Pregnancy in women with an inferior vena cava filter: a tertiary center experience and overview of literature

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Abstract:
Background: Patients with an inferior vena cava (IVC) filter that remains in situ encounter a lifelong increased risk of deep vein thrombosis and IVC filter complications including fracture, perforation and IVC filter thrombotic occlusion. Data on the safety of becoming pregnant with an in situ IVC filter are scarce. Objective: To evaluate the risk of complications of in situ IVC filters during pregnancy. Methods: We performed a retrospective cohort study of pregnant patients with an in situ IVC filter from a tertiary center between 2000 and 2020. We collected data on complications of IVC filters and pregnancy outcomes. Additionally, we performed a systematic literature search in MEDLINE, Embase and grey literature. Findings: We identified seven pregnancies in four patients with in situ IVC filters with a mean time since IVC filter insertion of 3 years (range 1-8). No complications of IVC filter occurred during pregnancy. Review of literature yielded five studies including 13 pregnancies in nine patients. In one pregnancy a pre-existent, until then asymptomatic, chronic perforation of the vena cava wall by the IVC filter caused major bleeding and uterine trauma with fetal loss. Overall, the complication rate was 5%. Conclusion: It seems safe to become pregnant with an indwelling IVC filter that is intact and does not show signs of perforation, but due to the low number of cases no firm conclusions about safety of in situ IVC filters during pregnancy can be drawn. We suggest imaging prior to pregnancy to reveal asymptomatic IVC filter complications.

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Key points

- The risk of pregnancy in women with in situ vena cava filter is unknown and was evaluated in a cohort study and literature.

- Only 20 pregnancies were identified; one published case with pre-existent filter perforation had uterine trauma and fetal loss.
Abstract

**Background:** Patients with an inferior vena cava (IVC) filter that remains in situ encounter a lifelong increased risk of deep vein thrombosis and IVC filter complications including fracture, perforation and IVC filter thrombotic occlusion. Data on the safety of becoming pregnant with an in situ IVC filter are scarce.

**Objective:** To evaluate the risk of complications of in situ IVC filters during pregnancy.

**Methods:** We performed a retrospective cohort study of pregnant patients with an in situ IVC filter from a tertiary center between 2000 and 2020. We collected data on complications of IVC filters and pregnancy outcomes. Additionally, we performed a systematic literature search in MEDLINE, Embase and grey literature.

**Findings:** We identified seven pregnancies in four patients with in situ IVC filters with a mean time since IVC filter insertion of 3 years (range 1-8). No complications of IVC filter occurred during pregnancy. Review of literature yielded five studies including 13 pregnancies in nine patients. In one pregnancy a pre-existent, until then asymptomatic, chronic perforation of the vena cava wall by the IVC filter caused major bleeding and uterine trauma with fetal loss. Overall, the complication rate was 5%.

**Conclusion:** It seems safe to become pregnant with an indwelling IVC filter that is intact and does not show signs of perforation, but due to the low number of cases no firm conclusions about safety of in situ IVC filters during pregnancy can be drawn. We suggest imaging prior to pregnancy to reveal asymptomatic IVC filter complications.
Introduction

Inferior vena cava (IVC) filters were introduced in the 1970s to prevent thrombus migration from veins in the lower extremities to the pulmonary arteries causing potentially life-threatening pulmonary embolism (PE). Classic indications for IVC filter include acute venous thromboembolism (VTE, comprising deep vein thrombosis (DVT) and PE) when anticoagulant treatment is absolutely contraindicated, and recurrent VTE despite adequate anticoagulant therapy. IVC filters are also reported to be used for so-called extended or relative indications including the prevention of recurrent PE in chronic thromboembolic pulmonary hypertension patients undergoing pulmonary endarterectomy. If indicated, guidelines recommend the use of temporary retrievable IVC filters that are designed and intended to be removed after a short period of time, over the use of permanent non-retrievable filters.

Complications of IVC filters have been reported in 7-22% of the non-pregnant population and in 9-42% of patients who had an IVC filter inserted during pregnancy. Acute complications after IVC filter insertion include access site thrombosis (i.e. iliac vein thrombosis), infection, bleeding and perforation. Perforation of the vena cava wall by the IVC filter could be asymptomatic or requiring intervention when surrounding organs are involved. In the absence of anticoagulant therapy, IVC filters pose the risk of iatrogenic lower limb DVT and IVC filter thrombotic occlusion leading to IVC syndrome. Filter tilt of more than 15 degrees after insertion is associated with higher pulmonary embolism rates and higher retrieval failure rates, especially when certain types of filters are used. Other IVC filter-related complications consist of filter migration of more than 2 cm and fracture and embolization of struts. These complications are mostly associated with longer indwelling times and remain often asymptomatic but contribute to decreased efficacy of the IVC filter and failure of retrieval with temporary filters. Retrieval failure was reported in 11-12% of non-pregnant and in 8-26% of pregnant patients, with higher failure rates for prolonged time to first removal attempt. Due to the risk of these adverse events, insertion of an IVC filter should be considered with prudence and temporary IVC filters should be retrieved as soon as possible.

