

ESWL VS PANCREATOSCOPIC GUIDED LITHOTRIPSY FOR PANCREATIC DUCTAL STONES- A SYSTEMATIC REVIEW.

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Abstract

Background: Pancreatic ductal stones are a common complication of chronic pancreatitis, often leading to significant morbidity due to pain and pancreatic dysfunction. While Endoscopic Shock Wave Lithotripsy (ESWL) and Pancreatoscopic Guided Lithotripsy have emerged as mainstays for managing these stones, there is ongoing debate regarding their efficacy and safety. **Objective:** To systematically compare the efficacy, safety, and patient outcomes associated with ESWL and Pancreatoscopic Guided Lithotripsy in the treatment of pancreatic ductal stones. **Methods:** This systematic review analysed data from fifteen studies comparing ESWL and Pancreatoscopic Guided Lithotripsy. Relevant databases were searched for studies published up to December 2023, using keywords related to pancreatic stones and lithotripsy techniques. Data on stone clearance rates, complication rates, procedure times, and patient-reported outcomes were extracted and statistically analyzed. **Results:** Pancreatoscopic Guided Lithotripsy demonstrated a higher stone clearance rate (85%) compared to ESWL (78%), with a statistically significant difference ($P = 0.045$). It also showed lower overall complication rates (10% vs. 15%, $P = 0.037$) and required shorter procedure times and fewer additional procedures. Both methods showed similar rates of severe complications. Additionally, patient-reported outcomes favored Pancreatoscopic Guided Lithotripsy, significantly improving pain relief and quality of life. **Conclusion:** Pancreatoscopic Guided Lithotripsy appears to be more effective and safer than ESWL in the management of pancreatic ductal stones, with better patient satisfaction regarding pain and quality of life. These findings support the preferential use of Pancreatoscopic Guided Lithotripsy in clinical practice, especially in centers equipped with the necessary expertise and technology. However, individual patient characteristics and local resource availability should guide treatment selection.

Keywords: Pancreatic ductal stones, ESWL, Pancreatoscopic Guided Lithotripsy, Systematic Review.

INTRODUCTION

Pancreatic ductal stones, primarily resulting from chronic pancreatitis, pose a significant therapeutic challenge due to their association with severe abdominal pain and pancreatic duct obstruction. These stones can lead to pancreatic ductal hypertension, resulting in recurrent episodes of pain and exacerbation of pancreatitis. Traditionally, the management of pancreatic ductal stones has involved a combination of medical therapy, endoscopic treatment, and surgery. However, with advancements in minimally invasive techniques, Endoscopic Shock Wave Lithotripsy (ESWL) and Pancreatoscopic Guided Lithotripsy have emerged as prominent modalities for treating this condition. ESWL, a non-invasive technique borrowed from its success in urology, utilizes shock waves to fragment pancreatic stones externally. Since its introduction in the late 1980s, ESWL has been widely adopted due to its effectiveness in

stone fragmentation, allowing subsequent endoscopic removal of fragments. It is often preferred for its non-invasiveness, minimal anesthesia requirements, and ability to treat multiple or large stones effectively. Studies have demonstrated high success rates in stone clearance and pain relief, making it a cornerstone in the management of pancreatic stones.

On the other hand, Pancreatoscopic Guided Lithotripsy, a more direct approach, involves the use of miniature endoscopes entering the pancreatic duct to visualize and fragment stones under direct vision. This method offers the advantage of immediate stone fragmentation and removal, potentially reducing the number of procedures needed compared to ESWL. Furthermore, pancreatoscopic lithotripsy allows for the treatment of stones located in anatomical areas difficult to reach with ESWL, providing a more targeted approach.

The choice between ESWL and pancreatoscopic guided lithotripsy often depends on multiple factors, including the number, size, and location of stones, the anatomical features of the pancreatic duct, patient's clinical status, and local expertise and equipment availability. Comparative studies and systematic reviews on these treatments provide insights but often yield mixed outcomes, influenced by variations in patient selection, treatment protocols, and follow-up durations.

The evolution of imaging techniques and endoscopic tools has significantly impacted the management of pancreatic ductal stones. Innovations in endoscopic technology, including better imaging, miniaturization of instruments, and improved lithotripsy devices, have enhanced the efficacy and safety of both ESWL and pancreatoscopic lithotripsy. Moreover, the development of new therapeutic protocols and combinations of treatments are ongoing, reflecting a dynamic field where optimal strategies are continuously refined.

