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Costs and complications of endovascular inferior vena cava filter retrieval

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ABSTRACT

Objective: Advanced endovascular techniques are frequently used for challenging inferior vena cava (IVC) filter retrieval. However, the costs of IVC filter retrieval have not been studied. This study compares IVC filter retrieval techniques and estimates procedural costs.

Methods: Consecutive IVC filter retrievals performed at a tertiary center between 2009 and 2014 were retrospectively reviewed. Procedures were classified as standard retrieval (SR) if they required only a vascular sheath and a snare device and as advanced endovascular retrieval (AER) if additional endovascular techniques were used for retrieval. Cost data were based on hospital bills for the procedures. Patients' characteristics, filter dwell time, retrieval procedure details, complications, and costs were compared between the groups. All statistical comparisons were performed using SAS 9.3 software.

Results: There were 191 IVC filter retrievals (SR, 157; AER, 34) in 183 patients (mean age, 55 years; 51% male). Fifteen filters (7.9%) were placed at an outside hospital. The indications for placement were mostly therapeutic (76% vs 24% for prophylaxis). All IVC filters were retrievable, with Bard Eclipse (Bard Peripheral Vascular, Tempe, Ariz; 34%) and Cook Günther Tulip (Cook Medical, Bloomington, Ind; 24%) the most common. Venous ultrasound examination of the lower extremities of 133 patients (70%) was performed before retrieval, whereas only 5 patients (2.6%) received a computed tomography scan of the abdomen. There was no difference in the mean filter dwell time in the two groups (SR, 147.9 ± 146.1 days; AER, 161.4 ± 91.3 days; $P = .49$). AERs were more likely to have had prior attempts at retrieval (23.5%) compared with SRs (1.9%; $P < .001$). The most common AER techniques used were the wire loop and snare sling (47.1%) and the stiff wire displacement (44.1%). Bronchoscopy forceps was used in four cases (11.8%); this was the only off-label device used. AERs were more likely to require more than one venous access site for the retrieval procedure (23.5% vs 0%; $P < .001$). AERs were significantly more likely to have longer fluoroscopy time (34.4 ± 18.3 vs 8.1 ± 7.9 minutes; $P < .001$) and longer total procedural time (102.8 ± 59.9 vs 41.1 ± 25.0 minutes; $P < .001$) compared with SRs. The complication rate was higher with AER (20.6%) than with SR (5.2%; $P = .006$). Most complications were abnormal radiologic findings that did not require additional intervention. The procedural cost of AER was significantly higher (AER, \$14,565 ± \$6354; SR, \$7644 ± \$2810; $P < .001$) than that of SR. This translated to an average increase in cost of \$6921 ± \$3544 per retrieval procedure for AER.

Conclusions: Advanced endovascular techniques provide a feasible alternative when standard IVC filter retrieval techniques do not succeed. However, these procedures come with a higher cost and higher rate of complications. (J Vasc Surg: Venous and Lym Dis 2019;7:653-9.)

Keywords: Inferior vena cava filter retrieval; Advanced endovascular techniques; Cost of procedures

Retrieval of inferior vena cava (IVC) filters is often a technically simple procedure performed with a snare and a coaxial sheath. A variety of technical factors, such as filter tilt, IVC filter migration, IVC penetration, and prolonged dwell time, make retrieval difficult in some cases.[1-3] A variety of advanced endovascular techniques have demonstrated success in retrieval of IVC filters with challenging configurations.[4-6] However, these advanced techniques pose additional risks of complications to the patient and probably increase the costs of filter retrieval.[4,6-8]

In the current era focused on value-based care, procedural costs and risks from complications need to be

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weighed against the benefits of IVC filter retrieval to the patient. The purpose of this study was to estimate the procedural cost of retrieving IVC filters. The secondary objectives were to compare the technical factors and to review the complications associated with the various techniques of IVC filter retrieval in a tertiary academic medical center.