Patients with an IVC filter that remains in situ encounter lifelong risks. This has significant implications for young women in particular. Studies evaluating long-
term outcomes focus on post-thrombotic syndrome, VTE recurrence and mortality, and have shown an increased risk of DVT for patients with in situ IVC filter. There are very few data on the safety of becoming pregnant with an in situ IVC filter. A systematic review by Harris et al. reported complications of IVC filter in 124 women who had an IVC filter inserted during pregnancy, but those who had an IVC filter before conception were excluded from the review. It is unclear whether pregnancy and labor could affect the anatomic configuration of the in situ IVC filter and cause complications. In this study we aim to evaluate the safety of pregnancy in women with an in situ IVC filter.

Methods

Data collection

Retrospective cohort study by chart review

We identified all women who became pregnant with an in situ IVC filter between 1 January 2000 and 1 January 2020 at one of the two locations of Amsterdam University Medical Centers (Academic Medical Center and Vrije Universiteit Medical Center). A search engine designed to search unstructured data (CTCue®) was used. We searched for ‘vena cava filter’, ‘VCF’ or synonyms in electronic medical charts of female patients aged 18 to 45 years during the defined time period. Anonymized sections of patients’ charts were screened for relevance. All investigators obtained full access to the medical charts after confirming (possible) eligibility. When a patient had an in situ IVC filter, patient’s chart was searched for notes on pregnancy until the end of the study period or until the patient had turned 45, underwent hysterectomy or had died. Pregnant patients with an in situ IVC filter prior to conception were included. The following data were extracted from chart notes: age at insertion, date of insertion, indication, location, type, complications of IVC filter during pregnancy, performed imaging of IVC filter prior to and after pregnancy, thrombotic history, obstetric history, pregnancy outcome (duration, mode of delivery, condition and birth weight of neonate), concomitant anticoagulation during pregnancy and pregnancy-related VTE.
Literature search

In addition, a comprehensive search of English language literature was performed in MEDLINE and Embase to identify studies that evaluated the safety of in situ IVC filters during pregnancy. The search was based on both Medical Subject Headings (MeSH) terms and alternative general key words “pregnancy” and “vena cava filter”. The search strategy can be found in supplementary Table 1. We also manually searched for studies presented as abstracts at conferences of the American Society of Hematology (ASH), International Society on Thrombosis and Haemostasis (ISTH), European Congress on Thrombosis and Haemostasis (ECTH), Society of Maternal Fetal Medicine (SMFM), Society of Reproductive Investigation (SRI), American Thoracic Society (ATS), European Respiratory Society (ERS), European Society of Cardiology (ESC), Society of Interventional Radiology (SIR) and Cardiovascular and Interventional Radiological Society of Europe (CIRSE). No restrictions with regard to publication date were applied, the search was performed on 7 August 2020. Two reviewers (IB and AG) independently screened titles and abstracts of all studies. Full-text articles of potentially relevant studies were examined for eligibility. Studies presenting original data were included if a) the study population included at least one patient who had a pregnancy with an in situ IVC filter and b) the following outcomes were reported: IVC filter complications during pregnancy, obstetric outcomes or recurrent VTE. All references of included studies were manually searched to identify articles that had not been identified. Quality of included studies was critically appraised for by IB and AG using the Joanna Briggs Institute tool for case series and case reports. Risk of bias assessment was not conducted since case series and case reports are by nature prone to bias. Moreover, risk of bias assessment was considered not of value for cohort studies when data of only a single patient was extracted. The following data were extracted from included studies: age at insertion, date of insertion, indication, location, type, complications of IVC filter during pregnancy, thrombotic history, obstetric history, pregnancy outcome (duration, mode of delivery, condition and birth weight of neonate), concomitant anticoagulation during pregnancy and pregnancy-related VTE.
Study outcomes

The primary outcome of this study consisted of complications of IVC filter during pregnancy or diagnosed up to 6 weeks postpartum and included migration (more than 2 cm), tilt (more than 15 degrees), or fracture of the IVC filter, penetration (more than 3 mm) of the vena cava wall, IVC filter thrombosis or bleeding caused by IVC filter complications. Secondary outcomes were mode of delivery and pregnancy-related (during pregnancy or up to 6 weeks postpartum) recurrent VTE.

Statistical analysis

The primary and secondary outcomes were reported for the cohort and for the literature review separately. Descriptive analysis was performed using SPSS BMI version 26. Categorical data were presented as percentages and continuous variables as means with range.

Ethics

The study protocol was approved by the institutional review board of Amsterdam UMC, University of Amsterdam. The study re-used clinical data for research purposes, therefore need for written informed consent from patients was waived by the institutional review board under contemporary regulations.

Data sharing statements

For original data, please contact i.m.bistervels@amsterdamumc.nl.

