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Systematic Review

An Algorithm for Inferior Vena Cava Filter Placement in Severely Injured Patients: A Systematic Review–Based Consensus and Guidelines by SMA-VS

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Abstract

Aims/Background: Venous thromboembolism is a major complication of severe injury, and the role of inferior vena cava (IVC) filters in patients suffering from this condition remains controversial. The current clinical practice guideline, developed by the Shanghai Medical Association Vascular Surgery Branch, aims to clarify the role of IVC filters in severely injured patients based on evidence and consensus-derived recommendations. **Methods:** We conducted a systematic review and random-effects meta-analysis of randomized controlled trials and observational cohort studies, reported in accordance with PRISMA 2020, followed by a two-round Delphi consensus process involving 21 experts from five specialties. Because the included studies spanned clinically heterogeneous populations and combined prophylactic with therapeutic filter placement, a post hoc sensitivity analysis restricted to trauma and fracture populations was performed. Pooled estimates were derived using the DerSimonian–Laird random-effects estimator in Review Manager (RevMan) 5.4. Certainty of evidence was not formally graded; reported agreement percentages denote the strength of expert consensus rather than Grading of Recommendations Assessment Development and Evaluation (GRADE) or equivalent formal ratings. Because each outcome was informed by only two to five studies, pooled estimates should be interpreted with caution. **Results:** Six studies were included. In the principal analysis, which pooled studies of both prophylactic and therapeutic filter placement, IVC filters were associated with a lower incidence of symptomatic pulmonary embolism (five studies; risk ratio [RR] 0.22, 95% confidence interval [CI] 0.08–0.66), an association informed by four observational studies and one randomized trial. Filters were not associated with reduced all-cause mortality (RR 0.88, 95% CI 0.41–1.89) or with a difference in bleeding (RR 1.08, 95% CI 0.91–1.28), and were associated with a higher incidence of deep vein thrombosis (RR 1.38, 95% CI 1.02–1.87), although this finding was not robust in leave-one-out analysis. When the analysis was restricted to trauma and fracture populations, the reduction in symptomatic pulmonary embolism persisted (RR 0.15, 95% CI 0.04–0.59), whereas the association with deep vein thrombosis was no longer evident (RR 1.31, 95% CI 0.68–2.50). Fifteen recommendations were formulated, of which fourteen achieved consensus. These recommendations include: (i) pharmacologic thromboprophylaxis is the mainstay of prevention; (ii) IVC filters are reserved for defined indications; and (iii) availability of institutional retrieval infrastructure is a prerequisite for IVC placement. A clinical decision algorithm was developed to integrate the recommendations. **Conclusion:** The certainty of evidence was low for most components, although substantial agreement was achieved among expert clinicians. Pharmacologic prophylaxis should remain the default strategy, with prophylactic IVC filter use restricted to selected indications, dependent on retrieval infrastructure, and limited in duration. The seven-day contraindication threshold should be regarded as a deliberative prompt rather than a decision rule and warrants further investigation. Because the available evidence is drawn largely from fracture rather than polytrauma cohorts, and the pooled estimates combine prophylactic with therapeutic filter placement, these recommendations should be applied to severely injured patients with appropriate caution. **Systematic Review Registration:** PROSPERO (CRD420261334942).

Keywords: vena cava filters; venous thromboembolism; multiple trauma; practice guidelines as topic; Delphi technique; systematic review

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1. Introduction

Venous thromboembolism remains one of the primary complications following major trauma. Without prophylaxis, deep vein thrombosis develops in up to 58% of severely injured patients [1]. Pulmonary embolism accounts for a substantial proportion of preventable in-hospital deaths after injury [2,3]. Immobilization, endothelial damage, and hypercoagulability are a constellation of common attributes in the polytrauma population [4]. Post-traumatic hypercoagulability is not, however, a purely mechanical consequence of stasis and vessel injury. Major injury provokes a systemic innate immune response in which activated platelets, neutrophils and complement interact with a damaged endothelium to promote intravascular coagulation—a process termed immunothrombosis [5,6]. Damage-associated molecular patterns released from injured tissue, together with degradation of the endothelial glycocalyx, contribute to the endotheliopathy of trauma and to the transition from early coagulopathy to a later prothrombotic state [7]. Inflammation is clinically relevant in this setting because patients most likely to be considered for inferior vena cava (IVC) filter placement are those with injuries severe enough to both preclude early anticoagulation and elicit a pronounced inflammatory response. Pharmacologic thromboprophylaxis with low-molecular-weight heparin is an established standard of care [8,9]. However, timely anticoagulation is not possible in a significant subset of trauma patients due to active hemorrhage, intracranial bleeding, or planned surgical intervention.

This clinical dilemma has motivated the widespread adoption of IVC filters as a mechanical means of pulmonary embolism prevention. Prophylactic IVC filter utilization rose through the mid-to-late 2000s before declining [10,11]. Utilization of said filter varied widely across centers, with one national analysis reporting a range of 0–13 prophylactic filters per 100 admissions across 680 trauma centers [12]. However, the da Vinci trial found that there was no significant reduction in symptomatic pulmonary embolism or death at 90 days following prophylactic filter placement in severely injured patients [13], providing insights that fundamentally challenge the efficacy of this practice. The Prévention du Risque d'Embolie Pulmonaire par Interruption Cave (PREPIC) trial demonstrated that permanent filters reduced short-term pulmonary embolism but increased deep vein thrombosis without improving survival [14,15]. The PREPIC 2 trial confirmed that the utilization of retrievable filters did not offer additional benefits other than ensuring adequate anticoagulation [16]. These findings have been substantiated in multiple meta-analyses [17,18,19].

Several prestigious society guidelines recommend against routine prophylactic filter placement in patients with trauma [9,20,21], citing a synchronous increased incidence of device-related complications as a major reason for objection. Filter migration, fracture, caval perforation, and thrombosis have been well-documented in patients receiving IVC filter placement, and the risks of these complications increase with prolonged dwell time [22]. Despite the call for timely retrieval in safety communications issued by the United States Food and Drug Administration (FDA) in 2010 and 2014 [23], the real-world retrieval rates of IVC filters remain alarmingly low, with the SAFE-IVC study on over 270,000 Medicare beneficiaries reporting a retrieval rate of only 15.3% [24].

Despite the broader shift away from routine use, substantial clinical uncertainty persists in specific high-risk subgroups. Patients with traumatic brain injury, spinal cord injury, and complex pelvic fractures frequently face prolonged contraindications to anticoagulation [25,26]. The da Vinci trial subgroup analysis suggested a potential protective role for filters in patients unable to receive anticoagulation within seven days [13]. This narrow window of possible benefit, coupled with the absence of confirmatory evidence, leaves clinicians without definitive guidance for this challenging population.

The Shanghai Medical Association Vascular Surgery Branch developed a set of clinical practice guidelines to address this gap, aiming to clarify the role of IVC filters in severely injured patients through evidence-based recommendations tailored to clinical practice. The methodology comprises a comprehensive literature review and meta-analysis, followed by two rounds of Delphi consensus polling in a multidisciplinary panel [27,28] that comprises experts from the fields of trauma surgery, acute care surgery, interventional radiology, vascular surgery, and critical care medicine. The target audience includes clinicians involved in the acute and perioperative management of severely injured patients for whom venous thromboembolism prevention is a clinical priority.

2. Methods

2.1 Study Design and Setting

A guideline development group (GDG) was established comprising physicians of trauma surgery (n = 1), acute care surgery (n = 1), interventional radiology (n = 1), vascular surgery (n = 2), and critical care medicine (n = 1), selected from among the Shanghai Medical Association (SMA) members. The GDG reviewed and finalized the scope of the guideline and agreed on the set of PICOS (population, intervention, comparator, outcomes, study design) for the systematic review and meta-analysis.

2.2 Ethics and Registration

The systematic review protocol was registered in PROSPERO (CRD420261334942, https://www.crd.york.ac.uk/PROSPERO/view/CRD420261334942) and conducted according to Cochrane Handbook methods. The clinical practice guideline was registered in PREPARE (Practice guideline REgistration for tRAnsparEncy; PREPARE-2025CN1106).

2.3 Systematic Review and Meta-Analysis

This study was conducted as a systematic review and meta-analysis of randomized controlled trials and observational cohort studies evaluating the effectiveness and safety of IVC filter placement with respect to clinically relevant outcomes. The systematic review and meta-analysis components were reported in adherence to the PRISMA 2020 guidelines [29]. The completed PRISMA 2020 checklist is provided as **Supplementary Table 1**.

2.4 Information Sources and Search Strategy

Relevant studies were identified through systematic searches of PubMed (https://pubmed.ncbi.nlm.nih.gov), Embase (https://www.embase.com), the Cochrane Library (https://www.cochranelibrary.com), and CINAHL (via EBSCOhost), from database inception through February 11, 2026. The search strategy comprised three concept blocks combined using the Boolean operator AND: anatomical terms for the lower extremity and pelvis, terms related to bone fractures, and terms for vena cava filters. The complete search strategy for each database, together with the numbers of records retrieved, is provided in **Supplementary Table 2**. As discussed in the Limitations, this fracture-anchored search strategy did not incorporate generic trauma or injury subject headings and therefore limited the population identified by the review. Accordingly, this limitation is acknowledged rather than presenting the search as comprehensive for the broader trauma literature.

2.5 Inclusion and Exclusion Criteria

Studies were eligible if they: (1) evaluated IVC filter placement as the primary intervention; (2) included a comparison group without filter placement; (3) reported clinical outcomes of interest with sufficient data to calculate effect estimates; and (4) were conducted in adult patients at risk of venous thromboembolism, including trauma or fracture populations or patients with deep vein thrombosis. Cross-sectional studies, case-control studies, case series, reviews, editorials, conference abstracts, and animal or *in vitro* studies were excluded. Duplicate publications were removed, and studies lacking a comparator, relevant outcomes, or extractable data were excluded as well. For multiple publications from the same cohort, the most recent or most comprehensive report was retained. We note that criterion (4), as originally specified, was broader than the guideline's stated target population of severely injured patients, thereby allowing the inclusion of one trial involving medical patients with established proximal deep vein thrombosis and one cohort study involving patients with metastatic pathologic fracture. It also means that the principal analysis combines studies in which filters were placed prophylactically, in the absence of documented venous thromboembolism, with one trial in which placement was therapeutic, serving as secondary prevention in patients with established proximal deep vein thrombosis. These represent distinct clinical indications with different evidence bases; therefore, the pooled estimates from the principal analysis should not be described as estimates of prophylactic filter effect alone. The consequences of this heterogeneity are quantified in the population-restricted sensitivity analysis described below and further discussed in the Limitations.