METHODS

Patients' characteristics. This study was approved by the human investigation committee at Yale University without the need of informed consent. Patients undergoing consecutive IVC filter retrieval were identified on the basis of *Current Procedural Terminology* (CPT) codes. The CPT codes queried were 37203 and 75961 before August 2012 and 37193 from then on (Supplementary Table, online only). The electronic medical records of patients undergoing consecutive IVC filter retrieval between 2009 and 2014 were reviewed. All procedures were performed by vascular surgeons or interventional radiologists. Patients' demographics and selected comorbidities that can affect the decision to place an IVC filter, such as cancer, hypercoagulable states, failure of anticoagulation, and trauma, were noted. The indications of IVC filter placement were divided into prophylactic and therapeutic. Filter placement was defined as therapeutic in the presence of venous thromboembolism (VTE) with contraindication to or failure of anticoagulation and as prophylactic in patients deemed to be at high risk for VTE in the presence of a transient contraindication to pharmacologic VTE prophylaxis. The type of IVC filter placed was captured when available.

Preretrieval evaluation. The indications for IVC filter retrieval were divided into routine and symptomatic. The type of symptoms that the patient experienced related to the IVC filter were noted. IVC filters with asymptomatic strut penetration were classified under routine indication for retrieval. The type of imaging, if any, before retrieval was noted, as was the dwell time from IVC filter placement until retrieval or attempted retrieval.

IVC filter retrieval procedures. IVC filter retrieval was considered standard retrieval (SR) if it was performed with the use of a snare and a coaxial sheath. The use of any additional techniques or tools to retrieve the IVC filter was considered advanced endovascular retrieval (AER). AER techniques were classified as stiff wire displacement, loop snare realignment, wire loop and snare sling technique, wire and snare flossing, balloon displacement, parallel wire and dual sheath, and dissection with off-label tools (endobronchial forceps) as described in the literature.[9-12] The techniques used were abstracted from the procedural notes. The procedural notes for IVC filter retrieval were reviewed in detail focusing on vascular access, techniques used, fluoroscopy time, and procedure time. The retrieval attempt was considered successful if the IVC filter was retrieved. Complications related to the IVC filter were reviewed.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective review of single-center cohort
- **Key Findings:** In this review of 191 inferior vena cava (IVC) filter retrievals, the success with standard retrieval (SR) was 96.2%. In challenging filter configurations, advanced endovascular retrieval (AER) provided a high success rate (73.5%). The average cost of IVC filter retrieval was $8852. The cost of AER ($14,565 ± $6354) was significantly higher than the cost of SR ($7644 ± $2810). The rate of complications was higher with AER (20.6%) compared with SR (5.2%).
- **Take Home Message:** Challenging IVC filter retrieval using AER increases the costs and complications compared with SR.

Costs of IVC filter retrieval. The hospital bills related to the IVC filter retrieval procedures were reviewed to estimate the costs of the procedures. The bills estimate the charges, but the corresponding data on collection were not available. Also, the bills and the charges of the vascular specialists (professional component) were not available for review. These bills were identified on the basis of the CPT codes 37203 and 75961 before August 2012 and 37193 from then on (Supplementary Table, online only). Cost to charge ratio was used to estimate costs from billing data and charges. All costs were adjusted for inflation using the medical care-specific Consumer Price Index and presented in 2018 U.S. dollars.

Data collection and statistical analysis. The procedures were divided on the basis of technique into SR and AER, and patients' characteristics, procedure details, complications, and costs were compared between the groups. Study data were collected and managed using REDCap (Research Electronic Data Capture) hosted at Yale University. REDCap is a secure, web-based application designed to support data capture for research studies.[13] Frequencies of variables and clinical outcomes between groups undergoing SR and AER were compared using the χ^2 or Fisher exact test for categorical variables. Differences in continuous variables were evaluated using two-sample *t*-tests. Differences were considered statistically significant with *P* value $<.05$. All analysis was performed using SAS version 9.3 software (SAS Institute, Cary, NC).

