# Carotid Stenosis PSV: Systematic Review with ☸SAIMSARA.

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**Abstract:** The aim of this paper is to systematically synthesize the current understanding of peak systolic velocity (PSV) in the context of carotid stenosis, evaluating its diagnostic utility, the factors that influence its measurement and interpretation, and its role in patient management and prognostication. The review utilises 230 studies with 79780 total participants (naïve ΣN). For severe carotid stenosis (defined as ≥70%), peak systolic velocity (PSV) thresholds commonly used or identified as effective range from 175 cm/s to >300 cm/s, with a median value of 230 cm/s. This indicates that PSV remains a critical, albeit varied, parameter in the diagnosis and management of carotid stenosis across diverse patient populations and clinical settings. The primary limitation affecting certainty is the significant heterogeneity in PSV thresholds and diagnostic criteria reported across studies. A crucial next step is to conduct a large-scale, prospective study to harmonize PSV thresholds and develop standardized protocols for its measurement and interpretation, thereby enhancing its clinical utility and reproducibility.

**Keywords:** Carotid stenosis; Peak systolic velocity; Duplex ultrasound; Internal carotid artery; Stenosis assessment; Hemodynamic significance; Diagnostic accuracy; Velocity thresholds; End-diastolic velocity; Carotid artery disease