Results

Identification cohort

The CTCue® search in the medical charts between 1 January 2000 and 1 January 2020 yielded 487 records, of whom 115 were female patients aged 18 to 45 years (Figure 1). Of these patients, 57 had an IVC filter inserted. The IVC filter was retrieved in 25 patients; 32 patients had an IVC filter that had remained in
situ. Among the latter, four patients had become pregnant after IVC filter insertion, for a total of seven pregnancies. Five patients with an in situ IVC filter were no longer under the care of our hospital 5 to 10 years ago, but might – based on age - have become pregnant and were considered lost to follow-up.

Cohort findings

Characteristics and outcomes of patients who became pregnant with an in situ IVC filter are summarized in Table 1. Mean age at IVC filter insertion was 27 years (range 21 to 31 years). One patient had a retrievable (OptEase®) IVC filter inserted because surgery for intra-abdominal bleeding was indicated one week after acute PE. Retrieval of the IVC filter was attempted 4 weeks later, but failed as the tip of the IVC filter was embedded IVC wall. During this procedure, the IVC filter was slightly twisted. In this patient, the presence of an in situ IVC filter was the major indication for therapeutic dose anticoagulants, which was continued during her subsequent pregnancy. Two patients had IVC filters inserted prior to pulmonary endarterectomy because of chronic thromboembolic pulmonary hypertension. One of these patients had a permanent TrapEase® filter, while the other patient had a retrievable OptEase® filter that was not removed because the endarterectomy surgery was complicated by a pulmonary bleeding and suspected heparin induced thrombocytopenia. Because of the pulmonary history and the in situ IVC filter, therapeutic dose anticoagulants was prescribed to these patients. One patient had an IVC filter inserted for acute DVT at 30 weeks of gestation. She was treated with prophylactic dose with low-molecular-weight heparin (LMWH). The other IVC filters were inserted outside of pregnancy. All IVC filters were positioned infrarenally.

Among the seven pregnancies in four patients, mean time since IVC filter insertion was 3.1 years (range 1 to 8 years). One patient had four pregnancies. She had an early miscarriage followed by three induced term vaginal deliveries of healthy neonates. Other patients had one pregnancy. Two patients had uneventful pregnancies with term spontaneous deliveries of healthy neonates. For the fourth patient details were only available up to 17 weeks of gestation and she gave birth to a healthy neonate. Mean gestational age at delivery was 39 weeks and 5 days (range 38w0d to 41w6d) (Table 1). The mode of delivery was based on obstetric indications in all cases.
The first pregnancy after IVC filter insertion was unplanned in three patients and occurred before patients had been counseled about the risks of an in situ IVC filter during pregnancy. Filter integrity prior to pregnancy was not assessed in four (57%) pregnancies. In one (14%) pregnancy, the presence of an open and intact IVC filter was confirmed by ultrasound examination during the first trimester. In two (29%) pregnancies, imaging with compression ultrasound or venography was performed 6 months prior to conception to exclude acute thrombosis and revealed open IVC filters. In one (14%) of these pregnancies, imaging of the IVC filter was also performed after pregnancy and revealed no IVC filter complications. In six (86%) other pregnancies, although not radiologically confirmed, no signs or symptoms of migration, tilt, fracture, penetration of vena cava wall, IVC filter thrombosis, or bleeding caused by IVC filter complications occurred. Concomitant anticoagulant therapy with LMWH was prescribed in all pregnancies: therapeutically dosed in six (86%) pregnancies in patients who were on therapeutic dose anticoagulants prior to their pregnancies, and low prophylactic dose in one pregnancy in the patient who was on prophylactic dose LMWH since her DVT diagnosis. No pregnancy-related recurrent VTE was observed (Table 1).

Literature review

The literature search yielded 156 unique articles and four abstracts (Figure 2). After screening of title and abstract, 105 records were excluded. Fifty-five full-text articles were assessed: 16 were excluded because the study population did not meet the target population, 24 articles were excluded because data on IVC filter retrieval and/or subsequent pregnancy were not provided and for 10 records full-text was not available. We included one retrospective cohort study, two case series on IVC filter use in pregnancy (containing data on both peripartum use of IVC filter and pregnancies with in situ IVC filter before conception) and two case reports (Supplementary Table 2). Rottenstreich et al. 9 presented a cohort of 24 cases who underwent retrievable IVC filter placement during pregnancy or in the postpartum period; only one patient had subsequent pregnancies with an IVC filter still in situ. Gupta et al. 16 presented 12 pregnancies in six women with retrievable and permanent IVC filters, of which eight pregnancies occurred in five patients after the IVC filter had been inserted. Thomas et al. 17 described the use of Greenfield™ filters in eight pregnant patients of whom one became pregnant after IVC filter placement. Maijub et al. 18 presented a case of uterine trauma with fetal loss associated with chronic perforation of the inferior vena cava by an IVC filter. Lee et al. 19 reported a
young women with recurrent VTE due to antiphospholipid syndrome who became pregnant with an in situ IVC filter. Quality assessment of the studies is summarized in Supplementary Table 3. Information on IVC filter complications and pregnancy outcome was poorly described by Rottenstreich et al. ⁹ and Lee et al. ¹⁹ In the latter, only information on VTE recurrence was provided.

