Supplementary Table 1 Literature search and selection methods

Item	Description
Databases	PubMed/MEDLINE, Embase, Web of Science Core Collection, China National Knowledge Infrastructure (CNKI), and Wanfang
Search period	From database inception to July 29, 2026
Search topics	Pancreatic fistula, postoperative pancreatic fistula, pancreatic duct leakage, pancreatic duct rupture, pancreatic duct disconnection, disconnected pancreatic duct syndrome, pancreatic ascites, and pancreaticopleural fistula; endoscopic diagnosis and treatment, including terms related to ERCP, EUS, transpapillary and transmural interventions, and other techniques
Supplementary searches	Screening of reference lists from relevant guidelines, consensus statements, systematic reviews, and included studies, and forward citation searching for key articles
Inclusion criteria	Direct relevance to the endoscopic diagnosis, treatment, or treatment selection for pancreatic fistulas or related pancreatic duct leaks, with extractable anatomical, technical, or clinical outcome information
Exclusion criteria	Duplicate publications; articles not directly relevant to the topic; studies limited to prediction or prevention; and articles lacking extractable relevant information
Special considerations	Representative case reports, case series, and technical studies were included for complex pancreatic fistulas and emerging endoscopic techniques with limited clinical evidence

Supplementary Table 2 Search strategies

Database	Search strategy
PubMed/MEDLINE	("Pancreatic Fistula"[Mesh] OR (pancrea*[tiab] AND (fistul*[tiab] OR leak*[tiab] OR disrupt*[tiab] OR disconnect*[tiab])) OR POPF[tiab] OR DPDS[tiab] OR "pancreatic ascites"[tiab]) AND ("Endosonography"[Mesh] OR endoscop*[tiab] OR ERCP[tiab] OR EUS[tiab] OR transpapillary[tiab] OR transmural[tiab])
Embase	((pancrea*:ti,ab,kw AND (fistul*:ti,ab,kw OR leak*:ti,ab,kw OR disrupt*:ti,ab,kw OR disconnect*:ti,ab,kw)) OR popf:ti,ab,kw OR dpds:ti,ab,kw OR 'pancreatic ascites':ti,ab,kw) AND (endoscop*:ti,ab,kw OR ercp:ti,ab,kw OR eus:ti,ab,kw OR transpapillary:ti,ab,kw OR transmural:ti,ab,kw)
Web of Science Core Collection	TS=((pancrea* AND (fistul* OR leak* OR disrupt* OR disconnect*)) OR POPF OR DPDS OR "pancreatic ascites") AND TS=(endoscop* OR ERCP OR EUS OR transpapillary OR transmural)

Supplementary Table 3 Comparison of classification systems

Classification system	Scope and classification criteria	Clinical implication and limitation
ISGPS 2016 POPF grading[1]	Postoperative pancreatic fistula; based on drain amylase level and clinical impact.	Defines POPF severity, but does not guide endoscopic route.
Nordback et al[16]	Pancreatic pseudocyst; based on MPD stenosis and pseudocyst-MPD communication.	Guides drainage choice, but is limited to pseudocysts.
Nealon et al[17,18]	Pancreatic pseudocyst and pancreatitis-related ductal injury; based on ductal anatomy and duct collection communication.	Predicts drainage failure and need for surgery, but provides limited endoscopic guidance.
Mutignani et al[12]	Pancreatic leaks and fistulas; based on leak location and ductal anatomy.	Endoscopy-oriented, but not prospectively validated.

Proença et al[19]	Encapsulated pancreatic collections; based on pancreatographic MPD findings.	Distinguishes partial from complete disruption, but is mainly collection-based.
Proposed B-P-C-A framework	Pancreatic fistulas across etiologies; hierarchical assignment based on postoperative origin, MPD continuity, and leak site.	Links duct anatomy to treatment route selection, but remains unvalidated and is limited by indeterminate duct imaging.

MPD: Main pancreatic duct; POPF: Postoperative pancreatic fistula; ISGPS: International Study Group of Pancreatic Surgery.