RESULTS

Patients' characteristics. A total of 191 retrieval procedures were attempted in 183 patients. The mean age of the patients in the study was 55 years. There was no

Table I. Patients' demographics and risk factors

	SR (n = 157)	AER (n = 34)	*P* value
Patient factors			
Age, years	56.25 ± 15.62	51.18 ± 17.21	.119
Male	83 (52.87)	14 (41.18)	.295
Indication			.463
Therapeutic	117 (74.52)	28 (82.35)	
Prophylaxis	40 (25.48)	6 (17.65)	
Risk factors			
Perioperative	77 (49.68)	13 (38.24)	.308
Compromised lung function	69 (45.10)	11 (33.33)	.296
Bleeding risk	47 (30.32)	11 (33.33)	.978
Trauma	34 (21.79)	5 (14.71)	.488
Obesity (BMI >35 kg/m^2)	29 (18.95)	8 (23.53)	.713
Neurologic disorder	26 (16.88)	4 (11.76)	.608
Cancer	25 (16.67)	6 (18.75)	.978
Hypercoagulable disorder	16 (10.32)	8 (24.24)	.042
Failed anticoagulation	6 (3.87)	1 (2.94)	.999
Pregnancy or post partum	3 (1.95)	0 (0.00)	.999

AER, Advanced endovascular retrieval; *BMI,* body mass index; *SR,* standard retrieval.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

difference in age, sex, or risk factors between the groups. IVC filters were placed for a variety of risk factors in both groups (Table I). There were 90 patients (47.1%) who received an IVC filter in a perioperative period. Trauma accounted for around 50% of perioperative filters (20.4% of all IVC filters). There was a history of cancer in 31 patients (16.2%) and a history of a hypercoagulable state in 24 patients (12.5%). The most common indication for IVC filter placement was therapeutic in 75.9%, whereas only 24.1% were prophylactic. There were 15 IVC filters (7.9%) placed at an outside facility. The types of filters and the corresponding frequencies are listed in Table II.

IVC filter retrieval. There were 34 (17.8%) AER and 157 (82.2%) SR procedures. The majority of the patients underwent retrieval as outpatients (97.4%) and for a routine indication (98.9%). Two patients (1%) underwent retrieval attempts because of symptoms from IVC filter-related morbidity (AER, 2.9%; SR, 0.6%; $P = .33$). One had perforation into the spine and presented with back pain, and the second had penetration into the right renal vein and presented with abdominal pain. The most common form of imaging before retrieval was lower extremity venous duplex ultrasound (69.6%), followed by no imaging (26.7%) and computed tomography of the abdomen in 2.6% (Table III). Before IVC filter retrieval, 58.1% were receiving anticoagulant agents (n = 111). Most of these patients were instructed to hold anticoagulation in the periprocedural period. Only 9.9% were therapeutic on anticoagulation at the time of retrieval. There was no significant difference between the groups in terms of imaging ($P = .99$). Most patients (94.2%) had no prior attempt at IVC filter retrieval (Table III). IVC filters in the AER group were significantly more likely to have undergone previously unsuccessful attempts (AER, 23.5%; SR, 1.9%; $P < .001$). In 26 patients (76%), SR was unsuccessful, and during the same procedure the operator attempted to use AER with overall success of 69.2% in IVC filter retrieval. On the other hand, the use of AER was staged in eight patients (24%), with the patients coming back for a second procedure after failed SR. The success rate for retrieval with staged AER was 75%. There was no statistically significant difference in the retrieval success using AER during the same procedure after failure of SR or in a staged fashion (69.2% vs 75%; $P = .99$). There was no significant difference in mean dwell time between groups ($P = .49$). AER procedures were significantly more likely to require longer fluoroscopy time (AER, 34.4 ± 18.3 minutes; SR, 8.1 ± 7.9 minutes; $P < .001$) and longer total procedural time compared with SR (AER, 102.8 ± 59.9 minutes; SR, 41.1 ± 25.0 minutes; $P < .001$; Table IV). In addition, AER procedures were significantly more likely to be performed with multiple venous access sites (AER, 23.5%; SR, 0%; $P < .001$). The most commonly attempted AER techniques were wire loop-snare sling (47.1%) and stiff wire displacement (44.1%), followed by loop snare realignment (29.4%), balloon displacement (14.7%), and wire-snare flossing (2.9%). Bronchoscopy forceps was the only off-label tool used in this series in four (11.8%) AER procedures. The most successful AER

