIR) standards of practice on IVC filters [11]. Briefly, patients were deemed eligible for removal following outpatient hematology clearance for patients that met removal criteria as outlined in Fig. 1. The decision to remove each filter was individualized for each patient.

Prior to IVC filter retrieval, fluoroscopic spot images and venography of the inferior vena cava were acquired to assess for filter complications including filter tilt, migration, or fracture. IVC filter retrievals were performed using an internal jugular approach under IV moderate sedation with placement of a 13–16 French sheath. Cavography was performed to assess for IVC patency and filter thrombus. Retrieval was initially attempted using standard loop snare technique. If standard retrieval techniques failed, advanced retrieval techniques were utilized at the discretion of the operator, including wire-loop technique, forceps retrieval, stiff wire-displacement, dual-access, and balloon-displacement techniques [12] (Fig. 2).

2.5. Measured outcomes and statistical analysis

The outcome measures of this study were (1) IVC filter retrieval rates, (2) correlation between patient characteristics (type of central nervous system pathology, cancer, age, gender, IVC filter type, and insurance, length of stay, and patient disposition at discharge) and filter retrieval or conversion into a permanent device.

Descriptive statistics were utilized for demographical characterization of the study population. Comparisons for continuous normally distributed variables were performed by the independent samples t-test. Comparisons for categorical data were performed using Pearson's chi-squared test. Multivariate binary logistic regression analysis used to assess the influence of patient, disease, and procedure characteristics on IVC filter retrieval rates. A significance level of 0.10 in univariate analysis was used as a cutoff to include a variable in multivariate analysis. Statistical analyses were performed using commercially available software (SPSS version 22, IBM), and $p \leq 0.05$ was considered statistically significant.

3. Results

3.1. Filter retrieval and correlation with patient characteristics

Median filter dwell time was 186 (range 3–665) days. A total of 38/204 (19%) were retrieved, of which 2 (1%) filters were retrieved at an outside hospital. During retrieval, 9 filters were found to have an embedded hook, 7 filters had struts penetrating more than 3 mm beyond the inferior vena cava wall, 1 filter was partially fractured, 1 filter had clot trapped in the filter apex, 1 filter had migrated from its infrarenal placement position, and 1 case of filter related IVC occlusion occurred.

The majority of filters were retrieved using standard retrieval technique (27/38; 71%). Advanced retrieval techniques were utilized in 11 (29%) retrievals. One filter could not be removed despite utilization of advanced retrieval techniques.

One hundred twelve of 204 (55%) of filters were converted to permanent filters on clinical follow-up due to continuing contraindication to anticoagulation, persistent VTE risk factors, persistent or recurrent VTE, plan for future intra-cranial surgery, or non-compliance with follow-up; the remaining 54 non-retrieved filters were not retrieved because patients were deceased at the time of follow-up (44/204; 22%) or lost to follow-up after transfer to an outside facility (10/204, 5%).

Patients with subarachnoid hemorrhage (7/38; 18% vs. 58/166, 35%; $p = 0.025$) and intracranial malignancy (2/38; 5% vs. 42/166, 25%, $p = 0.009$) were less likely to have their filters removed. A trend towards significance was observed with patient age (56 years vs. 61 years, $p = 0.052$). Filter type ($p = 0.471$), gender ($p = 0.221$), neurosurgical procedure ($p = 0.639$), and insurance status ($p = 0.207$) did not demonstrate a correlation with filter retrieval. Tables 1 and 2 summarize these findings.

3.2. Clinical outcomes

Of 204 patients, 164 (80%) were alive at the time of Interventional Radiology follow-up. The majority of patients were either discharged to a rehabilitation facility (94/204, 46%) or home (84/204, 41%); 7% (15/204) of patients either expired during their hospital stay or were transferred to hospice; 5% (10/204) of patients were transferred to another healthcare facility, and 1 patient returned to prison.