**Review Stats**

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- Scope: All fields
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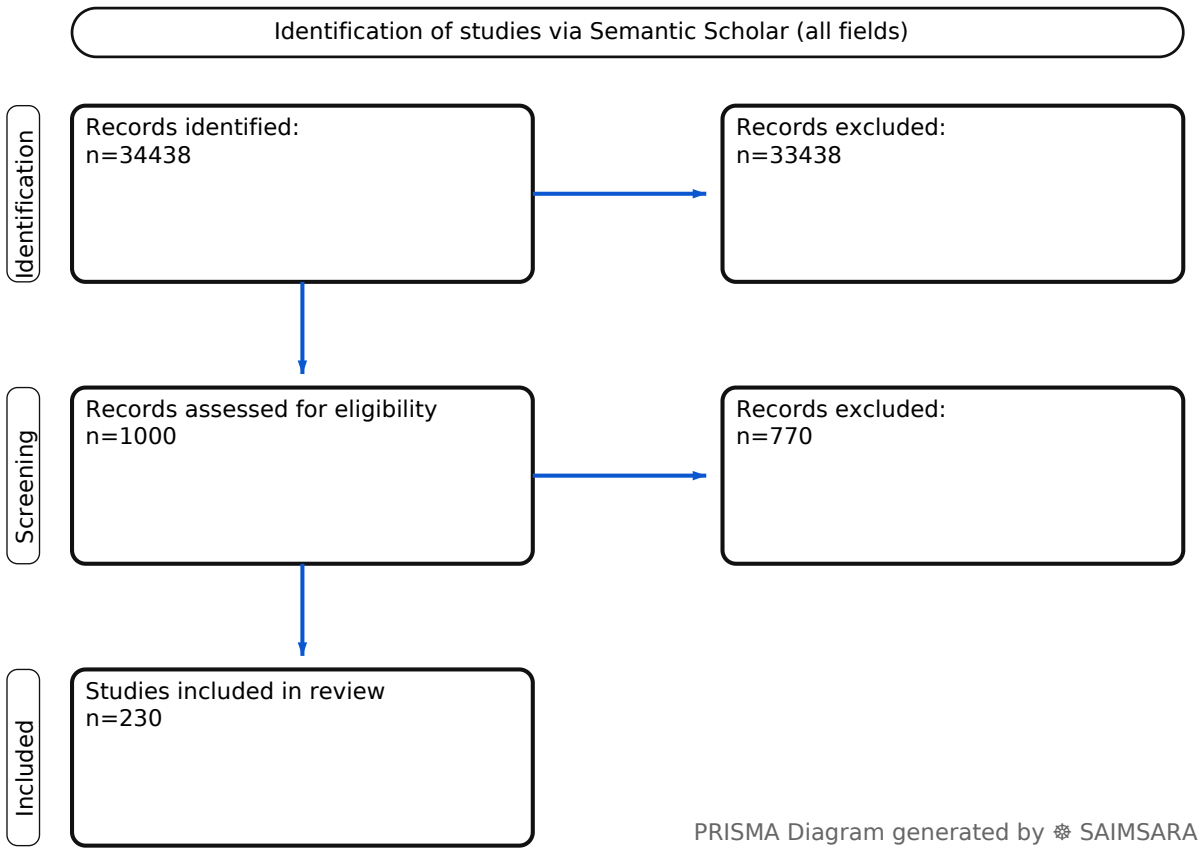
- Downloaded Abstracts/Papers: 1000
- Included original Abstracts/Papers: 230
- Total study participants (naïve ΣN): 79780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Records excluded:
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Screening
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Studies included in review
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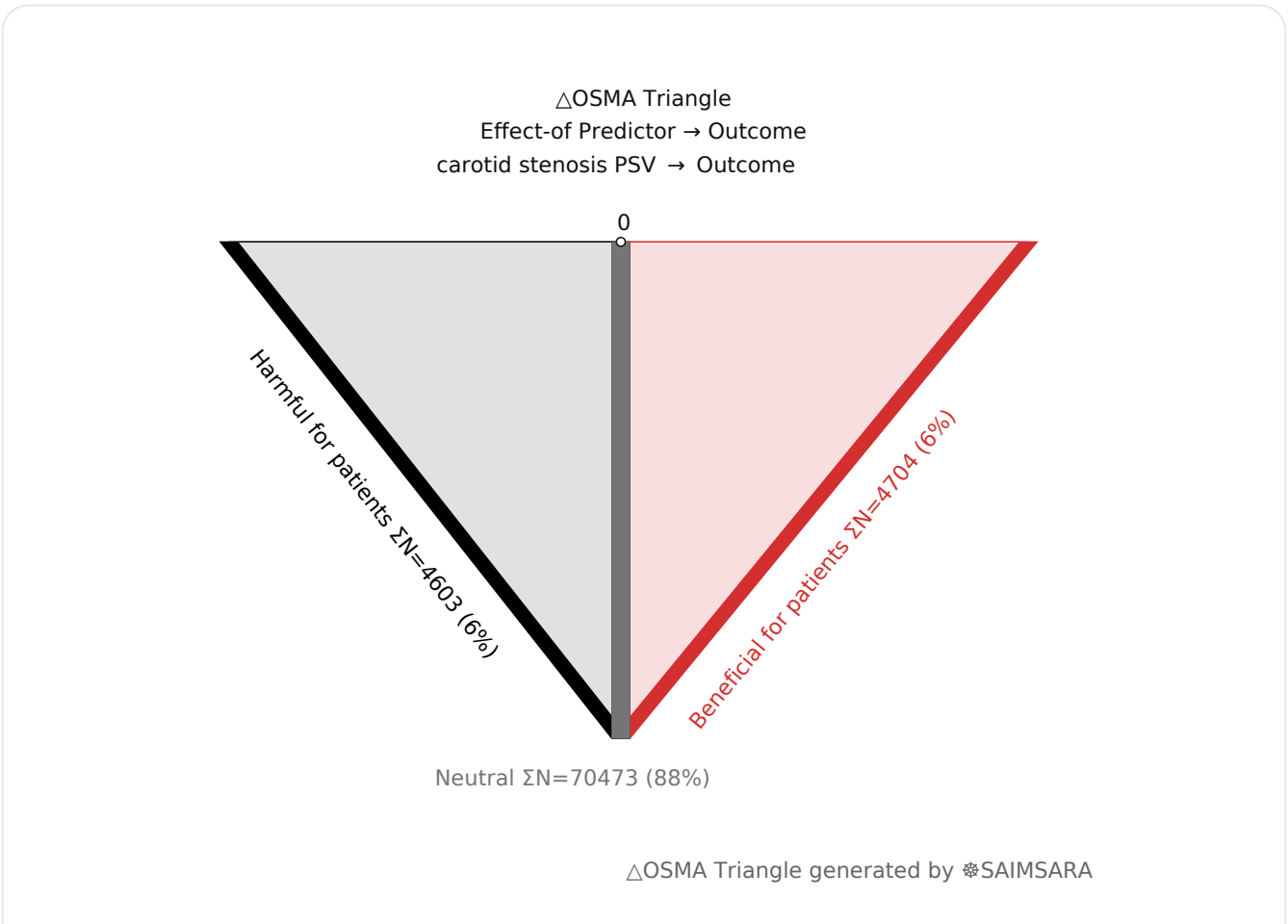
PRISMA Diagram generated by ☸ SAIMSARA


△OSMA Triangle
Effect-of Predictor → Outcome
carotid stenosis PSV → Outcome
0
Harmful for patients ΣN=4603 (6%)
Beneficial for patients ΣN=4704 (6%)
Neutral ΣN=70473 (88%)
△OSMA Triangle generated by ☸SAIMSARA

**Outcome-Sentiment Meta-Analysis (OSMA):** *(LLM-only)*

*Frame*: Effect-of Predictor → Outcome • *Source*: Semantic Scholar

*Outcome*: Outcome Typical timepoints: peri/post-op, 30-day. Reported metrics: %, CI, p.