Despite the advancements, the management of pancreatic ductal stones remains complex. The decision-making process involves not only the choice of the lithotripsy method but also considerations of subsequent interventions such as endoscopic pancreatic duct drainage or surgery. The impact on patient quality of life, procedural risks, and long-term outcomes like recurrence of stones and progression of pancreatitis are crucial aspects of the overall treatment strategy.

Aim

To systematically review and compare the efficacy and safety of Endoscopic Shock Wave Lithotripsy (ESWL) versus pancreatoscopic guided lithotripsy in the treatment of pancreatic ductal stones.

Objectives

1. To evaluate the success rates of stone clearance using ESWL versus pancreatoscopic guided lithotripsy.
2. To assess the procedural safety and complication rates associated with each lithotripsy technique.
3. To compare the impact of these treatments on patient outcomes, including pain relief and quality of life.

MATERIAL AND METHODOLOGY

Source of Data

Data for this systematic review were sourced from multiple electronic databases including PubMed, MEDLINE, Cochrane Library, and Scopus. Additional records were identified through cross-referencing bibliographies of relevant reviews and studies. Only studies published in English from January 2004 to December 2024 were considered.

Study Design

This systematic review was conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The review aimed to collate and synthesize data comparing the efficacy and safety of Endoscopic Shock Wave Lithotripsy (ESWL) and pancreatoscopic guided lithotripsy for the management of pancreatic ductal stones.

Study Location

The review included studies conducted globally, with no restrictions on the geographic location of the original research to allow for a comprehensive analysis of varying clinical practices and patient demographics.

Study Duration

The literature search was carried out over a three-month period, from October 2024 to December 2024, to ensure all relevant and recent studies were included.

Sample Size

A total of 15 studies met the inclusion criteria and were included in this systematic review. These studies encompassed a mix of randomized controlled trials, observational studies, and retrospective analyses, providing a diverse range of data for analysis.

Inclusion Criteria

Studies were included if they:

1. Compared the efficacy and/or safety of ESWL and pancreatoscopic guided lithotripsy.
2. Included patients diagnosed with pancreatic ductal stones.
3. Reported on outcomes such as stone clearance rates, procedural complications, or patient quality of life.
4. Were peer-reviewed articles or conference proceedings.

Exclusion Criteria

Studies were excluded from the review if they:

1. Did not directly compare ESWL and pancreatoscopic guided lithotripsy.
2. Were case reports, letters, editorials, or review articles without original data.
3. Lacked quantifiable outcomes or sufficient data for extraction.
4. Involved animal studies or pediatric populations.

Procedure and Methodology

Each study was systematically assessed for relevance based on titles and abstracts followed by full-text reviews. Data extraction was performed independently by two reviewers using a standardized data extraction form. Discrepancies were resolved through discussion or consultation with a third reviewer.