4. Discussion

The low retrieval rate in our study highlight the challenges associated with retrieval of IVC filters in neurosurgical patients. Despite tracking patients clinically in a multidisciplinary setting with Neurosurgery, Hematology, and Interventional Radiology, only 19% of filters in the current study were retrieved. Patients with subarachnoid hemorrhage and malignancy were less likely to have their IVC filter removed, and there was a trend towards significance with increasing patient age. In addition, more than half of the inserted filters were converted into permanent devices on follow-up. Challenges specific to filter retrieval in neurosurgical patients are the often-persistent contraindications to anticoagulation, increased rates of immobility and morbidity compared to general patient populations, and difficulty maintaining longitudinal follow-up in a tertiary care referral center. In a retrospective analysis of factors impacting retrieval, similar results were described by Gyang et al. in 65 patients with retrievable IVC filters and CNS pathology [13]. These authors noted that patients with CNS pathology were significantly less likely to obtain outpatient follow-up,

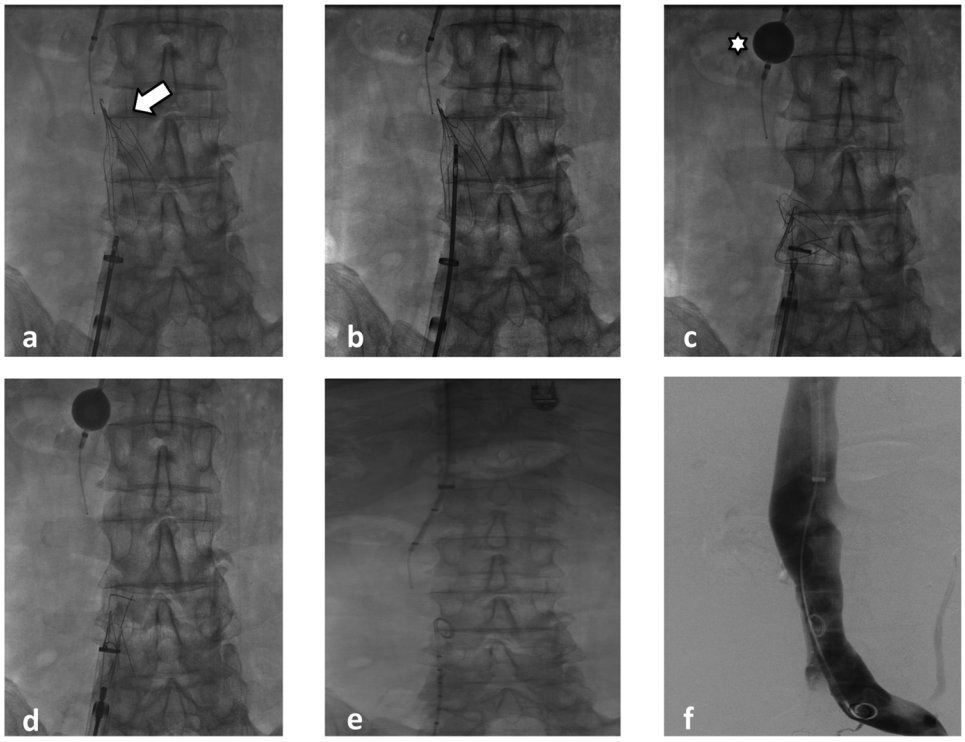

Fig. 2. Advanced IVC filter retrieval using bronchial forceps and dual sheath technique. A – Fluoroscopic spot image of the inferior vena cava demonstrates dual access and sheath placement from the right internal jugular and common femoral veins. Note filter deformity as a result of prior unsuccessful retrieval (arrow). B – Blunt dissection of fibrous tissue encasing the filter is performed with a bronchial forceps. C – Proximal temporary occlusion balloon (star) has been inflated to prevent proximal embolization of filter fragments. D–E – Complete removal of filter through common femoral sheath. **F** – Completion vena cavogram shows no caval narrowing or injury.

and suspected that filters implanted in these patients were often maintained as permanent filters in a population that is thought to be at higher long-term risk for VTE [13]. This finding was confirmed in the larger cohort in this current study.

Retrievable filters represent the majority of filters placed in current medical practice [14], and while placement of IVC filters has decreased over the past decade, retrieval rates remain low, approximating 13% [9]. A unifying feature of most retrievable IVC filters is the "cone" or "umbrella" design, with the apex directed cephalad. The apex typically contains a "hook" or structure that allows engagement with a dedicated retrieval device or a general endovascular snare to facilitate retrieval from a jugular venous approach. All of the retrievable IVC filters in this study featured the above design. When the filter apex or "hook" cannot be engaged by the designated retrieval cone or other retrieval snares, standard retrieval techniques may not allow filter retrieval. Inability to engage the filter apex can be due to a number of reasons, including

Table 2
Analysis of prognostic factors affecting IVC filter retrieval in 204 neurosurgical patients.