2.6 Study Selection

Records retrieved from all databases were exported to EndNote 2025 (Clarivate) and de-duplicated; the number of duplicate records removed is reported in accordance with PRISMA 2020 workflow (Fig. 1). Titles and abstracts were screened against the eligibility criteria independently by two reviewers. Full texts of all potentially eligible records were then retrieved and assessed independently by the same reviewers. Disagreements at either stage were resolved through discussion, and where consensus was not reached, via adjudication by a third senior reviewer. No machine-learning classifier or other automation tool was used to mark records as ineligible during screening, and the corresponding PRISMA 2020 field is therefore reported as zero [29,30].

2.7 Data Extraction and Handling

Data extraction was independently performed by two reviewers using a standardized form. Extracted information included author and publication year, study design, population, details of IVC filter placement and comparator, and reported clinical outcomes. For each outcome, the number of events and total participants in each group were recorded. The outcomes of interest were pulmonary embolism, deep vein thrombosis, all-cause mortality, and bleeding events. When multiple follow-up time points were reported, the earliest clinically relevant follow-up period was extracted. Disagreements were resolved through discussion or consultation with a third reviewer.

2.8 Statistical Analysis

All analyses were performed using Review Manager (RevMan), version 5.4 (The Cochrane Collaboration, Copenhagen, Denmark). For dichotomous outcomes, effect estimates were calculated as risk ratios (RRs) with 95% confidence intervals (CIs). Heterogeneity was assessed using Cochran's Q test and quantified using the I-squared (I^2) statistic. Given the expected clinical heterogeneity, all pooled analyses were performed using a random-effects model (DerSimonian–Laird method), which was applied consistently across every outcome. Statistical significance was defined as a two-sided p-value < 0.05. Forest plots were generated for each outcome. Because Review Manager 5.4 implements only the DerSimonian–Laird method for random-effects meta-analysis, sensitivity analyses using alternative estimators were not feasible. Prediction intervals were not calculated because each outcome was informed by only two to five studies; the implications of both are addressed in the Limitations.

2.9 Risk of Bias Assessment

The risk of bias of randomized controlled trials was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool [31]. Overall risk-of-bias judgements were derived using the RoB 2 algorithm, under which a trial is judged at low risk of bias only if it is at low risk in all five domains; a trial raising some concerns in at least one domain, without being at high risk in any domain, receives an overall judgement of some concerns [31]. Observational cohort studies were evaluated using the Newcastle–Ottawa Scale (NOS), which assesses Selection (4 stars), Comparability (2 stars), and Outcome (3 stars), for a maximum score of 9 stars. Studies scoring 7–9 stars were considered high quality, those scoring 5–6 stars moderate quality, and those scoring fewer than 5 stars low quality. In the Comparability domain, a star was withheld when the comparison group was not drawn from the same time period as the exposed group, since the calendar period could represent an uncontrolled source of confounding. Domain-level assessments are provided in **Supplementary Tables 3 (NOS) and 4 (RoB 2)** and presented graphically in **Supplementary Figs. 2,3**. All studies were independently assessed by two reviewers, with disagreements resolved by a third reviewer. No studies were excluded on the basis of quality, and quality assessments were not used to weight the pooled analyses.

2.10 Sensitivity Analysis, Subgroup Analysis, and Publication Bias

Robustness was evaluated using leave-one-out analysis, with each study sequentially excluded from the meta-analysis; the full results are provided in **Supplementary Table 5**. Although formal assessment of publication bias using funnel plots and Egger's test was pre-specified, it was not performed because fewer than 10 studies were available for each outcome, limiting the reliability of these analyses [32].

A design-stratified subgroup analysis (randomized versus observational) was pre-specified. In the corrected analysis, however, the number of studies contributing to each outcome was too small, and the distribution of studies across designs was too uneven for formal tests of subgroup differences to provide meaningful information. Current methodological guidance cautions that investigations of heterogeneity are unlikely to be reliable when fewer than approximately ten studies are available and that subgroup comparisons are observational in nature and prone to confounding by other study-level characteristics [33]. Design-stratified subgroup tests were therefore not performed for any outcome. This deviation from the protocol is reported in the interest of transparency. Where study design is relevant to interpretation, it is addressed narratively and through the leave-one-out and population-restricted analyses.

A post hoc sensitivity analysis restricted to trauma and fracture populations was additionally performed. This analysis excluded a trial involving medical patients with established proximal deep vein thrombosis and a cohort study involving patients with metastatic pathologic fracture, thereby retaining the studies whose populations fell within the scope of the guidelines. This analysis is only reported as exploratory.

2.11 Delphi Consensus Process

A multidisciplinary expert panel of 21 physicians from the Shanghai Medical Association was convened, comprising 5 trauma surgeons, 4 acute care surgeons, 2 interventional radiologists, 7 vascular surgeons, and 3 critical care physicians. An anonymous electronic Delphi process was conducted. In Round 1, panelists rated proposed statements on a four-point agreement scale (Agree, Neutral, Disagree, No Opinion) administered by email questionnaire. "No Opinion" denoted an explicit abstention, indicating that the respondent did not consider themselves positioned to rate the statement, and was therefore distinct from "Neutral", which represented a considered intermediate position. Agreement was calculated as the proportion of all responding panelists selecting "Agree", with "No Opinion" responses retained in the denominator. Statements reaching 75% agreement were considered to have reached consensus; those that did not meet this threshold were revised or removed based on panel feedback. Round 2 was conducted electronically using the same criterion. The final recommendations were agreed upon at a separate offline, in-person consensus meeting attended by 20 of the 21 panelists.

The recommendation statements report the strength of expert consensus, as defined by Delphi agreement: ≥90% agreement was classified as High; 80% to <90% as Moderate; 75% to <80% as Mild; and <75% as Not Recommended. Certainty of the underlying evidence was not formally graded; therefore, these categories were not interpreted as measures of evidence certainty. Round-by-round Delphi results are provided in **Supplementary Table 6**.

3. Results

3.1 Literature Retrieval

The PRISMA 2020 flow diagram is presented in Fig. 1. A total of 516 records were identified, and after stepwise screening, 6 studies were included in the meta-analysis [13,14,26,34,35,36]. The included studies comprised randomized controlled trials and observational cohort studies. Their characteristics are summarized in (Table 1, Ref. [13,14,26,34,35,36]).

3.2 Results of Risk of Bias Assessment

All four observational cohort studies scored 7 or more on the Newcastle-Ottawa Scale, indicating high methodological quality (**Supplementary Table 3**). The Cochrane RoB 2 assessment rated both randomized controlled trials as having a low risk of bias in the domains of randomization,

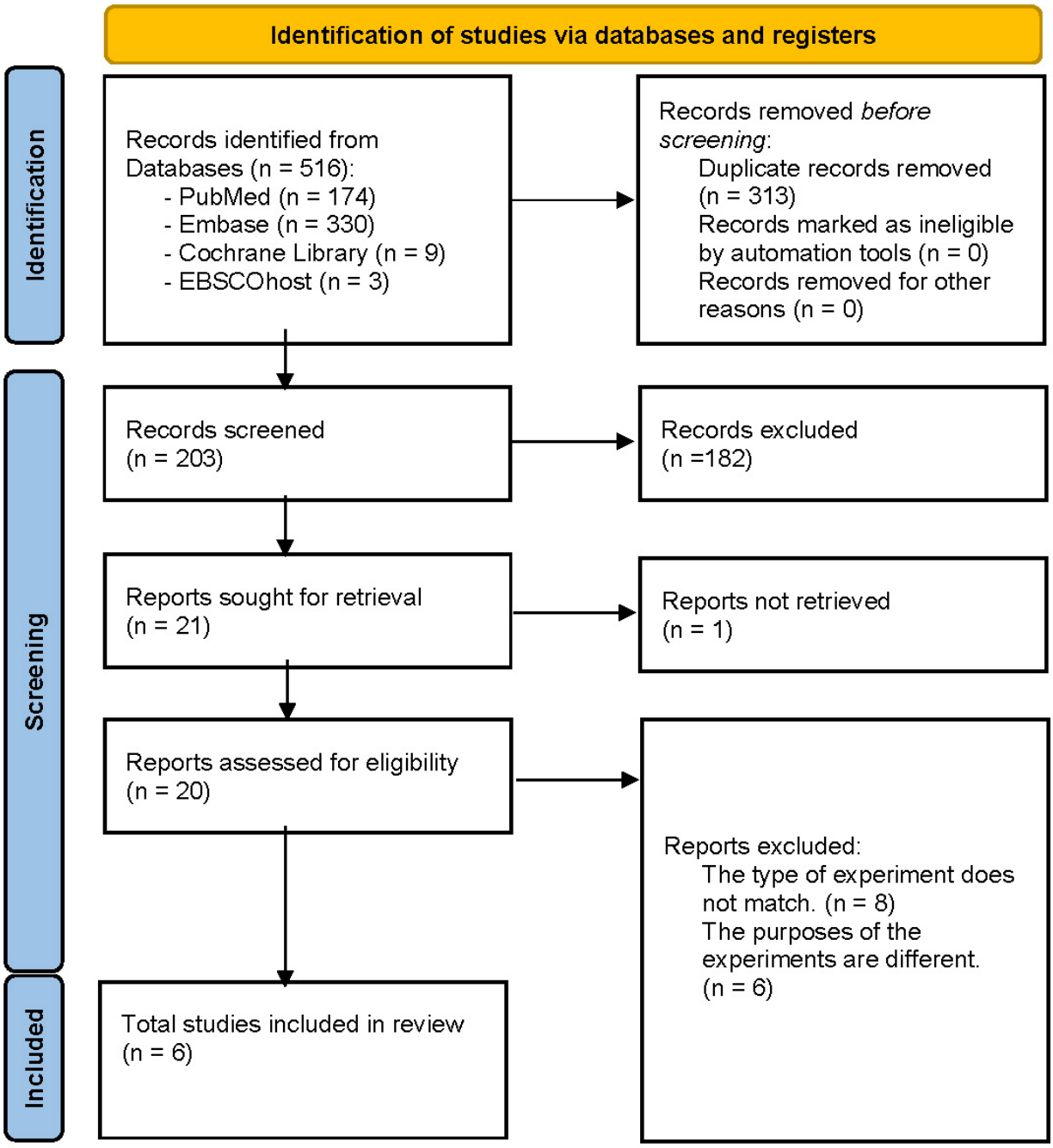

Fig. 1. Flow diagram of study identification, screening, and inclusion according to PRISMA 2020.

missing outcome data, measurement of the outcome, and selection of the reported result. However, some concerns were identified in the domain of deviations from intended interventions, reflecting the open-label nature of device implantation, which cannot be blinded. Applying the RoB 2 algorithm, the overall risk-of-bias judgement for both trials was therefore "some concerns" rather than "low risk" [31]. Domain-level judgements are presented in **Supplementary Table 4** and traffic-light and summary plots are provided in **Supplementary Figs. 1,2**.