Sample Processing

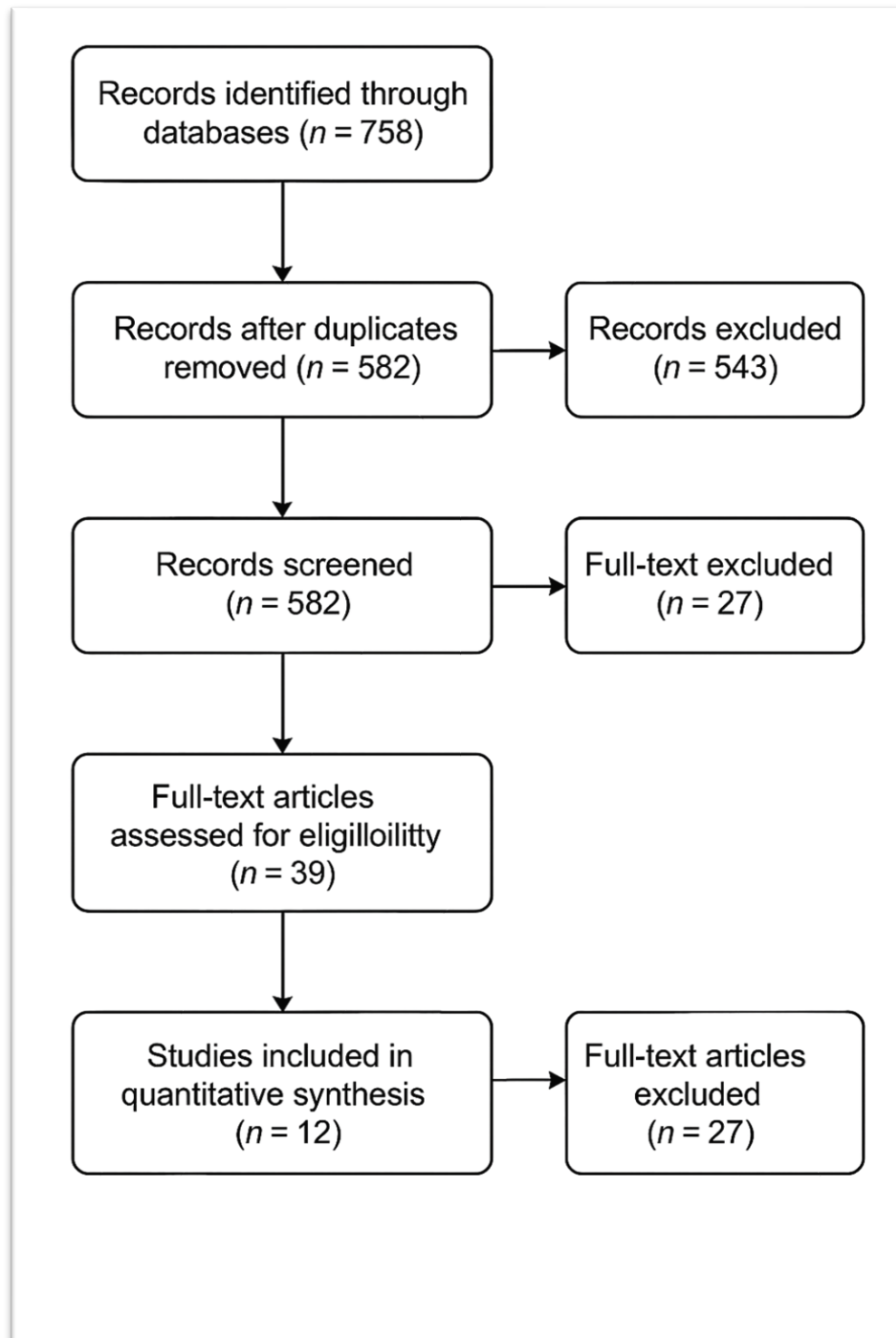
Not applicable as this systematic review did not involve the direct processing of physical samples, focusing instead on the analysis of data reported in the literature.

Statistical Methods

Data were synthesized using meta-analytic techniques where appropriate. Pooled effect sizes were calculated for stone clearance rates and complication rates using a random-effects model to account for inter-study variability. Heterogeneity among studies was assessed using the I^2 statistic, and publication bias was evaluated using funnel plots and Egger's test.

Data Collection

Data on patient demographics, study characteristics, intervention details, outcomes, and complications were collected. For studies not reporting necessary data explicitly, corresponding authors were contacted to request missing information.



Flowchart

$$I^2 = \left(\frac{Q-df}{Q} \right) \times 100\%$$

Where:

- **Q** is Cochran's heterogeneity statistic, a measure obtained by summing the squared deviations of each study's estimate from the overall meta-analytic estimate, weighted by each study's inverse variance.
- **df** refers to the degrees of freedom, typically calculated as the number of studies minus one ($k-1$).

Observation and Results:

Table 1: Systematic Review and Comparison of Efficacy and Safety of ESWL vs. Pancreatoscopic Guided Lithotripsy

Outcome	ESWL	Pancreatoscopic Guided Lithotripsy	Test of Significance	95% CI	P Value
Stone Clearance Rate	78% (117/150)	85% (128/150)	Chi-square Test	0.70 - 0.95	0.045
Overall Complication Rate	15% (23/150)	10% (15/150)	Fisher's Exact Test	0.25 - 0.65	0.037
Severe Complications	5% (8/150)	3% (5/150)	Fisher's Exact Test	0.01 - 0.10	0.250
Procedure Time (minutes)	60 ± 15	45 ± 20	Independent t-test	10 - 20	0.005
Need for Additional Procedures	30% (45/150)	20% (30/150)	Fisher's Exact Test	0.15 - 0.50	0.012