Factor	Retrieved (n = 38)	Not Retrieved (n = 166)	Retrieval correlation univariate analysis	Retrieval correlation multivariate analysis
Gender			0.221	
Male	19 (50%)	101 (61%)		
Female	19 (50%)	65 (39%)		
Average age (years)	56	61	0.035	0.052
Venous thromboembolism	38 (100%)	162 (98%)	0.334	
Deep venous thrombosis	30 (79%)	129 (78%)	0.591	
Pulmonary embolism	9 (24%)	40 (24%)	0.960	
Malignancy	2 (5%)	42 (25%)	**0.007**	**0.009**
Intracranial lesion	2 (5%)	19 (11%)	0.254	
IVC filter manufacturer			0.471	
Cook Gunther-Tulip, Celect	15 (39%)			
Bard Eclipse, Express, Meridian, Denali	15 (39%)	166	0.471	
Argon Option Elite	8 (22%)			
Intracranial hemorrhage	23 (61%)	98 (59%)	0.866	
Aneurysm	11 (29%)	26 (16%)	0.058	0.994
Arteriovenous malformation/fistula	3 (8%)	5 (3%)	0.165	
Subarachnoid hemorrhage	7 (18%)	58 (35%)	**0.046**	**0.025**
Subdural hemorrhage	2 (5%)	8 (5%)	0.915	
Spine pathology	9 (2%)	24 (14%)	0.169	
Insurance			0.207	
Medicare/Medicaid	14 (37%)	73 (44%)		
Health Maintenance Organization (HMO)	8 (21%)	39 (23%)		
Preferred Provider Organization (PPO)	14 (37%)	31 (19%)		
	0	4 (2%)		
Veterans Affairs (VA)	2 (5%)	17 (10%)		
No insurance	0	2 (1%)		
State insurance				
Average length of stay (days)	21 ± 15	22 ± 15	0.637	
Transfer to outside facility	26 (68%)	132 (79%)	0.121	

malpositioning of the filter apex in the renal vein, filter tilt, encasement of the filter apex in the adjacent IVC wall, filter fracture, significant extracaval protrusion of filter elements, fibrin cap, or filter associated thrombus. In these cases, advanced retrieval techniques can be utilized to successfully remove most retrievable IVC filters.

The benefits of dedicated IVC filter clinics that allow for standardized and consistent patient follow-up and outreach to facilitate retrieval has been well documented in the literature [15]. In the subset of patients with CNS trauma or bleeding, there is continued debate regarding the timing and course of anticoagulation [16,17]. Given the anticipated low retrieval rates in this population, some authors have advocated for the placement of permanent IVC filters in this specific subset of neurosurgical patients [18]. Permanent filters are placed at the author's institution at the discretion of the operating interventional radiologist, usually in patients with advanced age or an indication for long-term protection from venous thromboembolism when the likelihood of future retrieval is deemed low. The decision to place a permanent versus a retrievable device has to be individualized for each patient, and the interventional radiologist plays a critical role in advising referring clinicians on device selection. Prospective consultation with an interventional radiologist prior to filter utilization has been shown to improve retrieval rates [19]. A decision support tool utilizing nine clinical parameters to estimate probability of device retrieval has been previously described to assist the interventional radiologist in decision making regarding permanent versus retrievable filters [20]. Retrievable IVC filters present an attractive option if retrieval is performed; however, complication rates for retrievable compared to permanent filters are significantly higher for retrievable filters [21,22]. This would suggest that permanent devices be used unless retrieval is anticipated sometime in the future. Based on the results of this study, insertion of permanent devices should be considered in the neurosurgical population, given that more than half of the filters placed in this cohort were eventually converted into permanent devices. Permanent IVC filtration eliminates the need for follow-up clinic visits to determine eligibility for potential filter removal, lowers the rate of device specific complications, and reduces potentially challenging filter removal procedures in patients with extended filter dwell times. Janne d'Othée et al. evaluated whether placement of a non-retrievable IVC filter would be more cost effective in selected patients [23]. Their results suggested that retrievable filters represent a financially profitable option if at least 41% of retrievable filters placed are retrieved, and the procedure is reimbursed at least 50% of the time. In our study, only 19% of filters were retrieved, which falls short of the 41% threshold suggested by Janne d'Othée et al., suggesting that permanent IVCF devices should be considered in all neurosurgery patients, though this conclusion needs to be supported by additional corroborative investigations.

