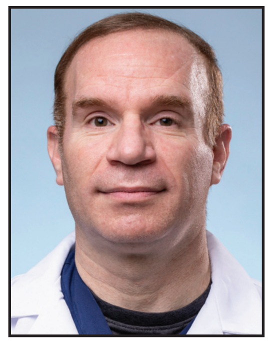
Douglas G. Adler MD, FACG, AGAF, FASGE, Series Editor

Electrohydraulic Lithotripsy for Biliary and Pancreatic Stones

Vatsal Khanna



Douglas G. Adler

Electrohydraulic lithotripsy (EHL) has emerged as a vital adjunct to endoscopic retrograde cholangiopancreatography (ERCP), providing an effective means of fragmenting large, impacted, or otherwise difficult-to-extract stones within the pancreatic and biliary ducts. This review integrates current evidence and technical considerations, with emphasis on clinical application by outlining the indications for EHL, strategies to optimize procedural safety, and its role in relation to mechanical lithotripsy, laser lithotripsy, and extracorporeal shock wave lithotripsy (ESWL).

Background

Electrohydraulic lithotripsy (EHL) is a critical adjunct to endoscopic retrograde cholangiopancreatography (ERCP) for the fragmentation of large, impacted, or otherwise difficult-to-remove pancreatic and biliary stones.[1,2,3,4,5] The technology generates microsecond-duration spark discharges at the probe tip that create cavitation bubbles, which collapse into high-pressure shock waves capable of fracturing mineralized concretions under direct vision.[6,7] Over the past decade, integration of EHL with digital single-operator cholangioscopy has led to improved ductal clearance rates with acceptable adverse event rates in patients with difficult stones.[8,9]

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Indications for EHL

Biliary Stones

For most common bile duct (CBD) stones, standard ERCP techniques such as sphincterotomy with balloon or basket extraction, and, in selected cases, endoscopic papillary large-balloon dilation (EPLBD), achieve ductal clearance in a single session.[1,2] A subset of stones remains difficult to manage. EHL should be considered for

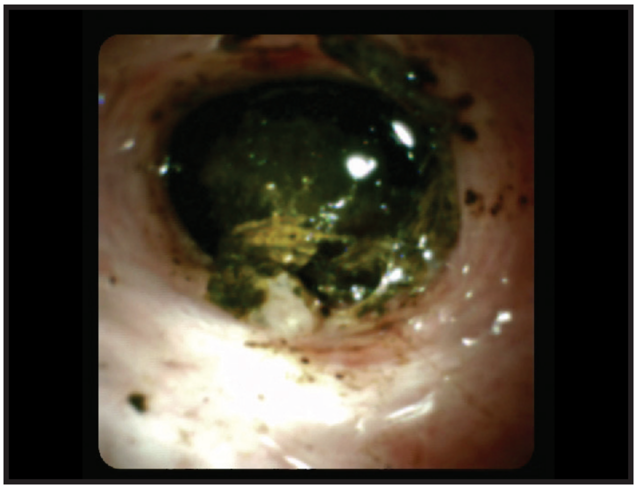

Figure 1a. Large impacted stone in the common bile duct seen via cholangioscopy

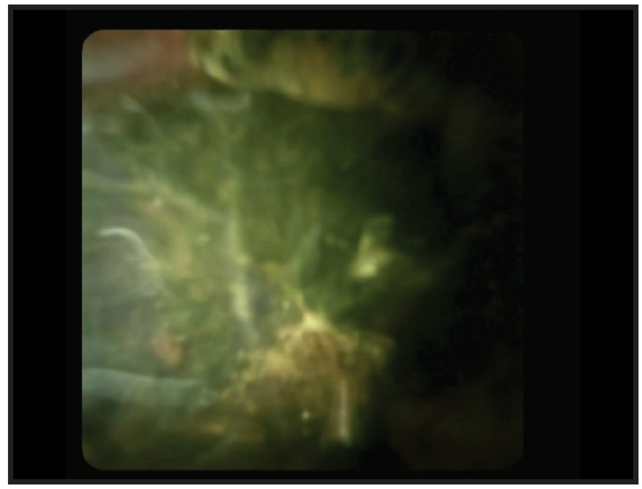

Figure 1b. EHL probe is advanced to the level of the stone

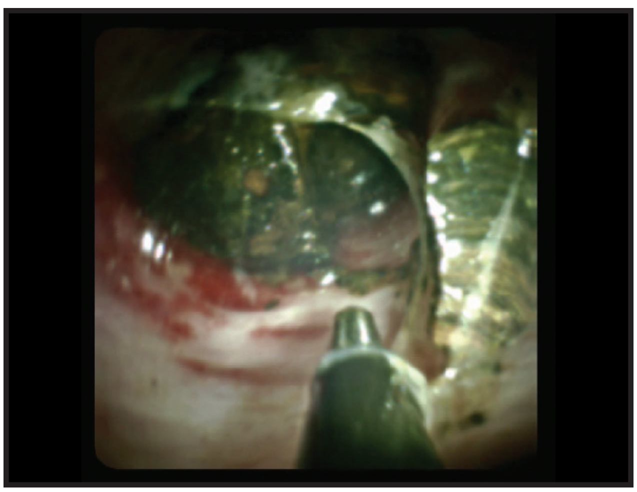

Figure 1c. Initial EHL probe discharges result in some fragmentation of the stone