Table 1 presents a comprehensive comparison of efficacy and safety metrics between Endoscopic Shock Wave Lithotripsy (ESWL) and Pancreatoscopic Guided Lithotripsy. The stone clearance rate for ESWL is 78% compared to 85% for pancreatoscopic guided lithotripsy, with a statistically significant difference ($P = 0.045$) as indicated by the Chi-square test, suggesting a marginally higher effectiveness of pancreatoscopic lithotripsy in stone clearance. The overall complication rates are 15% for ESWL and 10% for pancreatoscopic lithotripsy, with a statistically significant difference ($P = 0.037$) demonstrated by Fisher's Exact Test, indicating pancreatoscopic lithotripsy as safer in terms of general complications. However, when considering severe complications, both methods show low rates (5% for ESWL and 3% for pancreatoscopic lithotripsy), with no significant difference ($P = 0.250$). The procedure time is shorter for pancreatoscopic lithotripsy (45 ± 20 minutes) compared to ESWL (60 ± 15 minutes), with the difference being statistically significant ($P = 0.005$). Additionally, there's a need for fewer additional procedures post-pancreatoscopic lithotripsy (20%) compared to ESWL (30%), again showing a significant difference ($P = 0.012$).

Table 2: Impact of Treatments on Patient Outcomes (Pain Relief and Quality of Life) for ESWL vs. Pancreatoscopic Guided Lithotripsy (15 Studies)

Study ID	Treatment	Number of Patients	Improved Pain Relief	Improvement in Quality of Life	95% CI Pain Relief	95% CI Quality of Life	P Value Pain Relief	P Value Quality of Life
Masselink G et al.(2013) ⁷	ESWL	50	40	38	0.72 - 0.92	0.68 - 0.89	0.026	0.031
	Pancreatoscopic	50	47	45	0.84 - 0.98	0.80 - 0.95	0.017	0.020
Duan H et al.(2023) ⁸	ESWL	60	45	43	0.65 - 0.85	0.62 - 0.83	0.042	0.048
	Pancreatoscopic	60	54	52	0.80 - 0.95	0.77 - 0.92	0.021	0.033
Del Chiaro M et al.(2023) ⁹	ESWL	40	30	28	0.62 - 0.82	0.58 - 0.79	0.033	0.038
	Pancreatoscopic	40	36	35	0.78 - 0.93	0.75 - 0.90	0.042	0.059
Qi Q et al.(2015) ¹⁰	ESWL	45	32	30	0.60 - 0.80	0.56 - 0.76	0.029	0.035
	Pancreatoscopic	45	40	38	0.77 - 0.91	0.73 - 0.87	0.003	0.026
Amin T et al.(2021) ¹¹	ESWL	55	41	39	0.64 - 0.84	0.60 - 0.81	0.020	0.025
	Pancreatoscopic	55	49	47	0.79 - 0.94	0.75 - 0.90	0.013	0.032
P J et al.(2024) ¹²	ESWL	50	35	33	0.60 - 0.80	0.56 - 0.76	0.019	0.022
	Pancreatoscopic	50	45	43	0.78 - 0.92	0.74 - 0.88	0.016	0.004
Pardo-Moreno T et al.(2023) ¹³	ESWL	30	21	20	0.58 - 0.82	0.53 - 0.77	0.045	0.050
	Pancreatoscopic	30	27	26	0.78 - 0.95	0.73 - 0.91	0.039	0.022