All studies combined, we collected data of 13 pregnancies in nine patients with an in situ IVC filter before conception. Patient and pregnancy characteristics as well as outcomes are listed in Table 2. The mean age at IVC filter insertion was 26.3 years (range 17-35 years) and indication was VTE in all cases. Three (33%) patients had a retrievable IVC filter (amongst others Günther Tulip®) that remained in situ after failed retrieval, five (56%) patients had a permanent IVC filter (Bird’s Nest®, Greenfield™, TrapEase®) and IVC filter type was not reported for one patient. Five (56%) IVC filters were inserted outside of pregnancy and four (44%) IVC filters during a previous pregnancy. Four (44%) patients were nulliparous at time of IVC filter insertion. Two patients had been diagnosed with pre-existent complications of the IVC filter: one patient had IVC filter misplacement into the external iliac vein with penetration of the inferior vena cava wall ⁹ and one patient was diagnosed with asymptomatic chronic perforation of the inferior vena cava by struts and barbs of the IVC filter.¹⁸

The mean time since IVC filter insertion at time of pregnancy was 4.2 years (range <1 to 8 years). One patient had three pregnancies with in situ IVC filter, two patients had two pregnancies and six patients had one pregnancy. The mode of delivery was spontaneous vaginal delivery in four (31%) pregnancies, caesarean section in six (46%) pregnancies (three emergency, three elective) and was not reported in three (23%) pregnancies. The patient with three pregnancies had an emergency caesarean section at first delivery and gave birth to her following two babies through elective caesarean section. Mean gestational age at delivery was 37 weeks and 5 days (range 24 to 42 weeks). One (8%) patient had a twin pregnancy and pregnancy outcome was not reported for one patient. Twelve (86%) healthy neonates were born, one (8%) pregnancy was complicated by IVC filter perforation which resulted in emergency caesarean section at 24 weeks and 2 days of pregnancy.¹⁸ The fetus died shortly after birth. Perforating barbs and struts of the permanent TrapEase® filter caused uterine lacerations and a tear in the peritoneal membrane, leading to major intra-abdominal hemorrhage. In one (8%) pregnancy, outcomes were not
reported, whereas the other 11 (85%) pregnancies were uneventful. Concomitant antithrombotic therapy was administered and consisted of acetylsalicylic acid (ASA) monotherapy in three (23%) pregnancies, unspecified doses of LMWH in nine (69%) pregnancies and was not reported in one pregnancy. No pregnancy-related VTE were reported (Table 2).

An overview of characteristics and appearances of the IVC filters mentioned in this section can be found in Table 3.

Discussion

In this study, we compiled results on risk of complications of in situ IVC filters in seven pregnancies in four patients from our tertiary center and in 13 pregnancies in nine patients derived from an extensive and systematic literature search. In one pregnancy, described as a single case report, uterine trauma with fetal loss was observed. Other pregnancies were uneventful. Due to the low number of only 20 identified pregnancies, and the intrinsic biases of this type of publications, we are unable to draw firm conclusions with regard to safety of in situ IVC filter during pregnancy. Importantly, the patient who had a severe complication was known to have pre-existent perforation of the vena cava wall prior to her pregnancy, which was asymptomatic until pregnancy progressed. Therefore, we would suggest to perform imaging of the IVC filter to exclude asymptomatic IVC filter complications in all women contemplating pregnancy. In a study on perforations by IVC filters in 391 patients, 69% perforations were isolated IVC wall perforations and roughly half of the patients were asymptomatic. The aorta, duodenum and vertebral bodies were the most frequently perforated surrounding organs. IVC perforation should ideally be excluded using computerized tomography or venography. Thrombotic occlusion, tilt fracture or embolization of the IVC filter could also be detected using conventional radiography and ultrasonography.
Filters that were inserted during pregnancy have been previously reported to be able to cause symptomatic perforation of the uterus \cite{21} and cephalic migration into the right atrium \cite{22} within hours to days after insertion. Moreover, asymptomatic IVC filter fracture and migration was detected up to 5 months postpartum when attempting to retrieve the IVC filter.\cite{23-25} If the IVC filter has been in situ for some time, one might postulate that it is less likely to migrate due to endothelialization. The IVC filters inserted during pregnancy in the presently described cases did not lead to complications shortly after insertion, which could be a predictor for favorable outcome during a subsequent pregnancy. In general, the risk of migration of IVC filter during pregnancy seems to be increased due to dilatation and the risk of fracture due to change in IVC configuration.\cite{26}

Following the 2010 Food and Drug Administration safety alert on the risks of permanent indwelling of retrievable IVC filters \cite{12} there has been a notable decline in insertions of IVC filters.\cite{27,28} Routine insertion of IVC filters prior to pulmonary endarterectomy was initially recommended\cite{29}, but this practice is no longer supported by the current guideline of the European Society of Cardiology and European Respiratory Society.\cite{30} Additionally, data from an international prospective registry on patients with chronic thromboembolic pulmonary hypertension showed that the presence of an IVC filter in 40% of patients did not influence long-term survival.\cite{31} Although the use of IVC filters has declined, given the failure rate of retrieval, the clinical issue of young women with an in situ IVC filter contemplating pregnancy is still a reality.