3.3 Meta-analysis Results

Throughout the following subsections, prophylactic IVC filter placement denotes insertion in the absence of documented venous thromboembolism, and therapeutic IVC filter placement denotes insertion for confirmed acute proximal venous thromboembolism in a patient with an absolute contraindication to anticoagulation. These definitions are applied consistently in the Results and Discussion. Because the principal analysis pools studies of both indications, the indication contributed by each study is stated for every outcome below, and no pooled estimate from the

Table 1. Characteristics of included studies.

Study	Design	Population	Intervention/*n*	Comparator/*n*	Outcomes contributed to meta-analysis
Decousus 1998 (PREPIC) [14]	Randomized controlled trial	Medical patients with acute proximal deep-vein thrombosis	IVC filter/200	No filter/200	Symptomatic pulmonary embolism; all-cause mortality; deep vein thrombosis; bleeding
Ho 2019 (da Vinci) [13]	Randomized controlled trial	Severely injured trauma patients (Injury Severity Score >15) with a contraindication to prophylactic anticoagulation	IVC filter/122	No filter/118	All-cause mortality; deep vein thrombosis; major bleeding. Symptomatic pulmonary embolism alone was not reported for the whole trial and is not included in that outcome.
Fullen 1973 [34]	Observational cohort	Hip fracture patients	IVC filter/41	No filter/59	Symptomatic pulmonary embolism; all-cause mortality; bleeding
Pan 2016 [35]	Observational cohort (retrospective, single center)	Patients with deep vein thrombosis after lower-extremity fracture undergoing orthopedic surgery	IVC filter/823	No filter/1700	Symptomatic pulmonary embolism
Cohen-Levy 2019 [26]	Observational cohort	Patients with operative pelvic fractures	IVC filter/71	No filter/25	Symptomatic pulmonary embolism; deep vein thrombosis
Benevenia 2004 [36]	Observational cohort	Patients with metastatic pathologic lower-extremity fractures	IVC filter/24	No filter/23	Symptomatic pulmonary embolism; deep vein thrombosis

IVC, inferior vena cava; PREPIC, Prévention du Risque d'Embolie Pulmonaire par Interruption Cave. Study design is reported for each included study; the analysis comprised two randomized controlled trials and four observational cohort studies. The Outcomes column lists only those outcomes for which the study contributed data to a pooled analysis, so that each forest plot can be reconciled with this table.

principal analysis should be read as an estimate of the effect of prophylactic placement alone. For all outcomes, design-stratified subgroup analyses were not performed for the reasons outlined in the Methods.

3.4 Symptomatic Pulmonary Embolism

Five studies reported symptomatic pulmonary embolism. The da Vinci trial was not included in this outcome because it reported only a composite endpoint (symptomatic pulmonary embolism or death) and a subgroup pulmonary embolism endpoint, neither of which corresponds to a whole-trial count of pulmonary embolism events. The pooled analysis demonstrated a significantly lower risk of symptomatic pulmonary embolism associated with filter placement (RR 0.22, 95% CI 0.08–0.66; $p = 0.006$), with moderate heterogeneity ($I^2 = 40\%$). Four of the five contributing studies were observational cohort studies. The single randomized trial (Decousus 1998 [14]) evaluated therapeutic rather than prophylactic placement. The forest plot is shown in Fig. 2.

3.5 All-cause Mortality

Three studies reported all-cause mortality. The pooled analysis showed no significant difference between the IVC filter and no-filter groups (RR 0.88, 95% CI 0.41–1.89; $p = 0.75$), with moderate heterogeneity ($I^2 = 45\%$). Given the imprecision of the estimate, the confidence interval is compatible with effects in either direction; therefore, the absence of statistical significance should not be interpreted as demonstrating evidence of equivalence. The forest plot is shown in Fig. 3. Of the three contributing studies, two evaluated prophylactic placement and one evaluated therapeutic placement.

3.6 Deep Vein Thrombosis

Four studies reported deep vein thrombosis. The pooled analysis showed a higher incidence of deep vein thrombosis in the IVC filter group (RR 1.38, 95% CI 1.02–1.87; $p = 0.04$), with no heterogeneity ($I^2 = 0\%$). This estimate was, however, neither robust to leave-one-out exclusion nor sustained when the analysis was restricted to

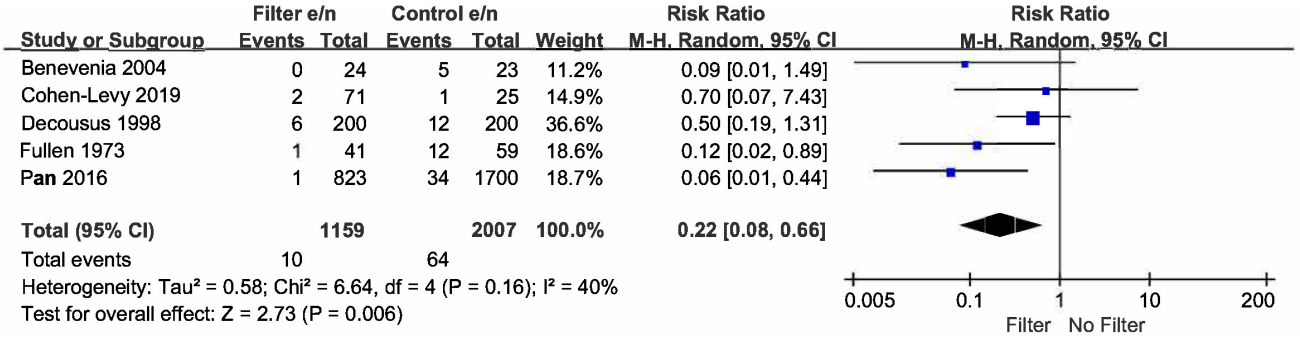

Fig. 2. Forest plot comparing the risk of symptomatic pulmonary embolism between patients receiving an inferior vena cava (IVC) filter and those receiving no filter. Random-effects model using the DerSimonian–Laird method; effect estimates are presented as risk ratios (RRs) with 95% confidence intervals (CIs).

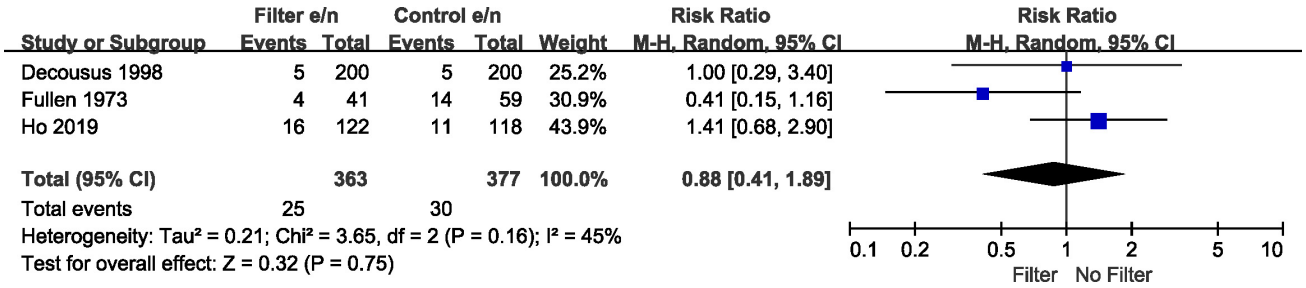

Fig. 3. Forest plot comparing all-cause mortality between patients receiving an inferior vena cava (IVC) filter and those receiving no filter. Random-effects model using the DerSimonian–Laird method; effect estimates are presented as risk ratios (RRs) with 95% confidence intervals (CIs).

trauma and fracture populations, as detailed below. The forest plot is shown in Fig. 4. Of the four contributing studies, three evaluated prophylactic placement and one evaluated therapeutic placement.

3.7 Bleeding

Three studies reported bleeding events. The pooled analysis showed no significant difference between groups (RR 1.08, 95% CI 0.91–1.28; $p = 0.39$), with no heterogeneity ($I^2 = 0\%$). The estimate was dominated by one trial that reported major bleeding under a specific definition, and the pooled figure should be read in light of the differing bleeding definitions across studies. The forest plot is shown in Fig. 5. Of the three contributing studies, two evaluated prophylactic placement and one evaluated therapeutic placement.

3.8 Sensitivity Analyses

Leave-one-out analyses were performed for each outcome (**Supplementary Table 5**). The association with symptomatic pulmonary embolism remained statistically significant across all five iterations. In contrast, the association with deep vein thrombosis was not significant. The finding was largely driven by the Decousus trial, which contributed the majority of the analytical weight; exclusion of this study yielded an RR of 1.34 (95% CI 0.72–2.51; $p = 0.35$), eliminating statistical significance. Similarly, excluding Cohen–Levy rendered the result non-significant (RR 1.35, 95% CI 0.98–1.84; $p = 0.063$). The apparent association between filter placement and deep vein thrombosis therefore rests substantially on a single trial conducted in patients with established proximal deep vein thrombosis receiving anticoagulation, rather than in a trauma prophylaxis population; therefore, the finding should be regarded as non-robust. Associations with all-cause mortality and bleeding remained non-significant in every iteration.