*Common endpoints*: Common endpoints: restenosis, complications, occlusion.

*Predictor*: carotid stenosis PSV — exposure/predictor. Routes seen: intravenous. Typical comparator: other duplex sonography, psv obtained with duplex, established values for native, normal eyes….

- **1) Beneficial for patients** — Outcome with carotid stenosis PSV — [15], [36], [48], [49], [79] — ΣN=4704
- **2) Harmful for patients** — Outcome with carotid stenosis PSV — [7], [25], [40], [77], [85], [92], [93], [99], [228], [230] — ΣN=4603
- **3) No clear effect** — Outcome with carotid stenosis PSV — [1], [2], [3], [4], [5], [6], [8], [9], [10], [11], [12], [13], [14], [16], [17], [18], [19], [20], [21], [22], [23], [24], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [37], [38], [39], [41], [42], [43], [44], [45], [46], [47], [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [78], [80], [81], [82], [83], [84], [86], [87], [88], [89], [90], [91], [94], [95], [96], [97], [98], [100], [101], [102], [103], [104], [105], [106], [107], [108], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127], [128], [129], [130], [131], [132], [133], [134], [135], [136], [137], [138], [139], [140], [141], [142], [143], [144], [145], [146], [147], [148], [149], [150], [151], [152], [153], [154], [155], [156], [157], [158], [159], [160], [161], [162], [163], [164], [165], [166], [167], [168], [169], [170], [171], [172], [173], [174], [175], [176], [177], [178], [179], [180], [181], [182], [183], [184], [185], [186], [187], [188], [189], [190], [191], [192], [193], [194], [195], [196], [197], [198], [199], [200], [201], [202], [203], [204], [205], [206], [207], [208], [209], [210], [211], [212], [213], [214], [215], [216], [217], [218], [219], [220], [221], [222], [223], [224], [225], [226], [227], [229] — ΣN=70473

**1) Introduction**

Carotid artery stenosis, a significant contributor to cerebrovascular events such as stroke, necessitates accurate and timely diagnosis for effective patient management. Duplex ultrasound, particularly the measurement of peak systolic velocity (PSV), has long been a cornerstone in the non-invasive assessment of carotid stenosis severity. PSV reflects the accelerated blood flow through

narrowed arterial segments, providing a quantitative metric for stenosis grading. However, the utility and interpretation of PSV are influenced by various anatomical, physiological, and technical factors, leading to ongoing research into its diagnostic precision, optimal thresholds, and integration with other diagnostic modalities. This paper synthesizes recent findings concerning PSV in carotid stenosis, encompassing its diagnostic performance, influencing factors, and role in clinical decision-making and post-intervention surveillance.

**2) Aim**

The aim of this paper is to systematically synthesize the current understanding of peak systolic velocity (PSV) in the context of carotid stenosis, evaluating its diagnostic utility, the factors that influence its measurement and interpretation, and its role in patient management and prognostication.

**3) Methods**

Systematic review with multilayer AI research agent: keyword normalization, retrieval & structuring, and paper synthesis (see SAIMSARA About section for details).

- **Bias:** Qualitatively, studies varied widely in design, including prospective cohort studies [1, 2, 7, 9, 12, 13, 16, 20, 33, 35, 36, 63, 68, 70, 71, 76, 78, 89, 93, 110, 111, 114, 115, 120, 132, 145, 150, 177, 181, 182, 186, 207, 208, 213, 214, 221, 222, 223], cross-sectional analyses [8, 25, 33, 35, 38, 42, 45, 79, 85, 92, 95, 97, 107, 108, 119, 149, 219, 221, 222], case-control studies [7, 18, 32, 36, 79, 85, 87], and mixed-design studies [2, 3, 4, 10, 11, 14, 15, 16, 19, 21, 22, 23, 26, 27, 28, 29, 30, 31, 34, 37, 39, 40, 41, 43, 44, 46, 47, 49, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 64, 65, 67, 69, 72, 73, 75, 77, 78, 80, 81, 82, 83, 84, 86, 88, 90, 91, 93, 94, 96, 100, 101, 103, 104, 105, 106, 111, 112, 115, 116, 117, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 146, 147, 148, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 178, 179, 180, 183, 184, 185, 187, 189, 190, 191, 192, 193, 194, 195, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 209, 210, 211, 212, 213, 214, 216, 217, 218, 220, 224, 225, 226, 227, 228, 229, 230]. Many studies were prospective (e.g., [1, 2, 7, 9, 12, 13, 16, 20, 33, 35, 36, 63, 70, 71, 76, 78, 89, 93, 110, 111, 114, 115, 120, 132, 145, 150, 177, 181, 182, 186, 207, 208, 213, 214, 221, 222]) or retrospective (e.g., [15, 19, 22, 40, 42, 43, 68, 69, 73, 77, 94, 96, 101, 103, 106, 111, 116, 197, 217, 224, 227, 229, 230]), with some not specifying directionality. Sample sizes ranged from single case reports [67] to large population-based cohorts of thousands [25, 38, 50, 119, 152]. Follow-up periods varied from immediate post-procedure assessment to several years, with many studies lacking explicit follow-up information. The heterogeneity in study designs and settings suggests a potential for variability in reported

outcomes and generalizability.