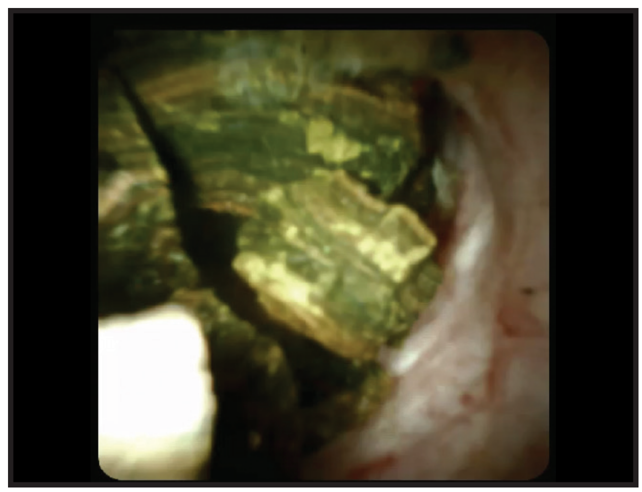

Figure 1d. Further EHL probe discharges result in complete fragmentation of the stone

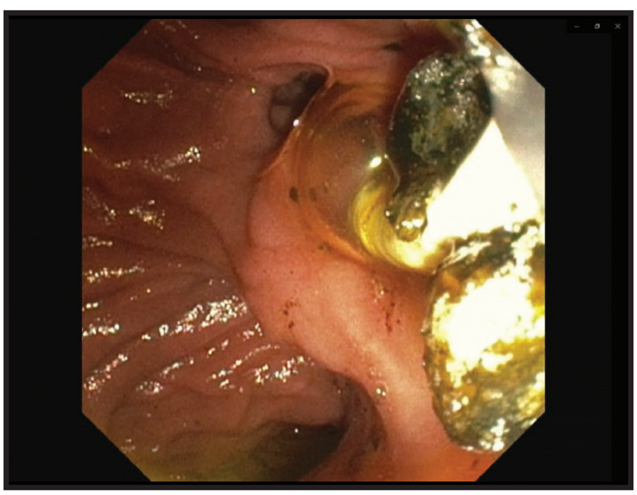

Figure 1e. Stone fragments are removed from the common bile duct using a balloon catheter

stones ≥15–20 mm, those impacted proximal to a biliary stricture, intrahepatic calculi not amenable to standard techniques, and in patients where conventional extraction methods have proven unsuccessful.[10,11,12,13,14,15,16,17,18] (Figure 1) When performed under direct cholangioscopic visualization, EHL allows precise fragmentation of stone surfaces and is particularly valuable in cases where conventional or mechanical lithotripsy has limited efficacy.[3,6] Meta-analyses of cholangioscopy-guided lithotripsy consistently demonstrate technical success and ductal clearance rates of ≥85–95%, with adverse event (AE) rates in the range of 8-10%, especially when performed under direct digital visualization.[3,4] The most frequently reported AEs include cholangitis, post-procedural fever, and, less commonly, pancreatitis; most are mild and manageable with supportive care.[3,4] The evidence suggests that EHL may be most effective when introduced earlier in the treatment course, rather than being deferred until after several unsuccessful ERCP attempts.[12] Pooled data from Jin et al. and Amaral et al. similarly demonstrated ductal clearance consistently exceeding 90% with acceptable adverse event rates ranging between 8-12%.[11,13] Recent systematic review by Manti et al. reported pooled ductal clearance rates of 90–94% with adverse event rates between 6–10%, confirming the efficacy of EHL in difficult biliary stones.[19]

Pancreatic Duct Stones

In chronic calcific pancreatitis with obstructing main pancreatic duct stones, extracorporeal shock wave lithotripsy (ESWL) combined with ERCP continues to serve as the cornerstone of therapeutic management if stones cannot be removed via pancreatic sphincterotomy and balloon or basket extraction.[20] Pancreatoscopy with intraductal lithotripsy (using either EHL or laser) has emerged as an effective second-line or alternative strategy, particularly in cases refractory to ESWL or when stones are concentrated in the head/neck adjacent to strictures.[21,22,23,24] (Figure 2) These locations are particularly amenable to intraductal therapy, as direct visualization permits targeted fragmentation of impacted stones, while adjunctive maneuvers such as stricture dilation and temporary stenting facilitate fragment clearance and ductal drainage.[21,22,23,24]

Systematic reviews have demonstrated high technical success rates and significant improvements in pain outcomes with this approach, with most adverse events related to mild post-ERCP pancreatitis.[23,24] Multicenter data from Gutierrez et al. demonstrated clearance rates > 95 % with low adverse event rates (< 5 %), confirming the safety and efficacy of digital cholangioscopy-guided lithotripsy in complex biliary stone disease.[8] These findings support the use of pancreatoscopy with intraductal lithotripsy as a salvage therapy following failed ESWL and as a potential first-line option in patients whose anatomy or clinical profile favors direct intraductal intervention.[21,22,23,24]

Set-up and Technique

Access and Visualization

For biliary stones, digital single-operator cholangioscopy performed in the context of ERCP offers a stable platform for targeted lithotripsy and subsequent stone retrieval.[25] Adequate irrigation is essential to maintain a clear visual field, as rapid accumulation of debris can obscure visualization and potentially increase intraductal pressure.[5,6]

For pancreatic stones, pancreatoscopy with intraductal lithotripsy requires careful advancement of the pancreatoscope to the level of the target stone to ensure stable positioning and safe energy delivery.[26] This may include passage of the pancreatoscope across strictures, which may be technically challenging.[22] In many cases, pre-dilation and temporary stent placement are required to facilitate passage of the scope through strictures to reach offending stones before EHL can even commence.[3,22]

Probe Selection and Energy Settings

Modern electrohydraulic lithotripsy (EHL) probes (1.9–2.5 Fr) are compatible with the working channel of digital single-operator cholangioscopy platforms, which can be applied for both biliary and pancreatic duct interventions.[27] The commercially available electrohydraulic lithotripsy (EHL) probes used in gastrointestinal (GI) endoscopy are typically 1.9 French (F) and 3 French (F) in size, with vendors including Boston Scientific Autolith Touch Biliary EHL system and Walz Elektronik (Germany). These probes are designed for use through the working channel of cholangioscopes or pancreatoscopes during ERCP or direct peroral cholangioscopy and are compatible with both single-operator and mother-baby endoscopic systems.[27] Direct peroral cholangioscopy using multibending ultra slim endoscopes has further expanded therapeutic access to difficult bile duct stones.[28] The 1.9F probe is most commonly used due to its compatibility with the narrow working channels of digital cholangioscopes (e.g., SpyGlass DS), while the 2.5F probe is used in larger-caliber scopes or for intraoperative applications.[27] Some suggest that power and frequency should be set at