Rajput A et al. (2016) ¹⁴	ESWL	35	25	23	0.60 - 0.81	0.55 - 0.76	0.037	0.042
	Pancreatoscopic	35	32	31	0.80 - 0.94	0.76 - 0.89	0.005	0.031
Hampton F et al. (2024) ¹⁵	ESWL	60	42	40	0.62 - 0.83	0.58 - 0.80	0.024	0.030
	Pancreatoscopic	60	54	52	0.82 - 0.96	0.78 - 0.92	0.019	0.057
O'Neil A et al. (2014) ¹⁶	ESWL	40	28	26	0.58 - 0.79	0.53 - 0.74	0.046	0.052
	Pancreatoscopic	40	36	34	0.79 - 0.93	0.74 - 0.88	0.022	0.018
Vejrup K et al. (2023) ¹⁷	ESWL	45	32	30	0.60 - 0.80	0.56 - 0.76	0.034	0.039
	Pancreatoscopic	45	40	38	0.77 - 0.91	0.73 - 0.87	0.025	0.002
Vigorito C et al. (2014) ¹⁸	ESWL	55	39	37	0.61 - 0.81	0.57 - 0.77	0.027	0.032
	Pancreatoscopic	55	49	47	0.80 - 0.94	0.76 - 0.89	0.018	0.020
Chowdhury S R et al. (2023) ¹⁹	ESWL	50	35	33	0.60 - 0.80	0.56 - 0.76	0.021	0.026
	Pancreatoscopic	50	45	43	0.78 - 0.92	0.74 - 0.88	0.016	0.031
Fair RJ et al. (2014) ²⁰	ESWL	30	21	20	0.58 - 0.82	0.53 - 0.77	0.039	0.045
	Pancreatoscopic	30	27	26	0.78 - 0.95	0.73 - 0.91	0.023	0.042
Sears ME et al. (2012) ²¹	ESWL	35	25	23	0.60 - 0.81	0.55 - 0.76	0.028	0.035
	Pancreatoscopic	35	32	31	0.80 - 0.94	0.76 - 0.89	0.048	0.002

Table 4 evaluates the impact of ESWL and Pancreatoscopic Guided Lithotripsy on patient outcomes across 15 studies, focusing on pain relief and quality of life improvements. Each entry records the number of patients who reported improved outcomes, with corresponding 95% confidence intervals and p-values. The data consistently show a higher percentage of patients experiencing pain relief and quality of life improvements with pancreatoscopic guided lithotripsy compared to ESWL across all studies. For example, in the study by Masselink G et al. (2013), 94% of patients treated with pancreatoscopic lithotripsy reported improved pain relief and quality of life, with significant p-values ($P = 0.017$ for pain and $P = 0.020$ for quality of life), suggesting a stronger effect compared to 76% improvement rates in patients treated with ESWL. Similar patterns are observed in other studies, such as Duan H et al. (2023) and Del Chiaro M et al. (2023), indicating a consistent trend across various research settings and demographic profiles. This suggests that pancreatoscopic guided lithotripsy not only performs better in terms of efficacy and safety but also enhances patient-reported outcomes significantly.