## 4) Results

### 4.1 Study characteristics:

The literature reviewed comprises a diverse array of study designs, predominantly mixed-type studies, cohort studies, and prospective investigations. Populations frequently included patients with varying degrees of carotid stenosis, both symptomatic and asymptomatic, often undergoing diagnostic imaging or interventional procedures. Common follow-up periods, when specified, ranged from immediate post-procedure to several months or years, although many studies did not report follow-up durations.

### 4.2 Main numerical result aligned to the query:

For severe carotid stenosis (defined as ≥70%), peak systolic velocity (PSV) thresholds commonly used or identified as effective range from 175 cm/s to >300 cm/s, with a median value of 230 cm/s [5, 6, 98, 99]. Specifically, a PSV cut-off of 200 cm/s showed high sensitivity (90.32%) and specificity (93.75%) for ≥70% NASCET internal carotid artery (ICA) stenoses [6], while other studies reported PSV >230 cm/s as a common threshold [5, 98]. For in-stent restenosis (ISR), PSV thresholds varied, with values such as ≥120 cm/s [228], ≥130 cm/s [69], ≥140 cm/s [230], ≥240 cm/s [178], and >300 cm/s [47] being reported for different degrees of restenosis.

### 4.3 Topic synthesis:

- **Diagnostic Accuracy and Thresholds:** PSV is a good marker for identifying severe ICA stenoses, with specific thresholds predicting ≥70% NASCET (e.g., 200 cm/s, sensitivity 90.32%, specificity 93.75%) [6] and ≥80% ECST (e.g., 180 cm/s, sensitivity 100%, specificity 81.82%) stenoses [6]. PSV values for ≥50% stenosis range from 110 to 245 cm/s (median 125 cm/s) [98], and for ≥70% stenosis, from 175 to 340 cm/s (median 230 cm/s) [98]. A PSV ≥125 cm/s or PSV ratio ≥2.0 defined atherosclerotic carotid stenosis [25].
- **Factors Influencing PSV Measurements:** Lesion length (LL) ≥ 7 mm significantly affects PSV and end-diastolic velocity (EDV), necessitating correction formulas [1]. A patent anterior communicating artery (ACoA) increases PSV and EDV, leading to overestimation of carotid artery stenosis [15]. The presence of a proximal tandem stenosis in the common carotid artery (CCA) renders the PSV ratio unreliable for ICA stenosis unless CCA velocity is measured proximal to the tandem lesion [24]. Large acoustic shadow (AS) artifacts severely degrade the accuracy of routine color Doppler ultrasonography (CDUS) PSV measurements [68].

- **Novel Assessment Techniques:** Proposed ultrasonic actuators enable real-time, non-invasive ICA stenosis assessment by extracting PSV [3]. An empirical physics-based model for PSV provides an accurate method for early assessment of carotid artery stenosis (CAS) [4, 90]. Quantitative flow ratio (QFR) significantly correlated with PSV ($r2=0.52$, $P<0.001$) and showed good accuracy for predicting functionally significant stenosis [9]. Vector concentration (VC) showed a strong correlation with stenosis degree compared to PSV obtained with duplex ultrasound (DUS) [21].
- **Post-Intervention Surveillance:** Higher postoperative PSV Doppler measurements (e.g., median 133 cm/s vs 114 cm/s in those without restenosis) were predictive of restenosis after carotid revascularization [73]. In-stent restenosis (ISR) after CAS was identified by PSV exceeding 300 cm/s or stenosis ≥50% [47], with a PSV ≥240 cm/s predicting ≥60% ISR with high sensitivity (100%) and specificity (97%) [178]. Elevated ICA PSV at baseline was an independent risk factor for ISR after CAS [40].
- **Hemodynamic Significance and Clinical Outcomes:** PSV was an independent risk factor for ICA stenosis (OR: 1.020, 95% CI: 1.011-1.029, $P < 0.001$) [7]. Higher PSV correlated with greater time-to-peak (TTP) delay, suggesting increasing hemodynamic impairment with greater degrees of stenosis above 70% [12]. PSV indices were independent predictors of acute anterior ischemic stroke (AAIS) (OR: 13.461) [36]. Lower PSV in the central retinal artery (CRA) was significantly associated with ICA stenosis and ocular ischemic syndrome (OIS) [32, 85].
- **Impact of Systemic Conditions:** Transcatheter aortic valve implantation (TAVI) led to a significant increase in PSV in the CCA, ICA, and vertebral artery (VA) (e.g., CCA from 64.5 to 78.0 cm/s, +24%; ICA from 67.0 to 90.5 cm/s, +36%; $P < 0.01$) [76]. Diabetes mellitus (DM) was associated with lower PSV values (age-sex-adjusted means -3.28 cm/sec lower for DM cases, $p < 0.0005$) [79]. Radiotherapy had minimal effects on PSV, EDV, and ICA/CCA ratios in carotid arteries, despite significant increases in carotid artery stenosis [44].
- **Comparison with Other Imaging Modalities:** PSV showed a good linear correlation with MDCTA-AVA software percentage stenosis ($r = 0.88$) in quantifying 50–70% carotid artery stenosis [23]. Duplex ultrasound (DUS) with standardized PSV criteria achieved 90% sensitivity and 83% specificity in identifying severe ICA stenosis, with combined MRA and DUS improving sensitivity to 98% and specificity to 90% [86].