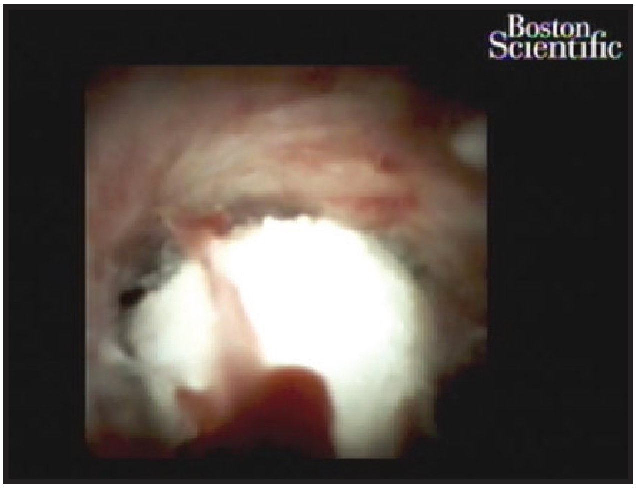

Figure 2a. Large obstructing pancreatic duct stone in a patient with chronic pancreatitis seen during pancreatoscopy

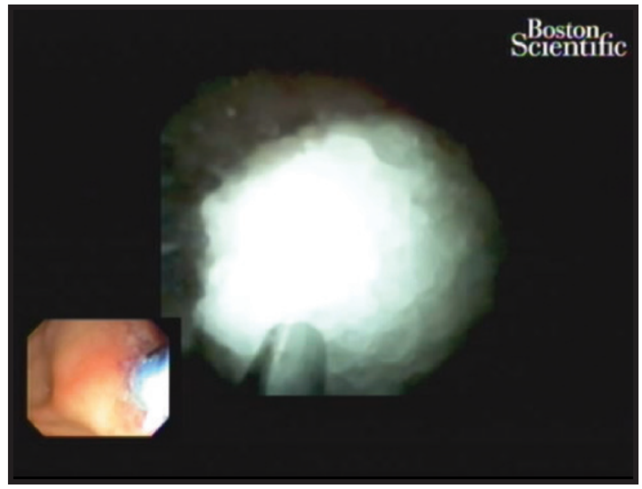

Figure 2b. EHL probe is advanced to the level of the stone

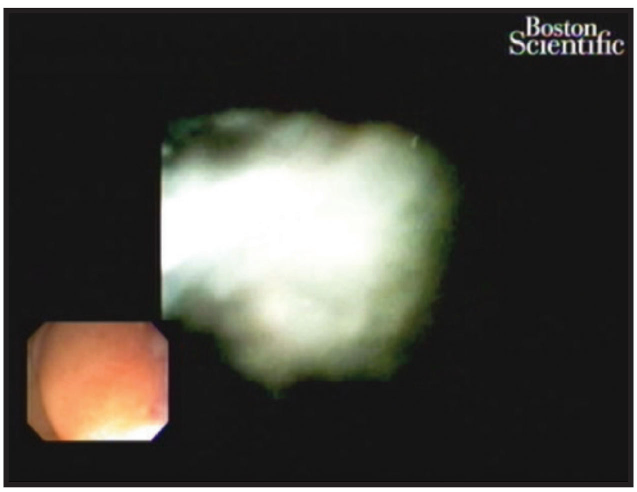

Figure 2c. The pancreatic duct stone is seen to fragment during EHL in a patient with chronic pancreatitis seen during pancreatoscopy

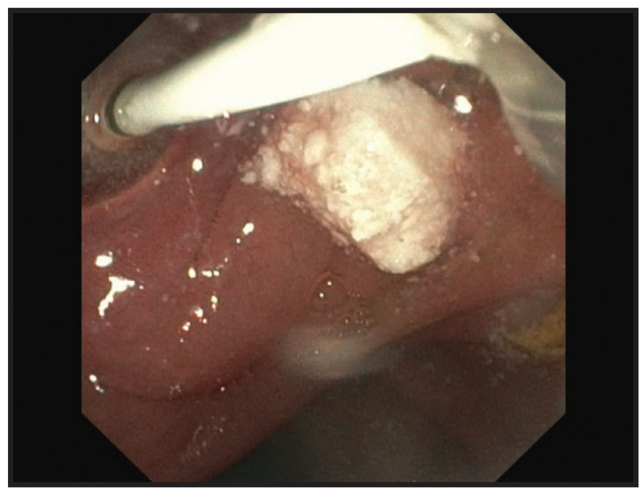

Figure 2d. Pancreatic duct stone fragments removed via a balloon catheter

low-to-moderate levels, with stepwise escalation only as needed to gradually fragment the stone while limiting the risk of injury to the ductal wall, but in practice settings are left to the discretion of the operator.[27] Safe use requires frequent probe repositioning and delivery of short, focused bursts to the stone surface rather than the surrounding mucosa.[5,6]

EHL probes have a limited life span, which is proportional to the potency chosen during the procedure.[29] The American Society for Gastrointestinal Endoscopy, in its most recent guideline, does not specify an exact number of shocks or procedures per probe, but clinical studies referenced in the guideline and in the broader literature support the practical approach of monitoring probe function and replacing the probe when performance declines and/or failure occurs.[30]