Several limitations warrant further discussion. First, this study is limited by its retrospective nature and limited sample size at a single institution studying a tertiary care neurosurgical population, and may not translate broadly. Second, several interventional radiologists were involved in the follow-up of patients, potentially influencing the approach and outcome of conversion to permanent filter devices. Third, routine imaging follow-up of patients with filters converted to permanent devices to detect long term device complications was not performed. Fourth, the presented data are subject to quality of documentation in the electronic medical record. Finally, the data are limited to a single institution tertiary referral center, with many neurosurgical patients transferred from outside institutions, which may prohibit generalization of the data, and possibly underestimate retrieval rates if additional filters were removed at outside hospitals. However, this sample of 204 consecutive patients over a 2-year period by and large captures a realistic demographic representation of neurosurgical patients that usually receive care at similar institutions.

5. Conclusion

In conclusion, these results indicate that retrieval of IVC filters in a neurosurgical population is challenging despite multidisciplinary clinical tracking of patients, and that a large amount of filters are converted into permanent devices during follow-up. Placement of permanent devices may be particularly appropriate in neurosurgical patients with cancer or subarachnoid hemorrhage. Additional studies are required to better understand the role of IVC filters in this patient population.

References

[1] K. Suzuki, Y. Kato, T. Hayashi, H. Maruyama, Y. Kikkawa, H. Kurita, The dose of direct oral anticoagulants and outcomes of intracerebral hemorrhage: preliminary findings, Clin. Neurol. Neurosurg. 174 (2018) 63–67.

[2] M.G. Hamilton, R.D. Hull, G.F. Pineo, Venous thromboembolism in neurosurgery and neurology patients: a review, Neurosurgery 34 (2) (1994) 280–296 discussion 296.

[3] M.P. Glotzbecker, C.M. Bono, K.B. Wood, M.B. Harris, Thromboembolic disease in spinal surgery: a systematic review, Spine (Phila Pa 1976) 34 (3) (2009) 291–303.

[4] V.R. Kshettry, B.P. Rosenbaum, A. Seicean, M.L. Kelly, N.K. Schiltz, R.J. Weil, Incidence and risk factors associated with in-hospital venous thromboembolism after aneurysmal subarachnoid hemorrhage, J. Clin. Neurosci. 21 (2) (2014) 282–286.

[5] M.B. Cloney, J.T. Yamaguchi, E.S. Dhillon, B. Hopkins, Z.A. Smith, T.R. Koski, N.S. Dahdaleh, Venous thromboembolism events following spinal fractures: a single center experience, Clin. Neurol. Neurosurg. 174 (2018) 7–12.

[6] A.J. Ghanim, C. Daskalakis, D.J. Eschelman, W.K. Kraft, A five-year, retrospective, comparison review of survival in neurosurgical patients diagnosed with venous thromboembolism and treated with either inferior vena cava filters or anticoagulants, J. Thromb. Thrombolysis 24 (3) (2007) 247–254.

[7] M.K. Rosner, T.R. Kuklo, R. Tawk, R. Moquin, S.L. Ondra, Prophylactic placement of an inferior vena cava filter in high-risk patients undergoing spinal reconstruction, Neurosurg. Focus 17 (4) (2004) E6.

[8] J.P. Montgomery, J.A. Kaufman, A critical review of available retrievable inferior vena cava filters and future directions, Semin. Intervent. Radiol. 33 (2) (2016) 79–87.

[9] E. Morris, R. Duszak Jr., A.K. Sista, J. Hemingway, D.R. Hughes, A.B. Rosenkrantz, National trends in inferior vena cava filter placement and retrieval procedures in the medicare population over two decades, J. Am. Coll. Radiol. 15 (8) (2018) 1080–1086.