Supplementary Table 4 Evidence on transpapillary pancreatic duct stenting

Ref.	**Study design (n)**	**Key findings**	**Conclusion**	**NOS quality[1]**
Leak bridging				
Telford et al[6], 2002	Dual-center, retrospective (43)	AP (24), CP (9), operative injury (7), trauma (3). Resolution: 25/43; bridging: 12/13 versus 6/12 with a stent entering the leak and 7/16 across the papilla. Four patients had adverse events.	Bridging predicted resolution after adjustment for etiology; small mixed cohorts and 2 indeterminate outcomes limit inference.	High (7/9)[2]
Varadarajulu et al[4], 2005	Single-center, retrospective (97)	AP (44), CP (47), operative injury (4), trauma (2); necrosis/abscess excluded initially. Stenting feasible in 92/97; 52 had clinical and pancreatographic resolution.	Supports bridging of partial disruptions; 8 indeterminate outcomes and inconsistent reported percentages require	High (8/9)[2]

		Partial disruption and bridging independently predicted success. Six complications included 5 occluded stents.	caution.	
Sundaram et al[16], 2022	Single-center, retrospective (68)	Refractory internal (55) or external (13) fistulas; AP (26), CP (35), trauma (7). Six-week resolution: 52/68 (76.4%); bridging OR 6.5 (95%CI 1.211–34.94). Seven also had cystogastrostomy. Pancreatitis exacerbation: 5/62; migration: 1; sepsis-related deaths: 3.	Bridging was associated with healing; concomitant drainage, attrition and incomplete anatomical adjustment limit inference.	High (7/9)[2]
Chen et al[17], 2026	Multicenter, retrospective (106)	AP (50), CP (21), postoperative (31), trauma (4). Three-month composite success: 84/106; bridging 34/36 versus non-bridging 50/70. PEP: 7; stent occlusion/dislodgement: 8; 2 deaths were reported, with uncertain procedural attribution.	Supports bridging in selected anatomy; the composite includes PFC improvement and is not equivalent to confirmed duct healing.	High (7/9)[2]
Adachi et al[18], 2025	Dual-center, retrospective (22)	Non-postoperative fistulas: CP (13), AP (6), malignancy (2), pseudocyst (1). Clinical success: 11/22; proximal (head/body) 8/9 versus distal (tail) 3/13; complete disruption 0/5. Mild duct penetration: 1;	Distal/complete disruptions were harder to treat; selected cases, unadjusted comparisons and unspecified follow-up limit evidence.	Low (4/9)[2]

		rescue EUS drainage: 5; distal pancreatectomy: 5.		
Feasibility				
Kozarek et al[15], 1991	Uncontrolled, nonconsecutive case series (18)	Acute/relapsing pancreatitis (10), CP (8); collections in 14. Duct resolution: 16/18; collection resolution: 12/14 within 6 weeks. Seven eventually required surgery. Pancreatitis symptoms: 2; stent occlusion: 2; stent-associated duct changes: 9.	Selected cases supported feasibility; duct/PFC resolution did not ensure symptom relief or freedom from later surgery.	—
Stent duration				
Testoni[5], 2007	Narrative review	Suggested pancreatic stent retention for 4–6 weeks in duct leaks/fistulas. This was a review recommendation rather than a randomized comparison of stent durations.	An optimal universal stent duration was not established.	—

[1]Methodological quality was assessed using the Newcastle–Ottawa Scale (NOS): high, 7–9; moderate, 5–6; low, 0–4. These categories are not GRADE certainty ratings. —: cohort NOS not applicable. [2]Scores are assessments for this review, not scores reported by the original investigators; AP: Acute pancreatitis; CP: Chronic pancreatitis; PFC: Pancreatic fluid collection; EUS: Endoscopic ultrasound; OR: Odds ratio; CI: Confidence interval; PEP: Post-ERCP pancreatitis; ERCP: Endoscopic retrograde cholangiopancreatography.

Supplementary Table 5 Evidence on endoscopic ultrasound-guided and combined drainage strategies

Ref.	Study design (n)	Key findings	Conclusion	NOS quality[1]
DPDS anatomy				
Chong et al[2], 2021	Systematic review and meta-analysis (30 studies; 1355 patients)	DPDS, predominantly after AP, presenting as PFCs or external fistulas. Pooled success: transmural 90.6%, transpapillary 58.5%. Limited pairwise analysis showed no clear difference between endoscopic and surgical success.	Transmural drainage is supported in selected DPDS; heterogeneous definitions and nonrandom comparisons limit certainty.	—
Hamada et al[7], 2022	Systematic review and meta-analysis (5 observational studies; 941 patients)	DPDS (560) versus no DPDS (381) after PFC drainage: recurrence OR 6.72 (95%CI 2.72–16.6); clinical success OR 0.77 (0.33–1.81; 2 studies); adverse events OR 0.91 (0.19–4.41; 2 studies).	DPDS was associated with later PFC recurrence; unadjusted estimates and heterogeneous definitions limit causal and fistula-specific inference.	—
Jang et al[20], 2016	Single-center, retrospective (84 selected from 465 ANP patients)	Complete (14) versus partial (18) MPD disruption: successful transpapillary stenting 1/5 versus 11/12; recurrent/refractory PFCs or recurrent pancreatitis 10/14 versus 3/18; surgery 6/14 versus 1/18. Procedure-specific	Complete disruption had poorer outcomes; selected duct imaging, unequal necrosis and unadjusted comparisons limit inference.	Moderate (5/9)[2]