## 5) Discussion

### 5.1 Principal finding:

For severe carotid stenosis (defined as ≥70%), peak systolic velocity (PSV) thresholds commonly used or identified as effective range from 175 cm/s to >300 cm/s, with a median value of 230 cm/s [5, 6, 98, 99], indicating a consistent, albeit varied, utility of PSV in grading high-grade stenosis.

**5.2 Clinical implications:**

- **Standardized Thresholds:** The median PSV threshold of 230 cm/s for ≥70% stenosis [5, 6, 98, 99] provides a reference for diagnosing severe carotid disease, aiding in revascularization decisions.
- **Monitoring Post-Intervention:** Postoperative PSV measurements are crucial for surveillance, as elevated PSV (e.g., ≥120 cm/s [228], ≥240 cm/s [178]) can predict in-stent restenosis (ISR) after carotid artery stenting (CAS) [73].
- **Contextual Interpretation:** Clinicians should consider factors like lesion length [1], ACoA patency [15], and tandem stenoses [24] when interpreting PSV, as these can lead to over- or underestimation of stenosis severity.
- **Risk Stratification:** PSV is an independent risk factor for ICA stenosis [7] and acute anterior ischemic stroke [36], supporting its role in identifying high-risk patients.
- **Ocular Ischemic Syndrome:** Reduced PSV in the central retinal artery is a sensitive marker for Ocular Ischemic Syndrome (OIS) in patients with ICA stenosis [85], highlighting a potential for PSV in ophthalmological assessment.

**5.3 Research implications / key gaps:**

- **Harmonization of PSV Thresholds:** A prospective, multicenter study is needed to establish universally accepted PSV thresholds for various degrees of carotid stenosis (e.g., ≥50%, ≥70%), validated against a gold standard like digital subtraction angiography (DSA) or intravascular ultrasound (IVUS) [98, 10].
- **Correction for Anatomical Factors:** Further research is required to refine and validate formulas for correcting PSV/EDV measurements based on lesion length [1] and to develop standardized protocols for managing tandem stenoses [24] and ACoA patency [15].
- **Long-term Outcomes of Novel Techniques:** Longitudinal studies are necessary to assess the long-term clinical utility and prognostic value of emerging PSV-based assessment tools, such as ultrasonic actuators [3], empirical physics-based models [4], and quantitative flow ratio (QFR) [9].
- **Impact of Systemic Conditions on PSV:** A cohort study could investigate how systemic conditions like diabetes mellitus [79] and severe aortic stenosis [76] systematically alter carotid PSV values, and how these alterations should be incorporated into diagnostic algorithms.
- **Optimal Surveillance Criteria for Restenosis:** A randomized controlled trial comparing different PSV thresholds and ratios for detecting ISR after CAS and restenosis after carotid endarterectomy (CEA) is needed to optimize surveillance protocols and improve patient outcomes [117, 178].

**5.4 Limitations:**

- **Heterogeneous Thresholds** — The wide range of PSV thresholds for similar stenosis grades across studies limits the generalizability and standardization of diagnostic criteria [98].
- **Methodological Variability** — Differences in ultrasound equipment, angle correction methods [104], and operator dependence can introduce variability in PSV measurements [209].
- **Influence of Confounding Factors** — Factors like lesion length [1], tandem stenosis [24], and ACoA patency [15] can significantly affect PSV, potentially leading to misdiagnosis if not accounted for.
- **Limited Long-term Follow-up** — Many studies lack extensive long-term follow-up data, particularly for novel assessment techniques and post-intervention outcomes, limiting the understanding of sustained efficacy and safety.
- **Bias from Acoustic Shadowing** — Acoustic shadowing artifacts can severely degrade the accuracy of PSV measurements, especially in heavily calcified lesions [68], impacting diagnostic reliability.