3.9 Population-restricted Sensitivity Analysis

Because the included studies spanned clinically heterogeneous populations, a post hoc analysis was performed restricted to the trauma and fracture cohorts, excluding Decousus 1998 [14] (medical patients with established proximal deep vein thrombosis) and Benevenia 2004 [36] (patients with metastatic pathologic fracture). In this restricted set, the reduction in symptomatic pulmonary embolism persisted (three studies; RR 0.15, 95% CI 0.04–0.59; $p = 0.007$; $I^2 = 20\%$; **Supplementary Fig. 3**). The association between filter placement and deep vein thrombosis was no longer evident (two studies; RR 1.31, 95% CI 0.68–2.50; $p = 0.42$; $I^2 = 0\%$; **Supplementary Fig. 4**). All-cause mortality remained non-significant (two studies; RR 0.81, 95% CI 0.24–2.68; $p = 0.72$; $I^2 = 72\%$), as did bleeding (two stud-

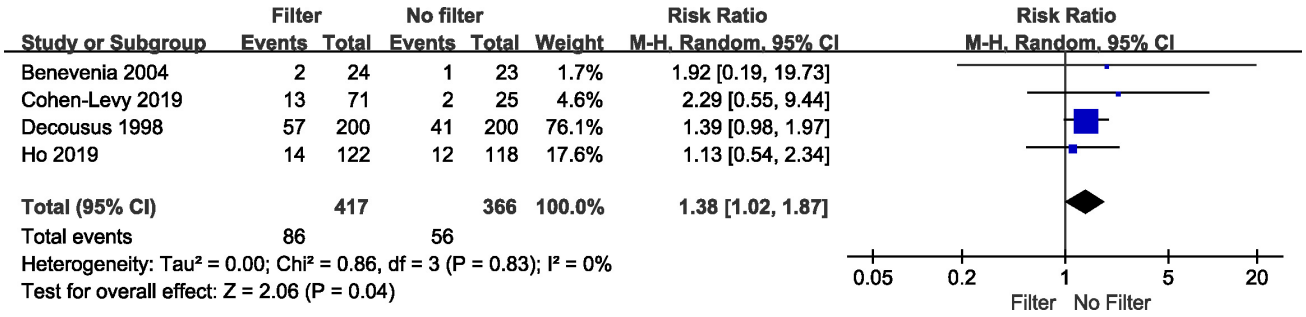

Fig. 4. Forest plot comparing deep vein thrombosis between patients receiving an inferior vena cava (IVC) filter and those receiving no filter. Random-effects model using the DerSimonian–Laird method; effect estimates are presented as risk ratios (RRs) with 95% confidence intervals (CIs).

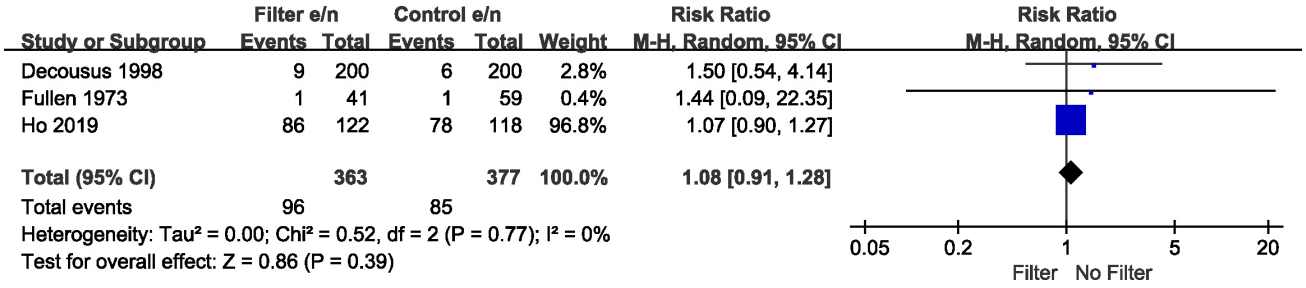

Fig. 5. Forest plot comparing bleeding between patients receiving an inferior vena cava (IVC) filter and those receiving no filter. Random-effects model using the DerSimonian–Laird method; effect estimates are presented as risk ratios (RRs) with 95% confidence intervals (CIs).

ies; RR 1.07, 95% CI 0.90–1.27; $p = 0.46$; $I^2 = 0\%$). The substantial heterogeneity in the restricted mortality analysis, based on only two studies from markedly different eras and with different designs, further supports interpreting this estimate as uninformative rather than reassuring. These restricted analyses were based on very few studies and were therefore imprecise and exploratory. They are reported because the restricted population more closely corresponds to the population targeted by this guideline. Full results are provided in **Supplementary Table 7**.

3.10 Delphi Rounds

Nineteen preliminary consensus statements were drafted based on the systematic review and meta-analysis by the GDG. In the first Delphi round, all 19 statements were sent to the expert panel by email. All participants (21/21) responded to the 19 statements. Eleven statements (57.9%) met the 75% agreement threshold. Six statements (31.6%) were revised, and two (10.5%) were removed. In the second round, 20/21 participants (95.2%) responded to 17 statements; thirteen (76.5%) met the threshold, two (11.8%) were revised, and two (11.8%) were removed. At the final offline consensus meeting, 20/21 participants (95.2%) attended, and consensus was reached on 14 of the 15 statements (93.3%). The flow diagram is shown in Fig. 6, and round-by-round results are provided in **Supplementary Table 6**.

3.11 Statements of Guidelines With Strength of Consensus

Each recommendation below reports its strength of expert consensus, based on the final Delphi agreement. The certainty of the underlying evidence was not formally graded; the narrative accompanying each statement describes the evidence base without assigning a formal certainty rating (Table 2).

Recommendation 1: Against Routine Prophylactic IVC Filter Placement in Trauma.

Routine prophylactic IVC filter placement is not recommended for venous thromboembolism prevention in severely injured patients. The only adequately powered randomized controlled trial in trauma, the da Vinci trial, found no reduction in symptomatic pulmonary embolism or death at 90 days in patients receiving early prophylactic filter placement. Multiple meta-analyses report no mortality benefit. All major society guidelines have now recommended against this practice. Pharmacologic thromboprophylaxis remains the cornerstone of VTE prevention and should be the default strategy for all trauma patients when feasible.

Strength of consensus (Delphi agreement): *Moderate (80% agreement).*

Supporting references: [8,13,14,19,20,21].

Recommendation 2: Early Pharmacologic Thromboprophylaxis as First-Line Prevention.

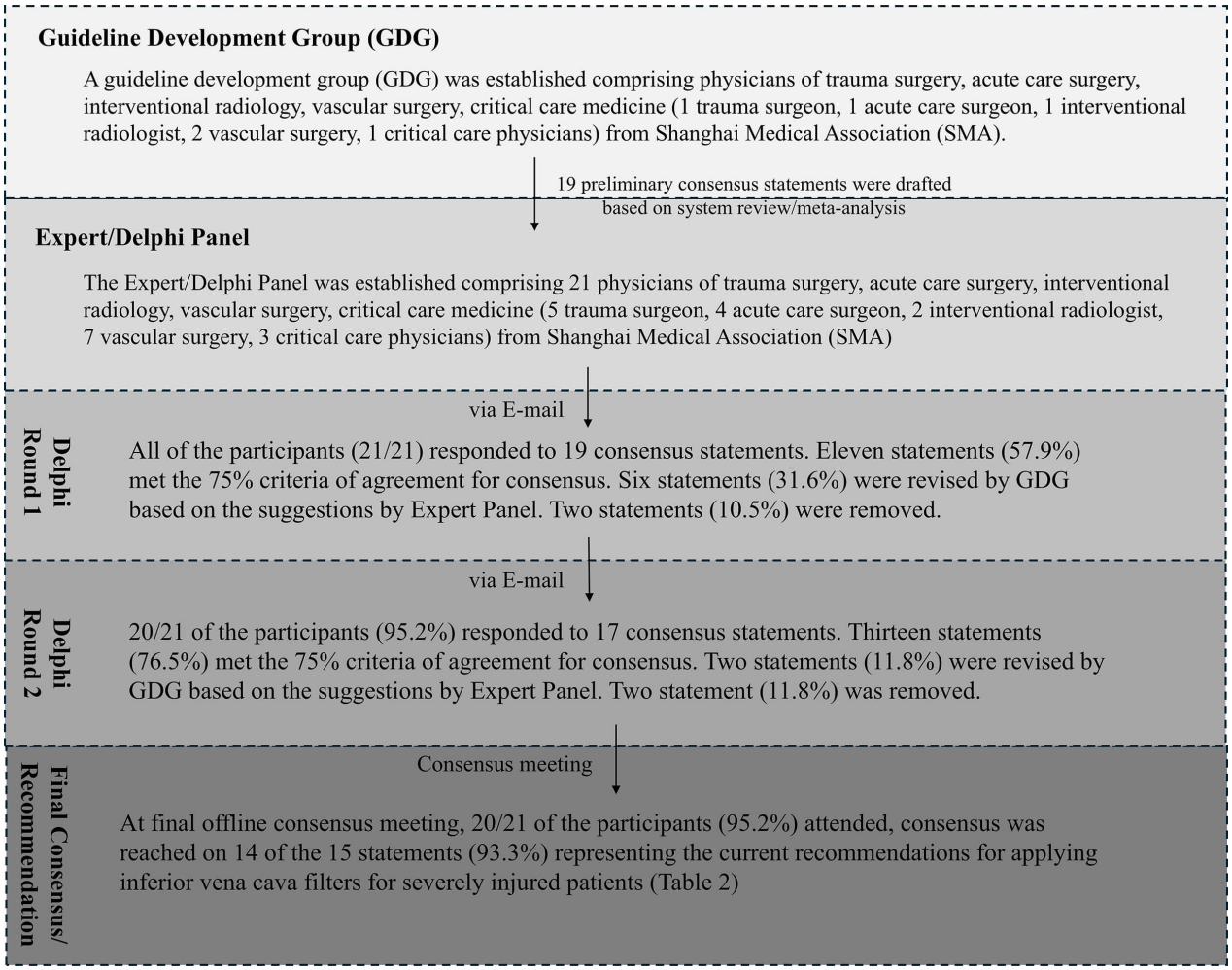

Fig. 6. Flow diagram of the Delphi consensus process. The diagram shows the number of candidate statements entering and exiting each round, the response rate at each round, and the number of statements that reached consensus, were revised, or were removed. Nineteen statements were drafted by the guideline development group; two were removed after Round 1 and two after Round 2, leaving the fifteen statements presented in Table 2. Consensus was defined *a priori* as ≥75% agreement, and the strength categories (High, Moderate, Mild, Not Recommended) were defined as described in the Methods. Round-by-round agreement percentages for every candidate statement are given in **Supplementary Table 6**. These percentages denote the strength of expert consensus only; the certainty of the underlying evidence was not formally graded.