Irrigation Strategy

Continuous irrigation is necessary to dissipate heat, clear debris, and effectively transmit shock waves to target stones.[26] Liberal intermittent suction is recommended by some authors to reduce intraductal pressure, as high-pressure irrigation may increase the risk of cholangitis and post-procedural fever.[31] Evidence regarding prophylactic antibiotics is inconclusive, with large studies showing limited overall benefit, although in general they are given to patients.[32] Nevertheless, prophylaxis is indicated in specific contexts, including obstructed systems, primary sclerosing cholangitis, and procedures requiring prolonged intraductal manipulation.[32]

Fragment Clearance

Following stone fragmentation, meticulous duct clearance is performed using balloons and retrieval baskets, while endoscopic papillary large balloon dilation (EPLBD) may be employed to expedite fragment removal when appropriate.[16,17] Cholangioscopy facilitates identification of residual stones or stone fragments that may have been overlooked on occlusion cholangiography; therefore, a final direct inspection is often performed prior to confirming complete ductal clearance.[15]

Outcomes and Comparative Effectiveness

Cholangioscopy-guided EHL vs conventional ERCP in Biliary Stone Management

Randomized trials demonstrate that cholangioscopy-guided lithotripsy improves single-session clearance and reduces the need for crossover to other rescue modalities (e.g., mechanical lithotripsy, repeat ERCP, or surgical intervention).[18] This advantage derives from direct intraductal visualization, which allows targeted fragmentation of difficult stones while minimizing the need for multiple procedures.[3] Several meta-analyses support these findings, showing high technical success rates and acceptable adverse event profiles when EHL is used earlier in the treatment course.[3,13] Korrapati et al. similarly reported ductal clearance rate of 88%, with an adverse event rate of 7%.[4]

Comparative Role of Mechanical, Laser, and Electrohydraulic Lithotripsy

Mechanical lithotripsy works by capturing the stone with a basket and fracturing it, which often allows immediate extraction.[2] In contrast, EHL and laser lithotripsy use energy-based fragmentation to break stones into smaller pieces that typically require balloon or basket extraction for clearance.[2] Mechanical lithotripsy remains the most established rescue modality for large or impacted bile duct stones, valued for its technical simplicity, low cost, and widespread availability.[33] Mechanical lithotripsy achieves clearance in more than 85% of cases involving stones ≤15–20 mm.[34] In contrast, success rates decline markedly when stones are very large, heavily calcified, or located intrahepatically, where basket capture may be difficult and/or incomplete.[18]

Laser lithotripsy has emerged as a highly effective alternative, particularly when combined with digital single-operator cholangioscopy.[10,12] It achieves high ductal clearance through precise photothermal fragmentation under direct visualization, with excellent fragmentation efficiency; pooled data suggest that in some series it may outperform EHL.[10,12] Its drawbacks include high equipment costs, requirement for specialized staff training, need for laser certification, and limited availability in many centers.[35]

EHL occupies an intermediate position when compared to laser lithotripsy: it is broadly accessible, compatible with existing single-operator cholangioscopy platforms, and consistently achieves ductal clearance with low adverse event rates.[8,10] Veld et al. found comparable safety between EHL and laser, with fragmentation efficiency numerically favoring laser, while overall clearance remained high for both technologies.[10] Amaral et al. directly compared EHL with laser lithotripsy and confirmed both to be safe, with no significant difference in AE profile.[11]

Pancreatoscopy with Intraductal Lithotripsy vs. ESWL

Pancreatoscopy with intraductal lithotripsy has demonstrated high technical and clinical success in patients with pancreatic duct stones, resulting in significant pain relief, with AE rates comparable to other ERCP-based therapies such as balloon or basket extraction, mechanical lithotripsy, and stenting.[22] Comparative studies suggest that pancreatoscopy with intraductal lithotripsy may serve as a reasonable alternative to ESWL-first strategies, particularly when stone location, ductal strictures, or other anatomic factors favor direct intraductal therapy.[22,23] Careful multidisciplinary case selection and the use of staged stenting remain important to optimize safety and outcomes.[21,23]

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Staged stenting refers to the sequential placement of one or more temporary pancreatic duct stents, often upsized over multiple procedures, to facilitate ductal decompression, maintain drainage, and reduce the risk of procedure-related complications before or after intraductal lithotripsy.[36] Systematic reviews by Huang et al. reported technical success rates of 90%.[24] Van der Weil et al. noted more than 50 % decrease in pain score or reduction in opioid usage at 6 months of follow-up.[22] Meta-analysis by Guzmán-Calderón et al. also demonstrated a pooled technical success rate of 91% and overall adverse event rates of approximately 12%, the majority of which were mild and self-limited.[37]

Adverse Events Related to Cholangioscopy-Guided Lithotripsy

Meta-analyses of cholangioscopy-guided lithotripsy report overall AE rates of approximately 7%, most often transient fever or cholangitis, with the majority classified as mild.[19] For pancreatoscopy with intraductal lithotripsy, pooled analyses show overall AE rates of 12%, again largely mild and self-limited, with post-ERCP pancreatitis (PEP) the most common event.[22,23] Severe adverse events are uncommon but have been described, including cholangitis with sepsis (2-4%) and perforation (1%).[4,38]

Troubleshooting and Special Scenarios

Impacted Proximal/Hilar Stones and Intrahepatic Bile Duct Stones

Impacted proximal/hilar and intrahepatic stones are particularly challenging because conventional balloon or basket extraction is often unsuccessful, owing to their location and the limited maneuverability of the balloon and extraction basket.[9] In such cases, the strategy involves using a lithotripsy probe to debulk the central portion of the stone first, creating space for subsequent peripheral fragmentation.[9] Prior and recent studies confirm the feasibility of EHL for intrahepatic stones, although multiple staged sessions may be required to achieve complete clearance.[9]