Table II. Frequencies of retrieved inferior vena cava (*IVC*) filters

IVC filter type	No. (%)
Bard Eclipse (Bard Peripheral Vascular, Tempe, Ariz)	64 (33.50)
Cook Günther Tulip (Cook Medical, Bloomington, Ind)	46 (24.08)
Argon Option (Argon Medical Devices, Plano, Tex)	37 (19.37)
Bard G2 (Bard Peripheral Vascular)	16 (8.37)
Bard Denali (Bard Peripheral Vascular)	10 (5.23)
Not specified	9 (4.71)
Cook Celect (Cook Medical)	7 (3.66)
Cordis OptEase (Cordis Corporation, Bridgewater, NJ)	2 (1.05)

Table III. Preretrieval evaluation

Preretrieval evaluation	SR (n = 157), No. (%)	AER (n = 34), No. (%)	*P* value
Imaging			.999
Duplex ultrasound of lower limb	109 (70.32)	24 (70.59)	
None	42 (27.10)	9 (26.47)	
Computed tomography of abdomen	4 (2.58)	1 (2.94)	
Indication for retrieval			.999
Routine retrieval	156 (99.36)	33 (97.06)	
Symptomatic	1 (0.64)	1 (2.94)	
Prior retrieval attempts	3 (1.91)	8 (23.53)	<.001

AER, Advanced endovascular retrieval; *SR*, standard retrieval.

Table IV. Retrieval characteristics

Retrieval characteristics	SR (n = 157)	AER (n = 34)	*P* value
Dwell time, days	147.90 ± 146.11	161.36 ± 91.32	.499
Fluoroscopy time, minutes	8.05 ± 7.97	34.37 ± 18.27	<.001
Total procedure time, minutes	41.15 ± 25.01	102.81 ± 59.85	<.001
Access sites			<.001
Single	157 (100.00)	26 (78.79)	
Dual or triple	0 (0.00)	8 (23.53)	
Successful filter retrieval	151 (96.18)	25 (73.53)	<.001

AER, Advanced endovascular retrieval; *SR*, standard retrieval.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.

Table V. Complications from inferior vena cava (*IVC*) filter retrieval

Retrieval complications	SR (n = 157), No. (%)	AER (n = 34), No. (%)	*P* value
Extravasation	2 (1.29)	1 (2.94)	.447
Access hematoma	1 (0.64)	0 (0.00)	.999
Dissection	2 (1.29)	1 (2.94)	.447
IVC stenosis	2 (1.29)	3 (8.82)	.040
Strut fracture and migration	1 (0.64)	1 (2.94)	.325
Emergent open surgery	0 (0.00)	1 (2.94)	.180
All morbidity	8 (5.19)	7 (20.58)	.006

AER, Advanced endovascular retrieval; *SR*, standard retrieval.

technique was stiff wire displacement (29.4%) and wire loop-snare sling (23.5%), followed by bronchoscopy forceps (11.7%) and loop snare realignment (8.8%). Thrombus was noted in the filter in 10 (5.23%) procedures and was deemed to be clinically insignificant. Most of these filters (70%) were retrieved during the same procedure. The presence of thrombus in the filter did not significantly affect SR or AER procedures ($P = .99$). Overall, the success rate of endovascular IVC filter retrieval was 91.6% (n = 175). Individual success rates in both groups were also high, but SR was more likely to be successful at filter retrieval than AER (SR, 96.2%; AE, 73.5%; $P < .001$).

Complications. There was no periprocedural mortality. The overall rate of complications was 7.9% (n = 15). The rate of procedural complications was higher with AER techniques than with SR techniques (AER, 20.6%; SR, 5.2%; $P = .006$; Table V). The use of anticoagulant agents did not significantly affect complications ($P = .27$). Most complications were based on radiologic reporting and required additional imaging or observation but did not have clinical sequelae.

One patient required urgent open femoral vein exploration. The filter (Günther Tulip; Cook Medical, Bloomington, Ind) was tilted such that the apex was embedded into the right renal vein and the struts were embedded in the right lateral IVC wall. After a failed attempt at an outside facility, the patient underwent an AER attempt through right internal jugular vein and right common femoral vein access sites in the interventional radiology suite. AER techniques used were loop snare realignment, wire loop and snare sling, and balloon displacement techniques. The legs of the IVC filter were bent in the process and could not be collapsed into the jugular sheath. The patient was then urgently transferred to the operating room for filter retrieval through cutdown of the right common femoral vein. The patient was then admitted to the hospital for observation overnight. Subsequently in the postoperative period, the patient also developed a lymphocele in the right thigh requiring multiple sessions of aspiration before resolution.