Low-molecular-weight heparin should be initiated within 24 to 72 hours of injury in all trauma patients unless an absolute contraindication exists. Low-dose unfractionated heparin is an acceptable alternative when LMWH is unavailable. Mechanical prophylaxis alone is inferior to pharmacologic agents and should serve only as an adjunct or bridge until anticoagulation can be safely administered. Institutional protocols should focus on removing barriers to early chemoprophylaxis rather than defaulting to IVC filter placement.

Strength of consensus (Delphi agreement): *High (90% agreement).*

Supporting references: [8,20,37,38,39].

Recommendation 3: IVC Filters for Established VTE with Absolute Contraindication to Anticoagulation.

An IVC filter is indicated in trauma patients with documented acute proximal deep vein thrombosis or pulmonary embolism who have an absolute contraindication to therapeutic anticoagulation. For the purposes of this guideline, an absolute contraindication denotes a clinical state in which therapeutic anticoagulation cannot be given because the immediate risk of major hemorrhage is prohibitive, such as active or uncontrolled major bleeding; this definition is adopted from existing anticoagulation guidance and was not itself the subject of a Delphi vote. This remains the strongest and most widely endorsed indication across the major society guidelines, including CHEST 2021, SIR 2020, and ACR 2019 [9,20,21]. The filter should be retrievable and removed once anticoagulation can be safely initiated. Where thromboembolism is suspected but not confirmed, definitive imaging should be performed be-

Table 2. Delphi consensus statements and strength of consensus at the final meeting.

Recommendation	Agree	Neutral	Disagree	No opinion
Recommendation 1: Against Routine Prophylactic IVC Filter Placement in Trauma Routine prophylactic IVC filter placement is not recommended for venous thromboembolism prevention in severely injured patients. The only adequately powered randomized controlled trial in trauma, the da Vinci trial, found no reduction in symptomatic pulmonary embolism or death at 90 days in patients receiving early prophylactic filter placement. Multiple meta-analyses reported no mortality benefit. All major society guidelines have now recommended against this practice. Pharmacologic thromboprophylaxis remains the cornerstone of VTE prevention and should be the default strategy for all trauma patients when feasible.	80%	5%	5%	10%
Recommendation 2: Early Pharmacologic Thromboprophylaxis as First-Line Prevention Low-molecular-weight heparin should be initiated within 24 to 72 hours of injury in all trauma patients unless an absolute contraindication exists. Low-dose unfractionated heparin is an acceptable alternative when LMWH is unavailable. Mechanical prophylaxis alone is inferior to pharmacologic agents and should serve only as an adjunct or bridge until anticoagulation can be safely administered. Institutional protocols should focus on removing barriers to early chemoprophylaxis rather than defaulting to IVC filter placement.	90%	5%	0	5%
Recommendation 3: IVC Filters for Established VTE with Absolute Contraindication to Anticoagulation An IVC filter is indicated in trauma patients with documented acute proximal deep vein thrombosis or pulmonary embolism who have an absolute contraindication to therapeutic anticoagulation. For the purposes of this guideline, an absolute contraindication denotes a clinical state in which therapeutic anticoagulation cannot be given because the immediate risk of major hemorrhage is prohibitive, such as active or uncontrolled major bleeding; this definition is adopted from existing anticoagulation guidance and was not itself the subject of a Delphi vote. The filter should be retrievable and removed once anticoagulation can be safely initiated. Where thromboembolism is suspected but not confirmed, definitive imaging should be obtained before placement.	80%	10%	5%	5%
Recommendation 4: Consideration of Prophylactic IVC Filters When Anticoagulation Cannot Be Initiated Within Seven Days A prophylactic IVC filter may be considered in severely injured patients who cannot receive any pharmacologic thromboprophylaxis for more than seven days after injury. The da Vinci trial prespecified subgroup analysis showed that among patients not anticoagulated within seven days, symptomatic pulmonary embolism occurred in 0% of the filter group versus 14.7% of controls. This was a secondary, non-powered endpoint and remains hypothesis-generating. The subgroup was defined by a post-randomization event and is therefore not subjected to randomization; confounding by indication cannot be excluded, as patients in whom anticoagulation is withheld are likely to be more severely injured and more comorbid. The seven-day threshold should be treated as a deliberative prompt rather than a decision rule.	75%	10%	5%	10%
Recommendation 5: Traumatic Brain Injury Does Not Constitute an Automatic Indication for IVC Filter Placement Prophylactic IVC filter placement is not routinely recommended in patients with traumatic brain injury. Although a substantial proportion of such patients may not receive anticoagulation within seven days, retrospective studies showed that IVC filters are not associated with freedom from pulmonary embolism at one year in this population, and retrieval rates in brain-injured patients are very low. The focus should be on safe, early initiation of pharmacologic prophylaxis guided by repeat neuroimaging.	75%	10%	0	15%
Recommendation 6: Pelvic and Acetabular Fractures Do Not Warrant Routine Prophylactic IVC Filters Prophylactic IVC filter placement is not recommended as routine practice in patients with operative pelvic or acetabular fractures. A 12-year single-center experience demonstrated that an aggressive filter policy failed to reduce pulmonary embolism or deep vein thrombosis incidence in this population. A large national analysis found no mortality reduction with prophylactic filters. Early pharmacologic prophylaxis should be prioritized.	80%	10%	5%	5%

Table 2. Continued.

Recommendation	Agree	Neutral	Disagree	No opinion
Recommendation 7: Spinal Cord Injury Patients Should Not Receive Routine Prophylactic IVC Filters Routine prophylactic IVC filter placement is not recommended in acute spinal cord injury. Retrospective data indicate that filters may be associated with a higher risk of deep vein thrombosis, with one study reporting DVT in 20.4% of filtered versus 5.2% of non-filtered patients. This observation is derived from a single retrospective cohort and is subject to confounding by indication, and the association was not robust in our pooled analysis. The recommendation rests principally on the absence of demonstrated benefit rather than on established harm. Pharmacologic thromboprophylaxis should be initiated as soon as hemostasis is achieved.	75%	15%	5%	5%
Recommendation 8: Only Retrievable Filters Should Be Used in Trauma Patients When an IVC filter is indicated in a trauma patient, only a retrievable filter should be placed. Permanent filters have no role in trauma, given the typically time-limited nature of anticoagulation contraindications. The PREPIC trial demonstrated that permanent filters increase long-term deep vein thrombosis risk. The ACR 2019 Appropriateness Criteria rate permanent filters as usually not appropriate in trauma settings. A documented retrieval plan should be established for every filter at the time of insertion.	80%	5%	10%	5%
Recommendation 9: Retrieve Filters as Soon as the Indication Resolves Retrievable IVC filters should be removed as soon as the indication resolves, which may be well before 29 days. The 29- to 54-day interval derived from an FDA-sponsored decision analysis describes the modeled window beyond which the risk-benefit balance deteriorates. It should therefore be regarded as an outer bound rather than a target retrieval interval and is not specific to any particular filter type or patient. The risks for complications, including caval wall perforation, filter fracture, and device migration, increase with prolonged dwell time. The timing of retrieval should be governed by individual clinical trajectory, including ongoing bleeding risk and surgical plans.	75%	15%	5%	5%
Recommendation 10: Institutional IVC Filter Registries and Dedicated Retrieval Programs Are Essential Every institution that places IVC filters should maintain a filter registry and implement a systematic retrieval program. Real-world retrieval rates remain unacceptably low; the SAFE-IVC study found a cumulative retrieval rate of only 15.3%, and a systematic review found that only 34.9% of filters are retrieved. These recommendations assume the availability of retrieval infrastructure. In settings lacking a retrieval program, the threshold for placement should be more restrictive, and retrieval pathways, including transfer where necessary, should be arranged before placement.	80%	10%	5%	5%
Recommendation 11: Reassessment of Filter Necessity Within 72 Hours and at Regular Intervals After IVC filter placement, the ongoing need for the device must be reassessed within 72 hours and then at least weekly thereafter. The treating team should document at each assessment whether anticoagulation can be safely initiated. Once pharmacologic anticoagulation is initiated, arrangements for filter retrieval should begin immediately.	90%	0	0	10%
Recommendation 12: Multidisciplinary Decision-Making for IVC Filter Placement The decision to place a prophylactic IVC filter should involve a multidisciplinary discussion including the trauma surgeon, intensivist, and interventional radiologist or vascular surgeon. No single provider should place a prophylactic filter without a documented consensus on the indication. Institutional protocols should require documentation of the specific contraindication, its anticipated duration, and a planned retrieval date.	90%	5%	0	5%
Recommendation 13: Timing of Filter Placement Should Be Within 72 Hours When Indicated When an IVC filter is deemed necessary, it should be placed within 72 hours of injury or within 72 hours of the VTE event. The da Vinci trial protocol mandated filter placement within 72 hours. Delays beyond this window reduce potential benefit. Bedside placement capability should be available for hemodynamically unstable patients.	80%	10%	0	10%

Table 2. Continued.