Cystic-duct Stones and Mirizzi Syndrome

Cystic-duct stones and Mirizzi syndrome are technically demanding scenarios where conventional ERCP often fails because of the angulated cystic-duct takeoff and stone impaction.[39] Mirizzi syndrome is defined as extrinsic compression of the common hepatic duct by an impacted stone in the cystic duct or gallbladder.[40] Patients with Mirizzi syndrome may also have cholecysto-choledocho fistulas, complicating matters significantly.[41] Cholangioscopy-guided EHL provides a valuable alternative to surgical intervention, enabling targeted fragmentation and clearance of stones in patients who might otherwise require cholecystectomy or complex biliary reconstruction.[40] Pawa et al. reported 21 patients with cystic-duct stones managed with cholangioscopy-guided EHL, achieving 87% clearance with adverse events in 7%, limited to mild post-ERCP pancreatitis and transient fever.[40] Despite these successes, repeat sessions are frequently required.[40] Adjunctive balloon or basket extraction is necessary for fragment clearance after lithotripsy.[16,17] Temporary stenting has also been described as an important adjunct to maintain drainage and reduce the risk of recurrent obstruction between procedures.[21,22,23,24]

Altered Anatomy or Enteroscopy-Assisted ERCP

EHL can be performed during device-assisted ERCP in patients with surgically altered anatomy, including those with Roux-en-Y gastric bypass, Billroth II gastrectomy, or hepaticojejunostomy.[42] In these settings, an enteroscope is often required to access the biliary-enteric anastomosis or the papilla, but the long length and narrow working channel of the enteroscope impose technical limitations that can restrict accessory use and fragment retrieval.[42]

Pancreatic Duct Strictures

Pre-dilation of high-grade strictures and staged pancreatic duct stenting can facilitate pancreatoscope passage and fragment clearance in patients with pancreatic duct stones upstream of pancreatic duct strictures.[23] This strategy often involves sequential stent exchanges with gradual upsizing to "remodel" the stricture, decompress the duct, and permit easier reintroduction of the pancreatoscope during subsequent sessions.[36]

Temporary stenting also helps reduce the risk of procedure-related pancreatitis by maintaining drainage between interventions.[36] In the head and neck of the pancreas, where the duct is more tortuous and mucosal surfaces are thin, short and controlled EHL bursts with continuous irrigation are strongly recommended to optimize visualization and minimize the risk of thermal or mechanical injury.[31] Careful irrigation control is particularly important in these regions, as excessive fluid infusion can elevate intraductal pressure and increase the risk of post-ERCP pancreatitis.[31]

CONCLUSIONS

Electrohydraulic lithotripsy (EHL) is an effective option for the management of difficult biliary and pancreatic duct stones. Evidence supports its role both as a rescue therapy and as an early option when conventional ERCP is unlikely to achieve clearance. Cholangioscopy-guided EHL achieves high success rates with mostly mild, manageable adverse events. Pancreatoscopy with intraductal lithotripsy is a useful option for pancreatic stones, offering an alternative to ESWL in patients refractory to standard treatment strategies. EHL occupies a middle ground among intraductal therapies. It is more effective than mechanical lithotripsy in complex scenarios, less costly, more widely available than laser, and broadly compatible with existing endoscopic platforms. Its safety and efficacy depend on careful techniques, including direct visualization, controlled irrigation, conservative energy use, and staged procedure when needed. EHL offers a reliable and accessible option for complex stone disease, with ongoing studies continuing to clarify its role within advanced endoscopic practice. ■