Two patients had strut fractures with migration to the right ventricle and the right inferior pulmonary artery during retrieval. Additional attempts to retrieve the migrated struts were made with no success during the same procedure. Both patients were asymptomatic and were monitored in the hospital for 24 hours. They remain asymptomatic at up to 7 years of follow-up, with repeated imaging documenting the fragments in the same positions.

In another case, after successful removal of a Bard Denali filter (Bard Peripheral Vascular, Tempe, Ariz), the patient was noted to have an intimal flap confirmed by intravascular ultrasound, suggestive of IVC dissection. The patient was admitted for observation overnight. The following day, repeated venography showed mild self-limited narrowing of the IVC. Given the interval improvement and lack of evidence of flow impairment, no intervention was performed. The patient remains asymptomatic after 6 years.

Follow-up. The median postretrieval follow-up was 593 days (25th-75th centile, 268-973 days) after successful IVC filter retrieval. There were no long-term complications related to filter removal or fractured fragments. A new deep venous thrombosis developed in 13 patients after filter removal, and a new pulmonary embolism developed in 7 (3.6%) patients from the SR group. Three patients (1.6%) received a new IVC filter after retrieval of the existing filter.

Costs of IVC filter retrieval procedures. The mean cost of IVC filter retrieval, irrespective of technique, was \$8852 ± \$4496. AER procedural cost was significantly higher in comparison to the SR group (AER, \$14,565 ± \$6354; SR, \$7644 ± \$2810; $P < .001$). On average, the financial burden of AER procedures for IVC filter removal was 91% (1.9 times) higher than that of SR procedures. This translated to an average increase in cost of \$6921 ± \$3544 per retrieval procedure for AER.

DISCUSSION

This study highlights the complications and costs associated with IVC filter retrieval. The procedural cost of AER was 1.9 times higher than that of SR, translating to an average increase in cost of \$6921 ± \$3544 per retrieval procedure. The average cost of retrieval of an IVC filter was ~\$9000, irrespective of technique. Makary et al[14] reported that the average cost of IVC filter placement was ~\$2000. The importance of quantifying the costs of filter retrieval stems from an exponential rise in retrieval rates.[15] Morris et al[16] showed a 47.7% increase in IVC filter retrieval rate in the Medicare population between 2012 and 2015. Also using Medicare claims data, Ahmed et al[17] demonstrated that 78.6% of IVC filters are retrieved in the outpatient setting. Based on this, an intuitive inference can be drawn that procedural costs account for most of the resources used for IVC filter retrieval.

The overall success rate for IVC filter retrieval in this study (92.1%) was high. The success rate using advanced techniques for IVC filters with challenging configuration is consistent with the published literature. Avgerinos et al[5] reported an overall success rate of 91.5% and a 71.1% success rate with advanced techniques. Al-Hakim et al[4] reported 73.2% success using standard techniques and 94.7% success with advanced techniques. Dowell et al[6] also reported a 65% success rate using advanced techniques and overall success rate of 96.5%. The success rate with AER was 73.5%. This is potentially due to the operator's comfort using various AERs. In this study, wire loop-snare sling (47.1%) and stiff wire displacement (44.1%) were the most common AER techniques. Laser sheath dissection and endoscopy forceps were not used in this series. This is consistent with reported practice patterns of operators. A recent survey of vascular surgeons and interventional radiologists reported that the majority of operators were not comfortable using bronchoscopy forceps (65%) or laser sheath (82%) for filter retrieval.[18] There was no significant difference in preretrieval imaging modality in this study. This is potentially due to the operator's preference as the majority of the retrievals were performed in asymptomatic patients. Overall, a higher rate of complications (7.9%) was noted in this study. The degree of manipulation and incorporation of multiple endovascular techniques increase the risk of complications. Most of the complications were self-limited and perceived as radiologic abnormalities requiring no intervention. Al Hakim et al[4] reported an overall procedural complication rate of 1.7%; however, advanced retrievals had a significantly higher rate of complications (5.3% vs 0.5%). This pattern was consistent with our results (20.6% in AER vs 5.2% in SR). In addition, overall procedural complications reported in this series are higher than in other reports. Most of the patients with these complications were discharged on the same day as the procedure. Interestingly, Dowell et al[6] reported no complications using advanced endovascular techniques. The difference in complications compared with other reported series of advanced IVC filter techniques potentially stems from the lack of uniform definition of complications across these series. There has been an increased success in the use of endobronchial forceps for filter retrieval.[19-22] In this study, endobronchial forceps was used in four cases only with 100% success. One of the patients had a strut fracture and migration to the pulmonary artery; this was the only complication with that technique. To date, Stavropoulos et al[22] have the largest reported experience with endobronchial forceps. In a series of 114 retrievals, they reported a 96% success rate using endobronchial forceps only. In addition, they reported four complications (3.5%), one of which was directly attributed to forceps dissection. These data represent the experience of a high-volume center using this technique.