**5.5 Future directions:**

- **Standardized PSV Guidelines** — Develop and implement universally accepted PSV guidelines for carotid stenosis assessment, incorporating correction factors for anatomical variations.
- **AI-Enhanced PSV Analysis** — Integrate artificial intelligence (AI) and machine learning (ML) with ultrasound systems to automate PSV measurement and interpretation, improving consistency and accuracy.
- **Multi-Modal Imaging Integration** — Conduct studies combining PSV with other advanced imaging modalities (e.g., QFR, 4D flow MR) to enhance diagnostic precision and prognostic capabilities.
- **Personalized Risk Assessment** — Research the development of personalized risk assessment models that incorporate PSV values alongside patient-specific clinical and anatomical data.
- **Real-time Hemodynamic Monitoring** — Explore the use of real-time, non-invasive ultrasonic actuators for continuous monitoring of carotid hemodynamics, especially in high-risk patients or post-intervention.

**6) Conclusion**

For severe carotid stenosis (defined as ≥70%), peak systolic velocity (PSV) thresholds commonly used or identified as effective range from 175 cm/s to >300 cm/s, with a median value of 230 cm/s [5, 6, 98, 99]. This indicates that PSV remains a critical, albeit varied, parameter in the diagnosis and management of carotid stenosis across diverse patient populations and clinical settings. The primary limitation affecting certainty is the significant heterogeneity in PSV thresholds and diagnostic criteria reported across studies. A crucial next step is to conduct a large-scale, prospective study to harmonize PSV thresholds and develop standardized protocols for its measurement and interpretation, thereby enhancing its clinical utility and reproducibility.

**References**

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**Figure 1. Publication-year distribution of included originals**