Recommendation	Agree	Neutral	Disagree	No opinion
Recommendation 14: Prophylactic IVC Filters Are Not Cost-Effective in Most Trauma Populations				
Prophylactic IVC filter placement is likely not cost-effective in the general high-risk trauma population. Economic analyses demonstrate a median filter cost of approximately 759 US dollars per day compared with 4.32 US dollars per day for chemoprophylaxis, with an estimated number needed to treat of 379 to prevent one incidence of pulmonary embolism. This statement did not reach consensus; panel feedback attributed this to concern about the generalizability of single-center economic analyses across health systems with differing cost structures.	55%	20%	15%	10%
Recommendation 15: Future Research Should Prioritize the Prolonged-Contraindication Subgroup				
The most critical knowledge gap is the absence of a large, definitive randomized controlled trial of trauma patients with prolonged contraindication to anticoagulation exceeding seven days. A confirmatory trial adequately powered for this subgroup is essential. The dose-response relationship between duration of anticoagulation contraindication and filter benefit should be characterized using flexible modeling in individual-patient-data analyses.	100%	0	0	0

The agreement percentage represents the proportion of panelists selecting "Agree" at the final consensus meeting. Consensus was defined a priori as ≥75% agreement. Strength of consensus: High (≥90%), Moderate (80% to <90%), Mild (75% to <80%), Not Recommended (<75%). Agree, Neutral, Disagree, and No Opinion are the four response options available in the rating scale; "No Opinion" denotes an explicit abstention and was retained in the denominator when calculating agreement. Percentages are rounded off and may not sum to exactly 100%. These categories describe the strength of expert consensus only and are not measures of certainty of evidence, which were not formally graded. Abbreviations: ACR, American College of Radiology; DVT, deep vein thrombosis; FDA, United States Food and Drug Administration; IVC, inferior vena cava; LMWH, low-molecular-weight heparin; VTE, venous thromboembolism.

fore placement, and placement in the absence of confirmed thromboembolism should be treated as a prophylactic decision under Recommendations 1 and 4.

Strength of consensus (Delphi agreement): *Moderate (80% agreement).*

Supporting references: [8,9,15,20,21].

Recommendation 4: Consideration of Prophylactic IVC Filters When Anticoagulation Cannot Be Initiated Within Seven Days.

A prophylactic IVC filter may be considered in severely injured patients who cannot receive any pharmacologic thromboprophylaxis for more than seven days after injury. The da Vinci trial prespecified subgroup analysis showed that among patients not anticoagulated within seven days, symptomatic pulmonary embolism occurred in 0% of the filter group versus 14.7% of controls. This is the only subgroup in which a potential prophylactic benefit has been suggested in randomized data. This finding was a secondary, non-powered endpoint and remains hypothesis-generating. No direct randomized whole-trial evidence for pulmonary embolism in trauma exists. It should further be noted that this subgroup was defined by a post-randomization event, namely the failure to receive anticoagulation within seven days, and is therefore not subject to randomization. Patients in whom anticoagulation is withheld for more than a week are likely to differ systematically from those anticoagulated earlier, being on average more severely injured and carrying a greater burden of comorbidity and competing risk. Thus, confounding by indication cannot be excluded as an explanation for the observed difference. The trial investigators also cautioned that confidence intervals for secondary endpoints were not adjusted for multiplicity. The seven-day threshold should be regarded as a deliberative prompt rather than a decision rule. Clinical judgment should weigh the anticipated duration of anticoagulation contraindication against filter-related risks.

Strength of consensus (Delphi agreement): *Mild (75% agreement).*

Supporting references: [13,16,33,40].

Recommendation 5: Traumatic Brain Injury Does Not Constitute an Automatic Indication for IVC Filter Placement.

Prophylactic IVC filter placement is not routinely recommended in patients with traumatic brain injury. Although a substantial proportion of such patients may not receive anticoagulation within seven days, retrospective studies showed that IVC filters are not associated with freedom from pulmonary embolism at one year in this population, and retrieval rates in brain-injured patients are very low. The focus in traumatic brain injury management should be on safe, early initiation of pharmacologic prophylaxis guided by repeat neuroimaging to confirm hemorrhage stability. Only patients with documented inability to anticoagulate beyond seven days should be considered for filter placement, according to Recommendation 4.

Strength of consensus (Delphi agreement): *Mild (75% agreement).*

Supporting references: [13,25,41,42].

Recommendation 6: Pelvic and Acetabular Fractures Do Not Warrant Routine Prophylactic IVC Filters.

Prophylactic IVC filter placement is not recommended as routine practice in patients with operative pelvic or acetabular fractures. A 12-year single-center study demonstrated that an aggressive filter policy failed to reduce the incidence of pulmonary embolism or deep vein thrombosis in this population. A large national analysis found no mortality reduction with prophylactic filters. Early pharmacologic prophylaxis should be prioritized.

Strength of consensus (Delphi agreement)*: Moderate (80% agreement).*

Supporting references: [26,34,43].

Recommendation 7: Spinal Cord Injury Patients Should Not Receive Routine Prophylactic IVC Filters.

Routine prophylactic IVC filter placement is not recommended in acute spinal cord injury. Retrospective data indicate that filters may be associated with a higher risk of deep vein thrombosis in this population, with one study reporting DVT in 20.4% of filtered versus 5.2% of non-filtered patients. This observation is derived from a single retrospective cohort and is subject to confounding by indication. In our own pooled analysis, the association between filters and deep vein thrombosis was not robust to leave-one-out exclusion and was not evident when the analysis was restricted to trauma and fracture populations. The recommendation therefore rests principally on the absence of demonstrated benefit rather than on established harm. Pharmacologic thromboprophylaxis should be initiated as soon as hemostasis is achieved. Filters should only be considered when anticoagulation remains contraindicated beyond seven days or when documented VTE occurs.

Strength of consensus (Delphi agreement): *Mild (75% agreement).*

Supporting references: [25,44].

Recommendation 8: Only Retrievable Filters Should Be Used in Trauma Patients.

When an IVC filter is indicated in a trauma patient, only a retrievable filter should be placed. Permanent filters have no role in trauma, given the typically time-limited nature of anticoagulation contraindications. The PREPIC trial demonstrated that permanent filters increase long-term deep vein thrombosis risk. The ACR 2019 Appropriateness Criteria [21] rate permanent filters as usually not appropriate in trauma settings. A documented retrieval plan should be established for every filter at the time of insertion.

Strength of consensus (Delphi agreement): *Moderate (80% agreement).*

Supporting references: [9,14,15,21].

Recommendation 9: Retrieve Filters as Soon as the Indication Resolves.

Retrievable IVC filters should be removed as soon as the indication resolves, which may be well before 29 days. The 29- to 54-day interval derived from an FDA-sponsored decision analysis describes the modeled window beyond which the risk-benefit balance deteriorates. It should therefore be regarded as an outer bound rather than a target retrieval interval and is not specific to any particular filter type or patient. The risks for complications, including caval wall perforation, filter fracture, and device migration, increase with prolonged dwell time. The timing of retrieval should be governed by individual clinical trajectory, including ongoing bleeding risk and surgical plans.

Strength of consensus (Delphi agreement): *Mild (75% agreement).*

Supporting references: [23,24,45,46].

Recommendation 10: Institutional IVC Filter Registries and Dedicated Retrieval Programs Are Essential.

Every institution that places IVC filters should maintain a filter registry and implement a systematic retrieval program. Real-world retrieval rates remain unacceptably low. The SAFE-IVC study found a cumulative retrieval rate of only 15.3%, and a systematic review found that only 34.9% of filters are retrieved. Dedicated filter clinics, automated scheduling, multidisciplinary surveillance, and registries are expected to raise the retrieval rates, yet these recommendations are only feasible provided that retrieval infrastructure is available. In settings lacking a retrieval program, the threshold for placement should be more restrictive, and pathways for filter retrieval, including transfer where necessary, should be arranged before placement.

Strength of consensus (Delphi agreement): *Moderate (80% agreement).*

Supporting references: [24,47,48,49,50,51].

Recommendation 11: Reassessment of Filter Necessity Within 72 Hours and at Regular Intervals.

After IVC filter placement, the ongoing need for the device must be reassessed within 72 hours and then at least weekly thereafter. The treating team should document at each assessment whether anticoagulation can be safely initiated. Once pharmacologic anticoagulation is initiated, arrangements for filter retrieval should begin immediately. This practice reduces unnecessary dwell time and aligns with FDA safety recommendations.

Strength of consensus (Delphi agreement): *High (90% agreement).*

Supporting references: [23,45,52].

Recommendation 12: Multidisciplinary Decision-Making for IVC Filter Placement.

The decision to place a prophylactic IVC filter should involve a multidisciplinary discussion including the trauma surgeon, intensivist, and interventional radiologist or vascular surgeon. No single provider should place a prophylactic filter without a documented consensus on the indication. Institutional protocols should require documentation of the specific contraindication to anticoagulation, the anticipated duration of that contraindication, and a planned retrieval date.

Strength of consensus (Delphi agreement): *High (90% agreement).*

Supporting references: [20,37,38,39].

Recommendation 13: Timing of Filter Placement Should Be Within 72 Hours When Indicated.

When an IVC filter is deemed necessary, it should be placed within 72 hours of injury or within 72 hours of the VTE event. The da Vinci trial protocol mandated filter placement within 72 hours. Delays beyond this window reduce potential benefit and may expose the patient to the highest-risk period without protection. Bedside placement capability should be available for hemodynamically unstable patients who cannot be safely transported to interventional radiology wards.

Strength of consensus (Delphi agreement): *Moderate (80% agreement).*

Supporting references: [13,20].

Recommendation 14: Prophylactic IVC Filters Are Not Cost-Effective in Most Trauma Populations.

Prophylactic IVC filter placement is likely not cost-effective in the general high-risk trauma population. Economic analyses demonstrate a median filter cost of approximately 759 US dollars per day compared with 4.32 US dollars per day for chemoprophylaxis, with an estimated number needed to treat of 379 to prevent one episode of pulmonary embolism. This statement did not reach consensus (55% agreement). The panel's reservation was not that the published economic analyses are internally invalid or that the direction of the cost differential was disputed; rather, panelists agreed that conclusions regarding cost-effectiveness cannot be generalized across health systems, because filter acquisition and procedural costs, the costs of chemoprophylaxis, reimbursement structures, and baseline pulmonary embolism risk that determines the number needed to treat, may differ substantially between the individual centers in which these analyses were performed and the settings in which panelists practice. Panelists were therefore unwilling to endorse the statement as a general claim, while accepting its underlying observation regarding the higher cost of filters compared to pharmacologic prophylaxis. It is presented here transparently as a statement that did not reach consensus.