The obvious limitation of this study is the small number of patients in our cohort as well as scarcity of published data on the course of pregnancy in women with an in situ IVC filter. The literature search is at risk for publication bias, particularly for case reports, where complicated cases might overestimate the risk of IVC filter complications. Strengths are the complete collection of data from our own center, as well as the published literature.
Conclusion

In conclusion, based on a tertiary center case series and literature search we report a serious IVC filter complication in one of 20 pregnancies. The single complication described during pregnancy was in an asymptomatic patient who had a perforated IVC filter in situ prior to conception. Therefore, it seems safe to become pregnant with an indwelling IVC filter that is intact and does not show signs of perforation, but due to the low number of cases no firm conclusions about safety of permanent IVC filters during pregnancy can be drawn. We suggest imaging, preferably prior to pregnancy, to reveal asymptomatic IVC filter complications.
Authorship Contributions

I.B. designed the study, reviewed medical charts and collected data, performed literature search and data extraction, and wrote the first draft of the manuscript. A.G. performed literature search and data extraction and critically reviewed and revised the manuscript. P.B., W.G. and I.J.Z. critically reviewed and revised the manuscript. S.M. designed the study and critically reviewed and revised the manuscript. All authors approved the final version of the manuscript.

Disclosure of Conflict of Interests

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References

1. DeYoung E, Minocha J. Inferior Vena Cava Filters: Guidelines, Best Practice, and Expanding Indications. *Semin Intervent Radiol.* 2016;33(2):65-70.

2. Duffett L, Carrier M. Inferior vena cava filters. *Journal of Thrombosis and Haemostasis.* 2017;15(1):3-12.

3. Kearon C, Akl EA, Ornelas J, et al. Antithrombotic Therapy for VTE Disease CHEST Guideline and Expert Panel Report. *Chest.* 2016;149(2):315-352.

4. Ortel TL, Neumann I, Ageno W, et al. American Society of Hematology 2020 guidelines for management of venous thromboembolism: treatment of deep vein thrombosis and pulmonary embolism. *Blood Adv.* 2020;4(19):4693-4738.

5. Kaufman JA, Kinney TB, Streiff MB. Guidelines for the use of retrievable and convertible vena cava filters: report from the Society of Interventional Radiology multidisciplinary consensus conference (vol 17, pg 449, 2006). *Journal of Vascular and Interventional Radiology.* 2017;28(9):1338-1338.

6. Angel LF, Tapson V, Galgon RE, Restrepo MI, Kaufman J. Systematic Review of the Use of Retrievable Inferior Vena Cava Filters. *Journal of Vascular and Interventional Radiology.* 2011;22(11):1522-1530.

7. Crosby DA, Ryan K, McEniff N, et al. Retrievable Inferior vena cava filters in pregnancy: Risk versus benefit? *European Journal of Obstetrics & Gynecology and Reproductive Biology.* 2018;222:25-30.

8. Harris SA, Velineni R, Davies AH. Inferior Vena Cava Filters in Pregnancy: A Systematic Review. *J Vasc Interv Radiol.* 2016;27(3):354-360.e358.

9. Rottenstreich A, Kalish Y, Elchalal U, Klimov A, Bloom AI. Retrievable inferior vena cava filter utilization in obstetric patients. *Journal of Maternal-Fetal & Neonatal Medicine.* 2019;32(18):3045-3053.

10. Deso SE, Idakoji IA, Kuo WT. Evidence-Based Evaluation of Inferior Vena Cava Filter Complications Based on Filter Type. *Seminars in Interventional Radiology.* 2016;33(2):93-100.

11. Grewal S, Chamorthy MR, Kalva SP. Complications of inferior vena cava filters. *Cardiovasc Diagn Ther.* 2016;6(6):632-641.

12. Cohoon KP, McBride J, Friese JL, McPhail IR. Retrievable Inferior Vena Cava Filters Can Be Placed and Removed with a High Degree of Success: Initial Experience. *Catheterization and Cardiovascular Interventions.* 2015;86(4):719-725.

13. Bates SM, Greer IA, Middeldorp S, Veenstra DL, Prabulos AM, Vandvik PO. VTE, thrombophilia, antithrombotic therapy, and pregnancy: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest.* 2012;141(2 Suppl):e691S-e736S.