References

1. ASGE Standards of Practice Committee; Buxbaum JL, Abbas Fehmi SM, Sultan S, Fishman DS, Qumseya BJ, Cortessis VK, Schilperoort H, Kysh L, Matsuoka L, Yachimski P, Agrawal D, Gurudu SR, Jamil LH, Jue TL, Khashab MA, Law JK, Lee JK, Naveed M, Sawhney MS, Thosani N, Yang J, Wani SB. ASGE guideline on the role of endoscopy in the evaluation and management of choledocholithiasis. Gastrointest Endosc. 2019 Jun;89(6):1075-1105.e15. doi: 10.1016/j.gie.2018.10.001. Epub 2019 Apr 9. PMID: 30979521; PMCID: PMC8594622.
2. Manes G, Paspatis G, Aabakken L, Anderloni A, Arvanitakis M, Ah-Soune P, Barthet M, Domagk D, Dumonceau JM, Gigot JF, Hritz I, Karamanolis G, Laghi A, Mariani A, Paraskeva K, Pohl J, Ponchon T, Swahn F, Ter Steege RWF, Tringali A, Vezakis A, Williams EJ, van Hooft JE. Endoscopic management of common bile duct stones: European Society of Gastrointestinal Endoscopy (ESGE) guideline. Endoscopy. 2019 May;51(5):472-491. doi: 10.1055/a-0862-0346. Epub 2019 Apr 3. PMID: 30943551.
3. McCarty TR, Gulati R, Rustagi T. Efficacy and safety of peroral cholangioscopy with intraductal lithotripsy for difficult biliary stones: a systematic review and meta-analysis. Endoscopy. 2021 Feb;53(2):110-122. doi: 10.1055/a-1200-8064. Epub 2020 Oct 5. PMID: 32544959.
4. Korrapati P, Ciolino J, Wani S, Shah J, Watson R, Muthusamy VR, Klapman J, Komanduri S. The efficacy of peroral cholangioscopy for difficult bile duct stones and indeterminate strictures: a systematic review and meta-analysis. Endosc Int Open. 2016 Mar;4(3):E263-75. doi: 10.1055/s-0042-100194. Epub 2016 Feb 4. PMID: 27004242; PMCID: PMC4798839.
5. Nakai Y, Sato T, Hakuta R, Ishigaki K, Saito K, Saito T, Takahara N, Hamada T, Mizuno S, Kogure H, Tada M, Isayama H, Koike K. Management of Difficult Bile Duct Stones by Large Balloon, Cholangioscopy, Enteroscopy and Endosonography. Gut Liver. 2020 May 15;14(3):297-305. doi: 10.5009/gnl19157. PMID: 31581389; PMCID: PMC7234877.
6. Subhash A, Buxbaum JL, Tabibian JH. Peroral cholangioscopy: Update on the state-of-the-art. World J Gastrointest Endosc. 2022 Feb 16;14(2):63-76. doi: 10.4253/wjge.v14.i2.63. PMID: 35316979; PMCID: PMC8908329.
7. ASGE Technology Committee; Watson RR, Parsi MA, Aslanian HR, Goodman AJ, Lichtenstein DR, Melson J, Navaneethan U, Pannala R, Sethi A, Sullivan SA, Thosani NC, Trikudanathan G, Trindade AJ, Maple JT. Biliary and pancreatic lithotripsy devices. VideoGIE. 2018 Sep 26;3(11):329-338. doi: 10.1016/j.vgie.2018.07.010. PMID: 30402576; PMCID: PMC6205352.
8. Brewer Gutierrez OI, Bekkali NLH, Raijman I, Sturgess R, Sejpal DV, Aridi HD, Sherman S, Shah RJ, Kwon RS, Buxbaum JL, Zulli C, Wassef W, Adler DG, Kushnir V, Wang AY, Krishnan K, Kaul V, Tzimas D, DiMaio CJ, Ho S, Petersen B, Moon JH, Elmunzer BJ, Webster GJM, Chen YI, Dwyer LK, Inamdar S, Patrick VB, Attwell A, Hosmer A, Ko C, Maurano A, Sarkar A, Taylor LJ, Gregory MH, Strand DS, Raza A, Kothari S, Harris JP, Kumta NA, Manvar A, Topazian MD, Lee YN, Spiceland CM, Trindade AJ, Bukhari MA, Sanaei O, Ngamruengphong S, Khashab MA. Efficacy and Safety of Digital Single-Operator Cholangioscopy for Difficult Biliary Stones. Clin Gastroenterol Hepatol. 2018 Jun;16(6):918-926.e1. doi: 10.1016/j.cgh.2017.10.017. Epub 2017 Oct 24. PMID: 29074446.
9. Bokemeyer A, Gerges C, Lang D, Bettenworth D, Kabar I, Schmidt H, Neuhaus H, Ullerich H, Lenze F, Beyna T. Digital single-operator video cholangioscopy in treating refractory biliary stones: a multicenter observational study. Surg Endosc. 2020 May;34(5):1914-1922. doi: 10.1007/s00464-019-06962-0. Epub 2019 Jul 15. PMID: 31309312.
10. Veld JV, van Huijgevoort NCM, Boermeester MA, Besselink MG, van Delden OM, Fockens P, van Hooft JE. A systematic review of advanced endoscopy-assisted lithotripsy for retained biliary tract stones: laser, electrohydraulic or extracorporeal shock wave. Endoscopy. 2018 Sep;50(9):896-909. doi: 10.1055/a-0637-8806. Epub 2018 Jul 10. PMID: 29991072.
11. Amaral AC, Hussain WK, Han S. Cholangioscopy-guided

electrohydraulic lithotripsy versus laser lithotripsy for the treatment of choledocholithiasis: a systematic review. Scand J Gastroenterol. 2023 Jul-Dec;58(10):1213-1220. doi: 10.1080/00365521.2023.2214657. Epub 2023 May 19. PMID: 37203215.