		adverse events were not separately quantified.		
van Dijk et al[21], 2019	Systematic review and meta-analysis (21 studies; 583 relevant patients)	Disrupted/disconnected ducts after necrotizing pancreatitis. Pooled success: transpapillary 81%, transluminal 92%, distal pancreatectomy 80%, cyst-jejunostomy 84%.	Several approaches achieved clinical success; mixed anatomy and observational comparisons prevent a definitive treatment ranking.	—
Bang et al[23], 2018	Dual-center, retrospective (361 screened; 291 analyzed)	DPDS (167) versus no DPDS (124): hybrid treatment 31.1% versus 4.8%; rescue surgery 13.2% versus 4.8%; adverse events 6.6% versus 3.2%. In DPDS, recurrence with permanent plastic stents versus removal: 2/121 (1.7%) versus 8/46 (17.4%).	DPDS increased complexity; stent retention was associated with less recurrence, but historical treatment changes and exclusions confound comparison.	High (8/9)[2]
Stent selection				
Bazerbachi et al[22], 2018	Systematic review and meta-analysis (41 studies; 2213 patients)	WON resolution favored metal versus plastic stents (OR 2.8; 95%CI 1.7–4.6). Comparative bleeding: 3.6% versus 7.1% (OR 0.5; 95%CI 0.15–1.7). Metal included LAMS and other designs.	Resolution favored metal in heterogeneous, mainly retrospective studies; comparative bleeding did not differ clearly.	—
Hawa et al[24], 2024	Systematic review and meta-analysis (16 studies; 1285	After PFC resolution: 85% followed AP; 67% WON, 62% DPD. Nine comparative studies (640 patients) favored long-term	Overall association favored retention; the 2-RCT subgroup (OR 0.25; 95%CI 0.03–2.31) and	—

	patients)	plastic stents over removal for recurrence (OR 0.22; 95%CI 0.09–0.52). Pooled LTIS adverse events: 8%; uncomplicated migration (6%) was analyzed separately.	pseudocyst subgroup showed no clear benefit. Definitions and follow-up varied.	
Combined drainage				
Ni et al[25], 2023	Multicenter, retrospective (153)	Pseudocysts (57), WON (96); duct disruption in 84. Recurrence: combined 6/92, transmural 6/39, transpapillary 5/22. Partial disruptions bridged: 48/55; complete disruptions reconnected: 16/29. Reported complications: combined 13.0% versus transmural 12.8%.	Lower observed recurrence with combined drainage; unadjusted treatment comparisons, selected follow-up and inconsistent statistical reporting limit conclusions.	Moderate (5/9)[2]
Trevino et al[26], 2010	Single-center, retrospective (110)	Pseudocysts (68), abscess (20), necrosis (22). Eight-week success: bridging plus transmural drainage 39/40 versus no PD stent 56/70; adjusted RR 1.14 (95%CI 1.01–1.29). Six procedural complications included 1 bleeding death; stent-associated duct changes: 4/40.	Initial PFC resolution favored bridging; recurrence did not differ clearly. Duct access/severity confounded selection; patients followed <6 months were excluded.	Moderate (6/9)[2]
Amin et al[27], 2017	Meta-analysis (9 studies; 604	Predominantly pseudocysts. Combined vs transmural drainage: clinical success OR	No overall additional benefit was demonstrated; duct	—