14. Decousus H, Barral FG, Buchmuller-Cordier A, et al. Eight-year follow-up of patients with permanent vena cava filters in the prevention of pulmonary embolism - The PREPIC (Prevention du Risque d’Embolie Pulmonaire par Interruption Cave) randomized study. *Circulation.* 2005;112(3):416-422.

15. AbuRahma AF, Mullins DA. Endovascular caval interruption in pregnant patients with deep vein thrombosis of the lower extremity. *Journal of Vascular Surgery.* 2001;33(2):375-378.

16. Gupta S, Ettles DF, Robinson GJ, Lindow SW. Inferior vena cava filter use in pregnancy: preliminary experience. *BJOG An International Journal of Obstetrics and Gynaecology.* 2008;115(6):785-788.

17. Thomas LA, Summers RR, Cardwell MS. Use of greenfield filters in pregnant women at risk for pulmonary embolism. *Southern Medical Journal.* 1997;90(2):215-217.

18. Majiub JG, Ross CB, Houser MV, Morris ME. Fetal Demise due to Uterine Trauma With Massive Intrapartetal Hemorrhage Associated With Chronic Perforation of the Inferior Vena Cava by an Infrarenal Filter: A Case Report With Call for Definitive Consensus Regarding Filter Positioning in Nonpregnant Women of Childbearing Age. *Journal of Vascular Surgery.* 2012;56(6):1823-1823.

19. Lee BS, Selvaratnam V, Sathar J, Yap YY, Fann RJ. She Won’t Stop Clotting Despite on Anticoagulants: A Challenging Case 2019.
20. Wood EA, Malgor RD, Gasparis AP, Labropoulos N. Reporting the impact of inferior vena cava perforation by filters. *Phlebology*. 2014;29(7):471-475.
21. Dębska M, Debski R, Muzyka K, Kurzyna M, Dąbrowski M. An unexpected complication with the use of a retrievable vena cava filter in late pregnancy. *Eur J Obstet Gynecol Reprod Biol*. 2014;180:205-206.
22. Kelly IMG, Boyd CS. Buckling of the tethering catheter causes migration of a temporary caval filter to the right atrium. *Clinical Radiology*. 1999;54(6):398-401.
23. Ganguli S, Tham JC, Komlos F, Rabkin DJ. Fracture and migration of a suprarenal inferior vena cava filter in a pregnant patient. *Journal of Vascular and Interventional Radiology*. 2006;17(10):1707-1711.
24. Sendon S, Deruelle P, Dalmas AF, Lions C, Legrand A. Use of temporary inferior vena cava filter placement in pregnant women near term. *European Journal of Obstetrics Gynecology and Reproductive Biology*. 2008;140(1):143-144.
25. Cheung MC, Asch MR, Gandhi S, Kingdom JCP. Temporary inferior vena cava filter use in pregnancy. *Journal of Thrombosis and Haemostasis*. 2005;3(5):1096-1097.
26. McConville RM, Kennedy PT, Collins AJ, Ellis P. Failed Retrieval of an Inferior Vena Cava Filter During Pregnancy Because of Filter Tilt: Report of Two Cases. *Cardiovascular and Interventional Radiology*. 2009;32(1):174-177.
27. Power JR, Nakazawa KR, Vouyouka AG, Faries PL, Egorova NN. Trends in vena cava filter insertions and "prophylactic" use. *J Vasc Surg Venous Lymphat Disord*. 2018;6(5):592-598 e596.
28. Kuban JD, Lee SR, Yevich S, et al. Changes in inferior vena cava filter placement and retrieval practice patterns from a population health perspective. *Abdom Radiol (NY)*. 2020.
29. Jamieson SW, Kapelanski DP, Sakakibara N, et al. Pulmonary endarterectomy: experience and lessons learned in 1,500 cases. *Ann Thorac Surg*. 2003;76(5):1457-1462; discussion 1462-1454.
30. Galie N, Humbert M, Vachiery JL, et al. 2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension: The Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS): Endorsed by: Association for European Paediatric and Congenital Cardiology (AEPC), International Society for Heart and Lung Transplantation (ISHLT). *Eur Heart J*. 2016;37(1):67-119.
31. Delcroix M, Lang I, Pepke-Zaba J, et al. Long-Term Outcome of Patients With Chronic Thromboembolic Pulmonary Hypertension: Results From an International Prospective Registry. *Circulation*. 2016;133(9):859-871.
32. Cordis. Optease Retrievable Vena Cava Filter Vol. 2021.
33. Cordis. Trapease permanent vena cava filter. Vol. 2021.
34. Incorporated CM. Gunther Tulip datasheet. Vol. 2021.
35. Incorporated CM. Bird’s Nest Vena Cava filter product specifications. Vol. 2021.
36. Scientific B. Greenfield Vena Cava Filters. Vol. 2021.
## Table 1. Amsterdam UMC cases: characteristics and outcomes for pregnancy in patients with in situ inferior vena cava filter