12. Buxbaum J, Sahakian A, Ko C, Jayaram P, Lane C, Yu CY, Kankotia R, Laine L. Randomized trial of cholangioscopy-guided laser lithotripsy versus conventional therapy for large bile duct stones (with videos). Gastrointest Endosc. 2018 Apr;87(4):1050-1060. doi: 10.1016/j.gie.2017.08.021. Epub 2017 Sep 1. PMID: 28866457.
13. Jin Z, Wei Y, Tang X, Shen S, Yang J, Jin H, Zhang X. Single-operator peroral cholangioscope in treating difficult biliary stones: A systematic review and meta-analysis. Dig Endosc. 2019 May;31(3):256-269. doi: 10.1111/den.13307. Epub 2018 Dec 21. PMID: 30468534.
14. Beyna T, Farnik H, Sarrazin C, Gerges C, Neuhaus H, Albert JG. Direct retrograde cholangioscopy with a new prototype double-bending cholangioscope. Endoscopy. 2016 Oct;48(10):929-33. doi: 10.1055/s-0042-110395. Epub 2016 Jul 19. PMID: 27434769.
15 Sejpal DV, Trindade AJ, Lee C, Miller LS, Benias PC, Inamdar S, Singh G, Stewart M, George BJ, Vegesna AK. Digital cholangioscopy can detect residual biliary stones missed by occlusion cholangiogram in ERCP: a prospective tandem study. Endosc Int Open. 2019 Apr;7(4):E608-E614. doi: 10.1055/a-0842-6450. Epub 2019 Apr 12. PMID: 30993165; PMCID: PMC6461551.
16. Arya N, Nelles SE, Haber GB, Kim YI, Kortan PK. Electrohydraulic lithotripsy in 111 patients: a safe and effective therapy for difficult bile duct stones. Am J Gastroenterol. 2004 Dec;99(12):2330-4. doi: 10.1111/j.1572-0241.2004.40251.x. PMID: 15571578.
17. Moon JH, Cha SW, Ryu CB, Kim YS, Hong SJ, Cheon YK, Cho YD, Kim YS, Lee JS, Lee MS, Shim CS, Kim BS. Endoscopic treatment of retained bile-duct stones by using a balloon catheter for electrohydraulic lithotripsy without cholangioscopy. Gastrointest Endosc. 2004 Oct;60(4):562-6. doi: 10.1016/s0016-5107(04)02012-7. PMID: 15472679.
18 Angsuwatcharakon P, Kulpatcharapong S, Ridtitid W, Boonmee C, Piyachaturawat P, Kongkam P, Pareesri W, Rerknimitr R. Digital cholangioscopy-guided laser versus mechanical lithotripsy for large bile duct stone removal after failed papillary large-balloon dilation: a randomized study. Endoscopy. 2019 Nov;51(11):1066-1073. doi: 10.1055/a-0848-8373. Epub 2019 Feb 20. PMID: 30786315.
19. Manti M, Shah J, Papaefthymiou A, Facciorusso A, Ramai D, Tziatzios G, Papadopoulos V, Paraskeva K, Papanikolaou IS, Triantafyllou K, Arvanitakis M, Archibugi L, Vanella G, Hollenbach M, Gkolfakis P. Endoscopic management of difficult biliary stones: an evergreen issue. Medicina. 2024;60(2):340. doi:10.3390/medicina60020340.
20. Saghir SM, Mashiana HS, Mohan BP, Dhindsa BS, Dhaliwal A, Chandan S, Bhogal N, Bhat I, Singh S, Adler DG. Efficacy of pancreatoscopy for pancreatic duct stones: A systematic review and meta-analysis. World J Gastroenterol. 2020 Sep 14;26(34):5207-5219. doi: 10.3748/wjg.v26.i34.5207. PMID: 32982119; PMCID: PMC7495039.
21. Bekkali NL, Murray S, Johnson GJ, Bandula S, Amin Z, Chapman MH, Pereira SP, Webster GJ. Pancreatoscopy-Directed Electrohydraulic Lithotripsy for Pancreatic Ductal Stones in Painful Chronic Pancreatitis Using SpyGlass. Pancreas. 2017 Apr;46(4):528-530. doi: 10.1097/MPA.0000000000000790. PMID: 28196019.
22. van der Wiel SE, Stassen PMC, Poley JW, De Jong DM, de Jonge PJF, Bruno MJ. Pancreatoscopy-guided electrohydraulic lithotripsy for the treatment of obstructive pancreatic duct stones: a prospective consecutive case series. Gastrointest Endosc. 2022 May;95(5):905-914.e2. doi: 10.1016/j.gie.2021.11.047. Epub 2021 Dec 11. PMID: 34906545.
23. Hanada Y, Shah RJ. Pancreatoscopy-Guided Endotherapies for Pancreatic Diseases. Gastrointest Endosc Clin N Am. 2024 Jul;34(3):417-431. doi: 10.1016/j.giec.2024.02.007. Epub 2024 Apr 10. PMID: 38796290.
24. Huang P, Khizar H, Song W, Yang J. Pancreatoscopy-Guided Lithotripsy for Pancreatic Duct Stones: A Systematic Review and Meta-Analysis. Turk J Gastroenterol. 2024 Nov 1;35(11):811-821. doi: 10.5152/tjg.2024.24110. PMID: 39548977; PMCID: PMC11562744.
25. Minami H, Mukai S, Sofuni A, Tsuchiya T, Ishii K, Tanaka R, Tonozuka R, Honjo M, Yamamoto K, Nagai K, Matsunami Y, Asai Y, Kurosawa T, Kojima H, Homma T, Itoi T. Clinical Outcomes of Digital Cholangioscopy-Guided Procedures for the Diagnosis of Biliary Strictures and Treatment of Difficult Bile Duct Stones: A Single-Center Large Cohort Study. J Clin Med. 2021 Apr 12;10(8):1638. doi: 10.3390/jcm10081638. PMID: 33921514; PMCID: PMC8069886.
26. Oh CH, Dong SH. Recent advances in the management of difficult bile-duct stones: a focus on single-operator cholangioscopy-guided lithotripsy. Korean J Intern Med. 2021 Mar;36(2):235-246. doi: 10.3904/kjim.2020.425. Epub 2020 Dec 1. PMID: 32972127; PMCID: PMC7969058.
27. Franzini TA, Moura RN, de Moura EG. Advances in Therapeutic Cholangioscopy. Gastroenterol Res Pract. 2016;2016:5249152. doi: 10.1155/2016/5249152. Epub 2016 Jun 15. PMID: 27403156; PMCID: PMC4925961.
28. Lee WM, Moon JH, Lee YN, Shin IS, Lee TH, Yang JK, Cha SW, Cho YD, Park SH. Utility of Direct Peroral Cholangioscopy Using a Multibending Ultraslim Endoscope for Difficult Common Bile Duct Stones. Gut Liver. 2022 Jul 15;16(4):599-605. doi: 10.5009/gnl210355. Epub 2022 Jan 7. PMID: 35000935; PMCID: PMC9289834.
29. Canena J, Lopes L, Fernandes J, Alexandrino G, Lourenço L, Libânio D, Horta D, Giestas S, Reis J. Outcomes of Single-Operator Cholangioscopy-Guided Lithotripsy in Patients with Difficult Biliary and Pancreatic Stones. GE Port J Gastroenterol. 2019 Mar;26(2):105-113. doi: 10.1159/000488508. Epub 2018 May 16. PMID: 30976615; PMCID: PMC6454387.
30. Sheth SG, Machicado JD, Chhoda A, Chalhoub JM, Forsmark C, Zyromski N, Sadeghirad B, Morgan RL, Thosani NC, Thiruvengadam NR, Ruan W, Pawa S, Ngamruengphong S, Marya NB, Kohli DR, Fujii-Lau LL, Forbes N, Elhanafi SE, Desai M, Cosgrove N, Coelho-Prabhu N, Amateau SK, Alipour O, Abidi W, Qumseya BJ; ASGE Standards of Practice Committee Chair. American Society for Gastrointestinal Endoscopy guideline on the role of endoscopy in the management of chronic pancreatitis: methodology and review of evidence. Gastrointest Endosc. 2025 Jan;101(1):e1-e53. doi: 10.1016/j.gie.2024.05.017. Epub 2024 Sep 7. PMID: 39243238.
31. Takahashi K, Ohyama H, Takiguchi Y, Sekine Y, Toyama S, Yamada N, Sugihara C, Kan M, Ouchi M, Nagashima H, Iino Y, Kusakabe Y, Okitsu K, Ohno I, Kato N. Efficacy and Safety of Electrohydraulic Lithotripsy Using Peroral Cholangioscopy under Endoscopic Retrograde Cholangiopancreatography Guidance in Older Adults: A Single-Center Retrospective Study. Medicina (Kaunas). 2023 Apr 19;59(4):795. doi: 10.3390/medicina59040795.