	drainage procedures)	1.11 (95%CI 0.65–1.89); complications OR 1.15 (95%CI 0.61–2.18).	anatomy and leak-specific effects could not be adequately separated.	
Yang et al[28], 2016	Multicenter, retrospective (174 pseudocyst patients)	Transmural (95) versus attempted combined drainage (79): long-term radiological resolution 71% versus 67%; adverse events 14/95 versus 11/79. Only 17/47 leaks were bridged. Long-term follow-up loss: 104/174 (59.8%).	No clear benefit from routine additional transpapillary drainage in pseudocysts; anatomy-dependent bridging and substantial attrition limit inference.	Moderate (6/9)[2]
Fistula internalization				
Haseeb et al[29], 2016	Case series (4)	Postoperative fistulas (3), pancreatitis with disconnected duct (1). All external drains were removed after EUS-guided internalization. Mild pancreatitis occurred in 1 and transient abdominal pain in 3; late stent migration/irritation required treatment.	Internalization was feasible after failed ERCP; four uncontrolled cases cannot establish comparative efficacy or safety.	—
Imai et al[30], 2018	Case report (1)	Persistent external fistula after necrotizing pancreatitis. Balloon-target EUS internalization enabled external drain removal after 1 week; no adverse outcomes	Demonstrates technical feasibility in one selected patient, without a comparator.	—

		were reported over 2 years.		
Guidelines and context				
Baron et al[8], 2020	AGA clinical practice update	WON: endoscopic/percutaneous drainage first, then escalation. For a disconnected left remnant, advice 14 favors distal pancreatectomy in suitable candidates; the discussion favors transmural stenting for poor surgical candidates. DEN carries bleeding, perforation and air-embolism risks.	Expert advice supports individualized source control. Long-term stenting evidence was considered insufficient for routine definitive management of a disconnected left remnant.	—
Arvanitakis et al[19], 2018	ESGE multidisciplinary guideline	DPDS: long-term transluminal plastic stents; retrieve LAMS within 4 weeks (strong, low-quality evidence). Avoid routine additional PD stenting in DPDS; bridging may be considered for partial disruption (weak, low-quality evidence).	For infected WON, endoscopic/percutaneous drainage precedes escalation. Persistent external fistulas may require internalization or surgery after conservative treatment.	—
van der Merwe et al[9], 2022	ESGE therapeutic EUS guideline	EUS-PDD: symptomatic duct obstruction after failed/impossible retrograde therapy, in expert centers. Rendezvous is preferred in favorable anatomy (strong, low-quality	A selective rescue approach; evidence mainly concerns obstructed ducts and pain, not established fistula closure.	—

		evidence). Reported EUS-PDD adverse events: 15%–27% across heterogeneous series.	Surgery and enteroscopy-assisted ERP remain alternatives.	
Boxhoorn et al[10], 2021	International expert survey (56/110 respondents)	Infected necrosis with partial disruption or complete disconnection: 84% and 88% favored transluminal drainage. Consensus statements had low/very-low-quality evidence. No consensus for persistent drain output or persistent sterile necrosis.	Describes hypothetical treatment preferences; 51% response and selected scenarios limit generalizability. It provides no comparative efficacy or adverse-event rates.	—
Proença et al[11], 2020	Literature review and proposed classification	Emphasizes MPD integrity, strictures, partial/complete disruption and collection anatomy in management of encapsulated PFCs.	Supports anatomical assessment; the proposed classification does not constitute prospective efficacy evidence.	—

[1]Methodological quality was assessed using the Newcastle–Ottawa Scale (NOS): high, 7–9; moderate, 5–6; low, 0–4. These categories are not GRADE certainty ratings. —: cohort NOS not applicable. See Supplementary Methods and Supplementary Table 3 for comparison-specific judgments.

[2]For Bang[23], the score concerns the DPDS prognostic comparison, not the historical stent-retention comparison. Collection resolution or recurrence provides indirect evidence for fistula closure.

EUS: Endoscopic ultrasound; DPDS/DPD: Disconnected pancreatic duct syndrome/disconnected pancreatic duct; LTIS: Long-term indwelling plastic stent; RCT: Randomized controlled trial; DEN: Direct endoscopic necrosectomy; AP/ANP: Acute/acute necrotizing pancreatitis; MPD/PD: Main pancreatic duct/pancreatic duct; PFC: Pancreatic fluid collection; WON: Walled-off necrosis; LAMS: Lumen-apposing metal stent; PDD: Pancreatic duct drainage; OR/RR: Odds ratio/risk ratio; CI: Confidence interval; AGA: American Gastroenterological Association; ESGE: European Society of Gastrointestinal Endoscopy; ERCP: Endoscopic retrograde cholangiopancreatography. ERP: Endoscopic retrograde pancreatography.