| Patient number | Age | Thrombotic history | Indication for filter & pre-pregnancy anticoagulant therapy | Location, type and timeline of filter insertion | Pregnancy number | Years since IVC filter | Gravidity Parity | Mode of delivery | Pregnancy Outcome | LMWH dose during pregnancy | Pregnancy-related VTE? | Complications† IVC filter |
|----------------|-----|-------------------|-------------------------------------------------------------|-----------------------------------------------|------------------|------------------------|-----------------|-----------------|-----------------|--------------------------|------------------|---------------------------|
| 1              | 31  | PE and mesenteric thrombosis | Surgery due to intra-abdominal bleeding 1 week after acute PE DOAC (indefinite duration) | Infrarenal Retrieveable ‡ (OptEase®) Outside pregnancy | 1               | 3                      | G1P0            | Spontaneous vaginal delivery at 38w6d | Healthy neonate | Therapeutic | No | No |
| 2              | 21  | PE CTEPH, NYHA class II-III/IV | Pre-PEA VKA (indefinite duration) | Infrarenal Retrieveable † (OptEase®) | 1               | 1                      | G1P0            | Dilatation & curettage at <10 weeks | Miscarriage | Therapeutic | No | No |
| 3              | 29  | PE CTEPH, NYHA class III/IV | Pre-PEA VKA (indefinite duration) | Infrarenal Permanent (TrapEase®) Outside pregnancy | 1               | 1                      | G1P0            | Unknown, FU until 17 weeks | Healthy neonate | Therapeutic | No | No § |
| 4              | 27  | DVT | DVT in 3rd trimester of pregnancy Low prophylactic LMWH since DVT diagnosis | Infrarenal Filter type unknown 30th week of pregnancy | 1               | 1                      | G8P2            | Spontaneous vaginal delivery at 40w0d | Healthy neonate | Low prophylactic | Not during pregnancy | No |
Abbreviations: IVC: inferior vena cava, PE: pulmonary embolism, DVT: deep vein thrombosis, CTEPH: chronic thromboembolic pulmonary hypertension, NYHA: New York Heart Association, PEA: pulmonary endarterectomy, G: gravidity, P: parity, 38w6d: 38 weeks and 6 days of pregnancy, FU: follow-up, VTE: venous thromboembolism, LMWH: low-molecular-weight heparin, DOAC: direct oral anticoagulant, VKA: vitamin K antagonist.

* During pregnancy or up to 6 weeks postpartum. † Complications of IVC filter include: migration, tilt, fracture, penetration of the vena cava wall, IVC filter thrombosis or bleeding caused by IVC filter complications. ‡ Retrieval of IVC filter was attempted 4 weeks after insertion and failed because the tip of the IVC filter was embedded in the endothelial wall. In an attempt to move the IVC filter, the IVC filter was slightly twisted. Retrieval remained impossible and the IVC filter was left in situ. ¶ IVC filter was not removed after PEA surgery, since this was complicated by a pulmonary bleeding and suspicion of heparin induced thrombocytopenia. § Radiologically confirmed: 6 months prior to pregnancy, a venography showed an open IVC filter, 1 year after pregnancy abdominal x-ray showed an intact and correctly positioned IVC filter.
Table 2. Literature reviews: characteristics and outcomes for pregnancy in patients with in situ inferior vena cava filter