[10] S.F. Millward, C.J. Grassi, T.B. Kinney, S. Kundu, G.J. Becker, J.F. Cardella, L.G. Martin, J.E. Silberzweig, D. Sacks, R. Technology Assessment Committee of the Society of Interventional, Reporting standards for inferior vena caval filter placement and patient follow-up: supplement for temporary and retrievable/optional filters, J. Vasc. Interv. Radiol. 20 (7 Suppl) (2009) S374–6.

[11] J.A. Kaufman, T.B. Kinney, M.B. Streiff, R.F. Sing, M.C. Proctor, D. Becker, M. Cipolle, A.J. Comerota, S.F. Millward, F.B. Rogers, D. Sacks, A.C. Venbrux, Guidelines for the use of retrievable and convertible vena cava filters: report from the Society of Interventional Radiology multidisciplinary consensus conference, J. Vasc. Interv. Radiol. 17 (3) (2006) 449–459.

[12] B. Iliescu, Z.J. Haskal, Advanced techniques for removal of retrievable inferior vena cava filters, Cardiovasc. Intervent. Radiol. 35 (4) (2012) 741–750.

[13] E. Gyang, M. Zayed, E.J. Harris, J.T. Lee, R.L. Dalman, M.W. Mell, Factors impacting follow-up care after placement of temporary inferior vena cava filters, J. Vasc. Surg. 58 (2) (2013) 440–445.

[14] E. DeYoung, J. Minocha, Inferior vena cava filters: guidelines, best practice, and expanding indications, Semin. Intervent. Radiol. 33 (2) (2016) 65–70.

[15] J. Minocha, I. Idakoji, A. Riaz, J. Karp, R. Gupta, H.B. Chrisman, R. Salem, R.K. Ryu, R.J. Lewandowski, Improving inferior vena cava filter retrieval rates: impact of a dedicated inferior vena cava filter clinic, J. Vasc. Interv. Radiol. 21 (12) (2010) 1847–1851.

[16] F.B. Rogers, M.D. Cipolle, G. Velmahos, G. Rozycki, F.A. Luchette, Practice management guidelines for the prevention of venous thromboembolism in trauma patients: the EAST practice management guidelines work group, J. Trauma 53 (1) (2002) 142–164.

[17] A. Farooqui, B. Hiser, S.L. Barnes, N.S. Litofsky, Safety and efficacy of early thromboembolism chemoprophylaxis after intracranial hemorrhage from traumatic brain injury, J. Neurosurg. 119 (6) (2013) 1576–1582.

[18] A.J. Comerota, Retrievable IVC filters: a decision matrix for appropriate utilization, Perspect. Vasc. Surg. Endovasc. Ther. 18 (1) (2006) 11–17.

[19] R.K. Ryu, P. Parikh, R. Gupta, A.C. Eifler, R. Salem, R.A. Omary, R.J. Lewandowski, Optimizing IVC filter utilization: a prospective study of the impact of interventional radiologist consultation, J. Am. Coll. Radiol. 9 (9) (2012) 657–660.

[20] A.C. Eifler, R.J. Lewandowski, R. Gupta, J. Karp, R. Salem, J. Lee, R.K. Ryu, Optional or permanent: clinical factors that optimize inferior vena cava filter utilization, J. Vasc. Interv. Radiol. 24 (1) (2013) 35–40.

[21] J.M. Andreoli, R.J. Lewandowski, R.L. Vogelzang, R.K. Ryu, Comparison of complication rates associated with permanent and retrievable inferior vena cava filters: a review of the MAUDE database, J. Vasc. Interv. Radiol. 25 (8) (2014) 1181–1185.

[22] S.E. Deso, I.A. Idakoji, W.T. Kuo, Evidence-based evaluation of inferior vena cava filter complications based on filter type, Semin. Intervent. Radiol. 33 (2) (2016) 93–100.

[23] B. Janne d'Othee, S. Faintuch, A.W. Reedy, C.F. Nickerson, M.P. Rosen, Retrievable versus permanent caval filter procedures: when are they cost-effective for interventional radiology? J. Vasc. Interv. Radiol. 19 (3) (2008) 384–392.