Strength of consensus (Delphi agreement): *Not recommended (55% agreement - consensus not reached).*

Supporting references: [53].

Recommendation 15: Future Research Should Prioritize the Prolonged-Contraindication Subgroup.

The most critical knowledge gap is the absence of a large, definitive randomized controlled trial of trauma patients with prolonged contraindication to anticoagulation exceeding seven days. According to the da Vinci trial subgroup analysis, whether filters confer protection on this specific population remains hypothesis-generating. A confirmatory trial adequately powered for this subgroup is essential. The dose-response relationship between duration of anticoagulation contraindication and filter benefit should be characterized using flexible modeling, such as restricted cubic splines in individual-patient-data analyses. Until such evidence is available, the decision to place a prophylactic IVC filter in this narrowly defined population remains a matter of clinical judgment informed by low-certainty evidence.

Strength of consensus (Delphi agreement): *High (100% agreement).*

Supporting references: [13,19,40].

4. Discussion

Pharmacologic thromboprophylaxis is recognized as the mainstay of venous thromboembolism prevention in severely injured patients [1,4,8,9]. Yet high-quality evidence remains limited regarding the appropriate role of IVC filters as an adjunct to thromboprophylaxis and the circumstances that constitute a justifiable indication for filter placement when anticoagulation is temporarily contraindicated. The da Vinci trial found that no reduction in the composite of symptomatic pulmonary embolism or death was observed among patients receiving prophylactic filter placement [13]. In our corrected meta-analysis, the trial could not contribute whole-trial pulmonary embolism data because it reported only a composite endpoint and a non-powered subgroup endpoint. The only randomized pulmonary embolism evidence is derived from a trial involving patients with established proximal deep vein thrombosis; therefore, there is no direct randomized evidence on prophylactic filters for this outcome in trauma patients. A prespecified subgroup finding suggesting that filters may benefit patients unable to receive anticoagulation within seven days remains the most frequently cited signal supporting prophylactic use; however, this finding is hypothesis-generating only.

It is crucial to discern the distinction between prophylactic and therapeutic placement while interpreting the pooled estimates. Our principal analysis combines studies of prophylactic placement, undertaken in the absence of documented venous thromboembolism, with one trial of therapeutic placement in patients with established proximal deep vein thrombosis. These indications differ in the baseline risk of the populations concerned, the counterfactual against which the filter placement is evaluated, and the evidence base supporting their use. The pooled estimate for pulmonary embolism should therefore not be interpreted as an estimate of the effect of prophylactic IVC filters, and the population-restricted analysis, which excludes the therapeutic trial, provides the closer approximation to the clinical question addressed by this guideline.

The mechanistic context also deserves emphasis. Post-traumatic thrombosis is driven not only by immobility and vessel injury but by a systemic inflammatory response in which endothelial activation, neutrophil and platelet interaction, and complement activation converge to promote

intravascular coagulation [5,6,7]. The patients considered for prophylactic filters are, by definition, those whose injuries are severe enough to preclude early anticoagulation, and who therefore occupy the most intensely prothrombotic and inflammatory end of the clinical spectrum. This provides a coherent biological rationale for the elevated thromboembolic risk in this narrowly defined subgroup. It does not, however, establish that mechanical caval interruption modifies the risk favourably, and the inflammatory rationale should not be mistaken for evidence of filter efficacy.

Our reanalysis highlights an important methodological lesson. In an earlier version of this work, the da Vinci trial was entered under an incorrect study label and its composite endpoint was used in place of pulmonary embolism. This resulted in a spurious and highly significant difference between randomized and observational studies. Once corrected, this subgroup contrast disappeared, and the observed reduction in pulmonary embolism was derived almost entirely from observational studies.

The population-restricted analysis reinforces this caution from a different perspective. When the two studies conducted outside trauma and fracture populations were excluded, the association between filter placement and deep vein thrombosis was no longer evident. Taken together with the leave-one-out analyses, these findings indicate that the deep vein thrombosis signal in the full analysis is attributable principally to a trial involving patients with established proximal deep vein thrombosis receiving therapeutic anticoagulation—a population and a clinical question distinct from trauma prophylaxis. We therefore do not conclude that prophylactic filters cause deep vein thrombosis in trauma patients. Rather, the more defensible conclusion is that reliable benefit has not been demonstrated for the outcomes of greatest clinical importance, while a biologically plausible mechanism for filter-associated venous thrombosis has been observed in the PREPIC population. Accordingly, the burden of proof lies with demonstrating benefit rather than assuming it.

Over the past two decades, clinical practice has undergone a fundamental transformation. The convergence of negative trial data, meta-analyses showing no mortality benefit [17,18,19], and FDA safety communications [23] has driven a progressive decline in filter use. The current mainstream approach favors early pharmacologic prophylaxis as the default strategy [8,20]. When a documented absolute contraindication to anticoagulation is present, filter placement should be considered only after a multidisciplinary assessment and only with a retrieval plan established at insertion.

IVC filters can be beneficial as a temporary adjunct in a narrow population subgroup: those with established venous thromboembolism who cannot receive anticoagulation, and potentially those with prolonged inability to anticoagulate exceeding seven days [13,40]. However, the evidence is conflicting, and the occurrences of well-documented complications such as migration, fracture, caval perforation, and thrombosis—combined with retrieval rates of approximately 15% [24]—probably outweigh the benefits of IVC filter placement in the majority of trauma patients. Economic analyses reinforce this conclusion, with a number needed to treat of 379 and a substantial per-day cost differential compared with pharmacologic prophylaxis [53]. A summary of the recommendations is presented as a clinical decision algorithm in Fig. 7.

The certainty of the underlying evidence is low for most recommendations. Only three randomized controlled trials directly inform IVC filter practice [13,14,16], and only one was conducted in trauma patients [13]. We did not formally grade the certainty of evidence, but caution was exercised in distinguishing between the strength of expert consensus, which we report, and certainty of evidence, which we do not formally assess. Despite the low certainty, expert clinicians from five specialties were largely in agreement, with 14 of 15 recommendations reaching consensus.

The recommendation that generated the most heterogeneous responses was Recommendation 4, which addresses prophylactic filter placement in patients who are unable to anticoagulate within seven days. Some panelists interpreted the da Vinci subgroup finding as sufficient to support a stronger recommendation, while others viewed it as hypothesis-generating only. The panel's caution is supported by the structure of the subgroup, which was defined by a post-randomization event and therefore represents an observational comparison embedded within a randomized trial. This comparison is susceptible to confounding by indication and to the greater severity and comorbidity of patients in whom anticoagulation is withheld [33]. The final wording is therefore permissive rather than directive, treating the threshold as a deliberative prompt rather than a decision rule.

The term "prophylactic IVC filter" is often reported in trauma literature without clear distinction from therapeutic placement for established venous thromboembolism [54]. In the current analysis, a strict dichotomy was set between "therapeutic placement", defined as insertion for confirmed acute thromboembolism with absolute contraindication to anticoagulation, and "prophylactic placement", defined as insertion in the absence of documented thromboembolism, owing to the fundamental difference in evidence base and risk-benefit calculus between the two approaches. Pharmacologic and mechanical prophylaxis should be combined whenever feasible; neither should be considered a substitute for the other [8,9]. An IVC filter does not constitute adequate thromboprophylaxis and should not delay the initiation of pharmacologic prophylaxis once the contraindication has resolved.

Management after IVC filter placement is governed by two critical milestones: initiation of pharmacologic anticoagulation and filter retrieval. The management pathway should be guided by clinical progression criteria rather