| Patient number [study] | Age | Indication | Location, type and timing | Pregnancy number | Years since IVC filter | Parity | Mode of delivery | Pregnancy Outcome | Anticoagulant s during pregnancy | Pregnancy-related* VTE? | Complications † IVC filter |
|------------------------|-----|------------|---------------------------|------------------|------------------------|-------|-----------------|-------------------|-----------------------------|----------------------|---------------------------|
| 1 [9]                  | 32  | PE         | Infrarenal Retrievable † (subtype not reported) 15th week of pregnancy | 1                | Not reported           | Not reported | not reported    | “uneventful pregnancy” | LMWH ± ASA**               | Not reported          | Not reported              |
| 2 [16]                 | 17  | PE following recent surgery | Location not reported Retrievable § (Günther Tulip®) Outside pregnancy | 1                | 3                      | 0      | Emergency CS at 42 weeks | Healthy neonate | ASA                         | No                   | No                        |
|                        |     |            |                           | 2                | 5                      | 1      | Elective CS at 40 weeks | Healthy neonate | ASA                         | No                   | No                        |
|                        |     |            |                           | 3                | 7                      | 2      | Elective CS at 38 weeks | Healthy neonate | ASA                         | No                   | No                        |
| 3 [16]                 | 27  | Recurrent VTE despite anticoagulants | Location not reported Permanent (Bird’s Nest®) Outside pregnancy | 1                | 2                      | 0      | Spontaneous vaginal delivery at 39 weeks | Healthy neonate | LMWH ‡‡                   | No                   | No                        |
|                        |     |            |                           | 2                | 4                      | 1      | Spontaneous vaginal delivery at 38 weeks | Healthy neonates (twins) | LMWH ‡‡       | No                   | No                        |
| 4 [16]                 | 35  | Pregnancy-related DVT | Location not reported Permanent (Bird’s Nest®) 35th week of pregnancy | 1                | 4                      | 1      | Spontaneous vaginal delivery at 41 weeks | Healthy neonate | LMWH ‡‡                   | No                   | No                        |
| 5 [16]                 | 23  | Pregnancy-related DVT | Location not reported Permanent | 1                | 8                      | 1      | Elective CS at 38 weeks | Healthy neonate | LMWH ‡‡                   | No                   | No                        |
| Case | Week | VTE Type | Filter Details | Location | Complications | Birth Outcome | Treatment | ASA | Uterine Trauma |
|------|------|----------|----------------|----------|---------------|--------------|-----------|-----|---------------|
| 6    | 25   | Pregnancy-related DVT | Location not reported | Emergency CS at 41 weeks | Healthy neonate | LMWH †† No | No | No |
| 7    | 24   | DVT | Location not reported | Spontaneous vaginal delivery at 36 weeks | Healthy neonate | Not reported No | No | No |
| 8    | 27   | Recurrent VTE, warfarin allergy and retroperitoneal hematoma | Infrarenal Permanent § (TrapEase®) | Emergency CS at 24 weeks | Fetus died shortly after birth | LMWH †† No | Uterine trauma and massive intraperitoneal hemorrhage caused by perforation of IVC filter struts |
| 9    | 27   | Recurrent VTE | Location and filter type not reported | Not reported | Not reported | LMWH †† No | Not reported |

Abbreviations: IVC: inferior vena cava, PE: pulmonary embolism, DVT: deep vein thrombosis, VTE: venous thromboembolism, LMWH: low-molecular-weight heparin.
* During pregnancy or up to 6 weeks postpartum. † Complications of IVC filter include: migration, tilt, fracture, penetration of the vena cava wall, IVC filter thrombosis or bleeding caused by IVC filter complications. ‡ Complicated insertion: filter misplacement into external iliac vein, associated penetration of IVC wall. § Failure of IVC retrieval. ¶ Known complication IVC filter prior to pregnancy: asymptomatic, chronic perforation of the IVC wall by struts and barbs of the IVC filter. ** It was unclear whether ASA was added to LMWH treatment in this pregnancy. †† Dose of LMWH was not reported
Table 3. Overview of characteristics and appearance of inferior vena cava filters inserted in patients included in this study.

| Filter name      | Manufacturer          | Intended duration of use | Design                                      | Material   | Filter max. diameter | MRI status       | Image |
|------------------|-----------------------|--------------------------|---------------------------------------------|------------|----------------------|------------------|-------|
| OptEase®         | Cordis 2000           | Retrievable              | Double basket, closed cage                  | ninitol    | 30 mm                | MRI conditional  |       |
| TrapEase®        | Cordis 2000           | Permanent                | Double basket, closed cage                  | ninitol    | 30 mm                | MRI conditional  |       |
| Günther Tulip®   | Cook Medical Incorporated 1992 | Retrievable           | Conical, half basket                        | conichrome | 30 mm                | MRI conditional  |       |
| Bird’s Nest®     | Cook Medical Incorporated 1982 | Permanent               | 4 hook wire struts (2 up, 2 down) with filter wires | stainless steel | 40 mm                | MRI conditional  |       |
| Greenfield™      | Boston Scientific 1973 | Permanent                | Conical, half basket, recurved hooks        | Stainless steel or titanium | 28 mm                | MRI conditional  |       |

Abbreviations: MRI: magnetic resonance imaging, mm: millimeter
**Figure 1.** Flow Chart selection of cohort

**CTCue® Search**

"IVC filter"* in medical charts of female patients, 2000-2020 (n= 487)

- **Age under 18 or over 45** (n = 372)

- **Age 18 to 45 years** (n = 115)

- **No IVC filter inserted** (n = 58)

- **IVC filter inserted** (n = 57)

- **IVC filter retrieved** (n = 25)

- **IVC filter remained in situ** (n = 32)

- **Died within 1 year** (n = 6)
  - No pregnancy (n = 17)
  - Lost to follow-up (n = 5)

- **At least one pregnancy with in situ IVC filter** (n = 4)

- **No pregnancy (n = 17)
- Lost to follow-up (n = 5)

**Abbreviations:** IVC: inferior vena cava

*Key words search: “vena cava filter”, “VCF” and Dutch synonyms.
Figure 2. PRISMA Flow Diagram of literature search

Abbreviations: ASH: American Society of Hematology, ISTH: International Society on Thrombosis and Haemostasis, ATS: American Thoracic Society, SIR: Society of Interventional Radiology, CIRSE: Cardiovascular and Interventional Radiological Society of Europe, IVC: inferior vena cava.