This paper sheds light on the economic burden of IVC filter retrieval. AER poses increased resource utilization in the form of higher procedure duration, higher radiation exposure, and higher financial burden. The total procedure duration of AER was 2.5 times higher than SR. Moreover, fluoroscopy time was 4.25 times higher in AER compared with SR. This was comparable to data from Dowell et al[6] and Al Hakim et al[4] (6.5 times and 6.4 times higher, respectively). Although radiation exposure was not directly measured, an indirect association can be made between fluoroscopy times and radiation exposure. Higher fluoroscopy times indirectly represent a higher radiation dose exposure to both the patient and the operator. Moreover, on average, AER procedures accounted for a 91% higher procedural cost to the health care system. This increased financial burden can be attributed to the equipment used for advanced endovascular procedures, overall longer procedure time, ancillary staff, and operating room costs. There are multiple factors to bear in mind while interpreting the costs of filter retrievals in this study. The costs were extrapolated from billing data. This leaves room for significant variation across the nation based on contractual discounts, insurance copay, and other regional variables. Therefore, it is not very accurate and likely to be an overestimate of the actual cost. However, it does provide an estimate of the costs and importantly underscores the difference between standard and advanced retrievals.

This study is limited by its design, namely, a single-center retrospective cohort. The generalizability of findings is limited by confounders inherent to the study design. The type of AER used was not objectively assigned. It was based on the operator's preference and comfort. The images from venography were not reviewed, limiting the ability to capture filter tilt and hook apposition. An important factor to note is that there were no dedicated CPT codes used for IVC filter retrieval before 2012. Procedural costs in this study were quantified on the basis of hospital-charged bills for the retrieval procedures only. Physicians' charges were not included. The majority of the retrievals were performed on an outpatient basis using local anesthesia and moderate sedation. Thus, the breakdown of costs relating to anesthesia was not evaluated. In the real world, health care cost utilization is better represented after accounting for indirect costs, contractual discounts, allowed amounts, and patient copay based on insurance providers.

CONCLUSIONS

IVC filter retrieval can be successfully performed with standard techniques in most cases. Advanced endovascular techniques can improve retrieval rates but come with significantly higher cost (91%) and higher rate of complications. In an era of value-based care and bundled payments, these factors need to be considered in decision-making before IVC filter retrieval. More studies are needed to shed light on health care cost utilization in AERs.

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AUTHOR CONTRIBUTIONS

Conception and design: AB, COC
Analysis and interpretation: AB, LS, HM, JA, BS, AD, TS, COC
Data collection: AB
Writing the article: AB
Critical revision of the article: AB, LS, HM, JA, BS, AD, TS, COC
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Supplementary Table (online only). *Current Procedural Terminology* (*CPT*) codes for filter retrieval

CPT code	Description
37193	Retrieval (removal) of intravascular vena cava filter, endovascular approach including vascular access, vessel selection, and radiological supervision and interpretation, intraprocedural road mapping, and imaging guidance (ultrasound and fluoroscopy), when performed
37203	Endovascular foreign body retrieval and associated radiological supervision/interpretation
75961	Endovascular foreign body retrieval and associated radiological supervision/interpretation