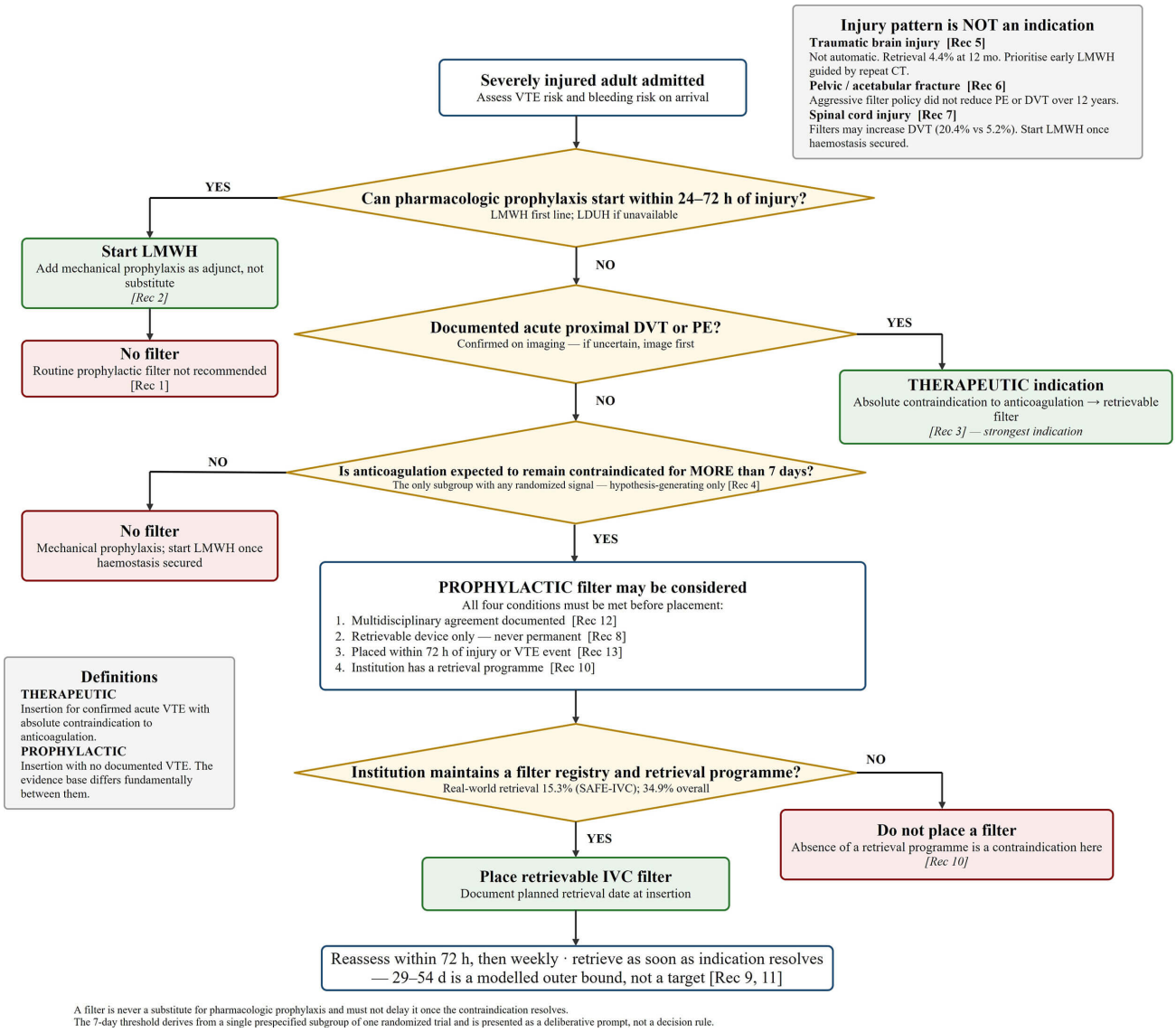

Fig. 7. Clinical decision algorithm for the use of inferior vena cava (IVC) filters in severely injured patients. Diamonds denote decision points, green boxes denote recommended actions, and red boxes denote points at which a filter should not be placed. Numbers in square brackets identify the recommendation in Table 2 from which each node derives; the definition of an absolute contraindication to anticoagulation is given in Recommendation 3 and the seven-day threshold is discussed in Recommendation 4, both in Table 2 and in the corresponding sections of the Results. The side panels define the therapeutic and prophylactic indications and summarize the injury patterns that do not by themselves constitute an indication. Abbreviations: DVT, deep vein thrombosis; IVC, inferior vena cava; LDUH, low-dose unfractionated heparin; LMWH, low-molecular-weight heparin; PE, pulmonary embolism; VTE, venous thromboembolism.

than arbitrary time intervals; the 29- to 54-day window [45] should be regarded as an outer boundary, and these criteria have not been validated prospectively. Clinician inertia, particularly failure to reassess the need for the filter, is a significant contributor to the low retrieval rates [24,55]. Placement of a filter and achievement of short-term pulmonary embolism prevention do not constitute comprehensive venous thromboembolism management; the transition to anticoagulation requires deliberate planning and coordinated handoff [20,52].

4.1 Barriers to Implementation

The high cost of and limited access to interventional radiology services may pose particular challenges for smaller trauma centers. Bedside IVC filter placement by trauma or vascular surgeons may provide a pragmatic alternative. Where dedicated retrieval clinics are not feasible, institutional registries and automated scheduling offer lower-cost substitutes that have been shown to improve retrieval rates [48,49,51]. Because these recommendations assume the availability of retrieval infrastructure, institutions that lack a retrieval program should adopt a more re-

strictive threshold for placement and establish a retrieval pathway, including transfer where necessary, before filter placement. Advanced retrieval techniques for embedded filters remain largely inaccessible outside specialized centers.

Adherence to retrieval protocols requires that expectations be set early, ideally at filter insertion. Setting realistic milestones, defining anticipated retrieval dates, and scheduling periodic reassessment are essential, particularly given the fragmented care pathways characteristic of trauma care. Moving forward, research should evaluate the implementation impact of standardized protocols, and prospective validation of objective criteria for transitioning from filter dependence to anticoagulation is warranted.

4.2 Limitations

This guideline has several strengths, including its foundation in a systematic review and meta-analysis, use of a structured two-round Delphi process, and development under the Shanghai Medical Association Vascular Surgery Branch. However, several limitations warrant explicit acknowledgment.

First, and most importantly, the population of the evidence base does not correspond exactly to the population addressed by this guideline. The electronic search was anchored on lower-extremity and pelvic fracture terminology combined with vena cava filter terminology, and did not incorporate generic trauma or injury subject headings. The retrieved evidence is consequently weighted towards fracture cohorts, and only one included study, the da Vinci trial, enrolled patients defined by injury severity (Injury Severity Score >15). Two additional studies were conducted outside a trauma population: one enrolled patients with established proximal deep vein thrombosis, and the other involved patients with metastatic pathologic fracture. We quantified the implications of this population mismatch in a population-restricted sensitivity analysis and moderated our conclusions accordingly, but the underlying limitation could not be resolved through re-analysis. A definitive synthesis for severely injured patients would require a search strategy incorporating trauma and injury terms, and we regard the present evidence as indirect for that population. This search constraint is the principal reason the recommendations in this guideline should be applied cautiously to general severely injured polytrauma populations, rather than being regarded as directly generalisable beyond the fracture-predominant cohorts from which the evidence was drawn.

Second, the principal analysis combines prophylactic with therapeutic filter placement. Because these are distinct clinical indications applied to populations with different baseline risk, the pooled estimates answer a composite question rather than a single one, and caution was exercised to avoid describing them as estimates of prophylactic effect.

Third, the evidence base was small, and several outcomes were based on two or three studies; therefore, all pooled estimates are imprecise, and none should be interpreted as establishing the absence of an effect. The DerSimonian–Laird estimator of between-study variance may underestimate variance when few studies are available, potentially resulting in overly narrow confidence intervals. Alternative estimators, including restricted maximum likelihood and Paule–Mandel, and the Hartung–Knapp–Sidik–Jonkman adjustment, generally provide more reliable performance in such settings [56,57]. Because Review Manager 5.4 implements only the DerSimonian–Laird method, sensitivity analyses using alternative estimators were not feasible, and the width of the reported confidence intervals should be interpreted with caution, particularly for outcomes informed by only two or three studies. Prediction intervals are increasingly recommended alongside confidence intervals in random-effects meta-analysis [58,59], but cannot be calculated for outcomes informed by two studies and are unreliable unless approximately five or more studies are available [60]. Because each outcome in this review was informed by two to five studies, prediction intervals were not calculated, and their absence is acknowledged as a limitation. The deep vein thrombosis finding is driven by a single trial involving a non-trauma population and does not persist under population restriction; the observational pulmonary embolism signal is subject to confounding by indication, as evident in the source data, where patients who underwent filter placement waited significantly longer for chemoprophylaxis and were less likely to receive it early. One included cohort study used both a contemporaneous and a historical comparison group, introducing the possibility of secular change in care as an additional source of confounding, and this is reflected in the Comparability rating assigned to that study, as shown in **Supplementary Table 3**.

Fourth, because so few studies contributed to each outcome, the pre-specified design-stratified subgroup analyses were considered not informative and were therefore not performed. This departure from the protocol is reported in the Methods. Fifth, we did not formally grade the certainty of evidence, and the recommendations should be interpreted as consensus-based rather than evidence-graded. Sixth, the Delphi panel comprised physicians from five specialties at academic centers and did not include clinicians from community hospitals, nursing or allied health professionals, or patient representatives. The recommendations may therefore require adaptation to community and resource-limited settings. Future studies should broaden panel composition and incorporate structured patient input. Seventh, formal assessment of publication bias was not feasible because fewer than 10 studies contributed to each outcome.

5. Conclusion

Routine prophylactic IVC filter placement is not recommended in severely injured patients, and pharmacologic thromboprophylaxis should remain the default strategy. IVC filters should be reserved for patients with defined indications and used only when retrieval infrastructure is available, and a retrieval plan can be established at the time of insertion. Overall, there is a low level of certainty for most components; however, expert clinicians were largely in agreement with the recommendations. Because the retrieved evidence is drawn predominantly from fracture rather than polytrauma cohorts, and because the principal analysis combines prophylactic with therapeutic filter placement, these recommendations should be regarded as indirect for the severely injured population and applied with appropriate caution. These recommendations may provide the basis for a clinical decision algorithm for applying IVC filters in severely injured patients, presented in Fig. 7.

Key Points

• Pharmacologic thromboprophylaxis with low-molecular-weight heparin, initiated within 24 to 72 hours of injury, is the mainstay of venous thromboembolism prevention in severely injured patients, and routine prophylactic inferior vena cava (IVC) filter placement is not recommended.

• IVC filters should be reserved for patients with documented venous thromboembolism and an absolute contraindication to anticoagulation, and considered cautiously only in the narrow subgroup with a contraindication to anticoagulation for more than seven days.

• The seven-day contraindication threshold derives from a single underpowered subgroup of one randomized trial, defined by a post-randomization event and therefore susceptible to confounding; it should be regarded as a deliberative prompt rather than a decision rule.

• When IVC filter placement is indicated, only retrievable devices should be used, and the availability of institutional retrieval infrastructure, including a registry and a systematic retrieval program, should be regarded as a prerequisite for placement.

• The recommendations are consensus-based rather than evidence-graded; the supporting evidence is drawn predominantly from fracture rather than polytrauma cohorts and combines prophylactic with therapeutic filter placement, limiting its direct applicability to the severely injured population targeted by this guideline.

Availability of Data and Materials

All data relevant to the study are included in the article and its supplementary files. Extracted event counts for every study and outcome are reported in Table 1 and its footnote, and the meta-analysis (RevMan) file, coding sheets, and the round-by-round Delphi records are available from the corresponding authors upon reasonable request.

Author Contributions

Conceptualization: YP, BYR. Methodology: KKZ, MQ. Systematic search and study selection: KKZ, MQ. Data extraction and quality assessment: HSW. Formal analysis/Statistics: MQ, BYR. Writing – original draft: All authors. Writing – review & editing: YP. Supervision/Project administration: YP. All authors approved the final manuscript and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with the drafting and language refinement of the Background, Methods, Discussion and Conclusion sections, and with language editing of the Abstract and of the narrative text accompanying the recommendation statements. Generative AI was not used for the literature search, study selection, data extraction, risk-of-bias assessment, statistical analysis, or generation of any figure or table, and it was not used to generate the Delphi statements or to conduct the consensus process. All AI-assisted text was subsequently reviewed and verified against primary sources and edited by the authors, who take full responsibility for the content of the publication. No generative AI tool is listed as an author. No images were created or altered using generative AI tools.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/BJHM55548.

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