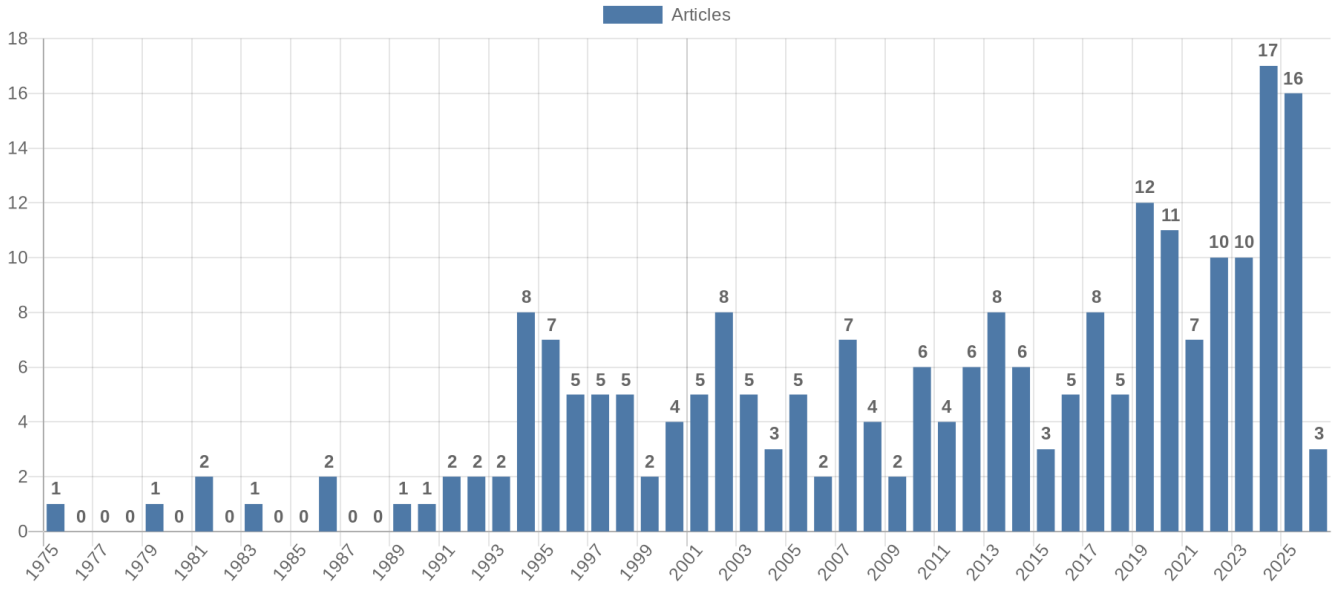


**Figure 2. Study-design distribution of included originals**

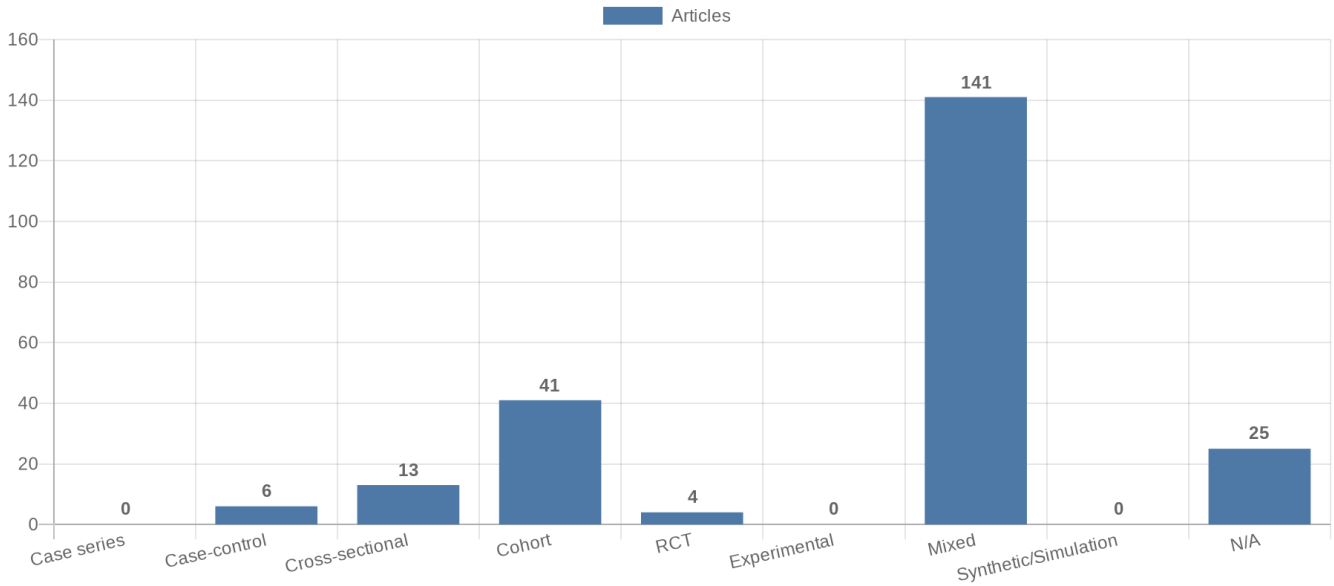

**Figure 3. Study-type (directionality) distribution of included originals**

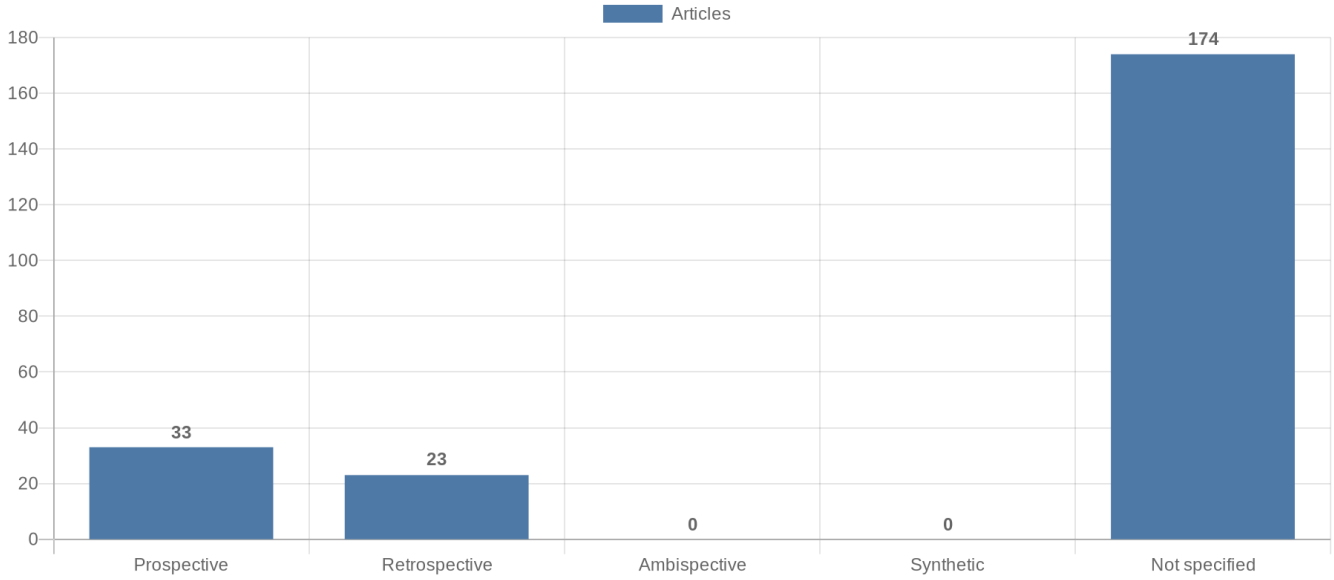