PMID: 37109751; PMCID: PMC10142049.

32. Merchan MFS, de Moura DTH, de Oliveira GHP, Proença IM, do Monte Junior ES, Ide E, Moll C, Sánchez-Luna SA, Bernardo WM, de Moura EGH. Antibiotic prophylaxis to prevent complications in endoscopic retrograde cholangiopancreatography: A systematic review and meta-analysis of randomized controlled trials. World J Gastrointest Endosc. 2022 Nov 16;14(11):718-730. doi: 10.4253/wjge.v14.i11.718. PMID: 36438881; PMCID: PMC9693690.
33. Syed, Imran & Hanif, Muhammad & Malik, Ahmad & Aujla, Usman. (2023). Cholangioscope-Guided Electrohydraulic Lithotripsy as a Rescue Technique for an Impacted Dormia Basket With Large Common Bile Duct Stone. ACG Case Reports Journal. 10. e00981. 10.14309/crj.0000000000000981.
34. Chang WH, Chu CH, Wang TE, Chen MJ, Lin CC. Outcome of simple use of mechanical lithotripsy of difficult common bile duct stones. World J Gastroenterol. 2005 Jan 28;11(4):593-6. doi: 10.3748/wjg.v11.i4.593. PMID: 15641153; PMCID: PMC4250818.
35. Lowe A, Gabriel LS. Laser lithotripsy. Patient care, staff education. AORN J. 1993 Nov;58(5):961-9. doi: 10.1016/s0001-2092(07)65636-1. PMID: 8257168.
36. Choi EK, Lehman GA. Update on endoscopic management of main pancreatic duct stones in chronic calcific pancreatitis. Korean J Intern Med. 2012 Mar;27(1):20-9. doi: 10.3904/kjim.2012.27.1.20. Epub 2012 Feb 28. PMID: 22403495; PMCID: PMC3295984.
37. Guzmán-Calderón E, Martinez-Moreno B, Casellas JA, Aparicio JR. Per-oral pancreatoscopy-guided lithotripsy for the endoscopic management of pancreatolithiasis: A systematic review and meta-analysis. J Dig Dis. 2021 Oct;22(10):572-581. doi: 10.1111/1751-2980.13041. PMID: 34436824.
38. Sethi A, Chen YK, Austin GL, Brown WR, Brauer BC, Fukami NN, Khan AH, Shah RJ. ERCP with cholangiopancreatoscopy may be associated with higher rates of complications than ERCP alone: a single-center experience. Gastrointest Endosc. 2011 Feb;73(2):251-6. doi: 10.1016/j.gie.2010.08.058. Epub 2010 Nov 24. PMID: 21106195.
39. Navaneethan U, Hasan MK, Kommaraju K, Zhu X, Hebert-Magee S, Hawes RH, Vargo JJ, Varadarajulu S, Parsi MA. Digital, single-operator cholangiopancreatoscopy in the diagnosis and management of pancreatobiliary disorders: a multicenter clinical experience (with video). Gastrointest Endosc. 2016 Oct;84(4):649-55. doi: 10.1016/j.gie.2016.03.789. Epub 2016 Mar 16. PMID: 26995690.
40. Pawa R, Dorrell R, Pawa S. Endoscopic management of cystic duct stones and Mirizzi's syndrome: experience at an academic medical center. Endosc Int Open. 2022 Jan 14;10(1):E135-E144. doi: 10.1055/a-1594-1515. PMID: 35047344; PMCID: PMC8759932.
41. Abou-Saif A, Al-Kawas FH. Complications of gallstone disease: Mirizzi syndrome, cholecystocholedochal fistula, and gallstone ileus. Am J Gastroenterol. 2002 Feb;97(2):249-54. doi: 10.1111/j.1572-0241.2002.05451.x. PMID: 11866258.
42. Martin H, El Menabawey T, Webster O, Parisinos C, Chapman M, Pereira SP, Johnson G, Webster G. Endoscopic biliary therapy in the era of bariatric surgery. Frontline Gastroenterol. 2021 Feb 24;13(2):133-139. doi: 10.1136/flgastro-2020-101755. PMID: 35295751; PMCID: PMC8862446.

Answers to this month's crossword puzzle:

1 C	I	2 R	R	3 H	O	4 S	I	5 S		6 F	7 O	8 C	U	9 S
O		E		O		T		O		10 E	A	R		E
11 L	I	V	E	R		12 R	13 E	S	E	C	T	I	O	N
O		E		14 S	C	A	N			A		M		N
15 N	E	R	V	E		16 N	E	O	17 P	L	A	S	I	A
O		S				D			R			O		S
18 S	T	E	T	19 H	O		20 O	21 P	E	22 N	I	N	G	
C				E		23 B		I		U				
24 O	25 B	26 E	S	E		27 L	A	X	A	T	I	28 V	E	29 S
30 P	A	N		D		O		E		R		A		T
31 Y	T	D		32 S	M	A	L	L		33 I	T	C	H	Y
		I				T				T		C		E
34 D	I	V	E	35 R	T	I	C	36 U	37 L	I	T	I	38 S	
E		E		Y		N		39 R	I	O		40 N	E	41 W
42 W	A	S	T	E		43 G	A	L	E	N		44 E	W	E