**Figure 4. Main extracted research topics**

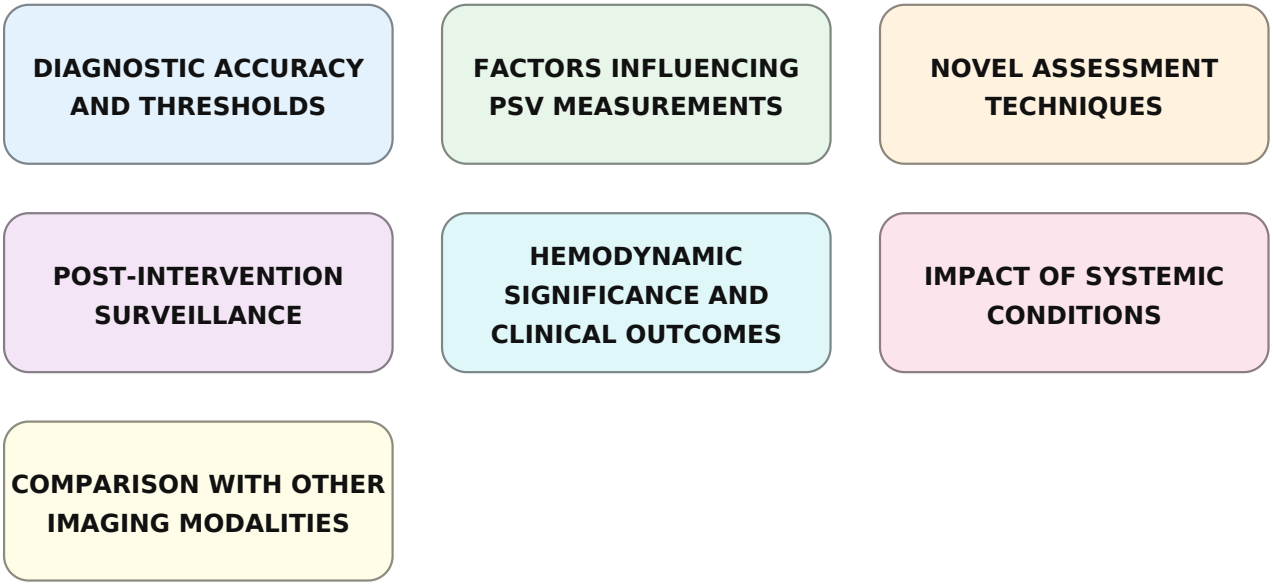


**Figure 5. Limitations of current studies (topics)**

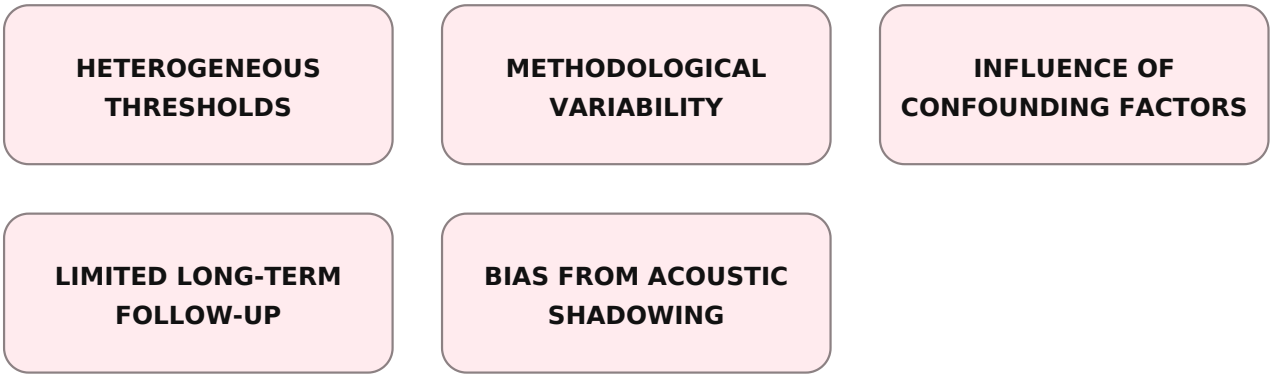

**Figure 6. Future research directions (topics)**