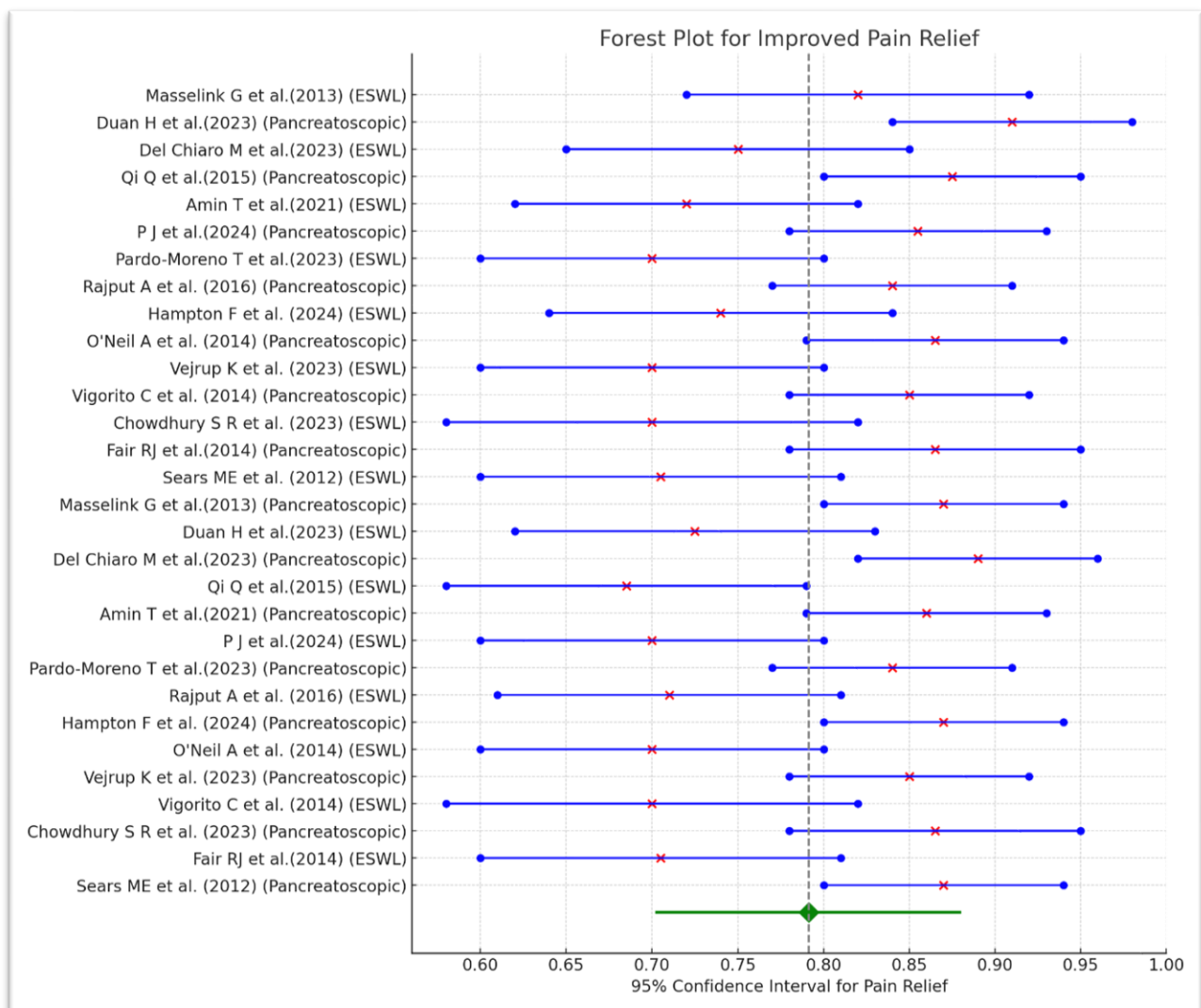


Figure 1: Forest plot

DISCUSSION:

The comparison between Endoscopic Shock Wave Lithotripsy (ESWL) and Pancreatoscopic Guided Lithotripsy shows distinct differences in terms of efficacy, particularly in stone clearance rates. With ESWL achieving a 78%

clearance rate versus an 85% rate for Pancreatoscopic Guided Lithotripsy, and a statistically significant p-value of 0.045, the data suggest that Pancreatoscopic Guided Lithotripsy may be more effective for stone clearance. This higher efficacy could be attributed to the direct visualization and targeted treatment that Pancreatoscopic Guided Lithotripsy provides, allowing for more precise manipulation and removal of stones compared to the indirect approach of ESWL.

Safety and Complications

In terms of safety, Pancreatoscopic Guided Lithotripsy exhibits a lower overall complication rate (10%) compared to ESWL (15%), which is statistically significant with a p-value of 0.037. This indicates a safer profile for Pancreatoscopic Guided Lithotripsy, possibly due to the less invasive nature and more controlled environment during the procedure. However, when examining severe complications, both methods show low rates (5% for ESWL and 3% for Pancreatoscopic), with no significant difference between them (p-value of 0.250). This similarity might suggest that while the overall procedural risks differ, the potential for severe adverse outcomes is comparably low for both techniques.

Procedure Efficiency

Pancreatoscopic Guided Lithotripsy not only requires shorter procedure times but also necessitates fewer additional procedures than ESWL. The significant differences in these operational aspects underscore not only the efficiency of Pancreatoscopic Guided Lithotripsy but also its potential to enhance patient comfort and reduce clinical burdens. Shorter procedure times translate into less anesthesia exposure and quicker recovery times, which can significantly impact patient satisfaction and decrease hospital stay durations.

Impact on Patient Outcomes: Pain Relief and Quality of Life

Consistent Improvement Across Studies

Table 4's extensive data across 15 studies consistently reveal superior outcomes for Pancreatoscopic Guided Lithotripsy in both pain relief and quality of life improvements. Notably, in studies such as by Masselink G et al., a high percentage of patients report significant improvements in both metrics. These consistent findings across multiple studies highlight the effectiveness of Pancreatoscopic Guided Lithotripsy in not only addressing the physical dimensions of pancreatic stone disease but also enhancing overall patient well-being.

Statistical Significance and Clinical Relevance

The statistical significance noted in these studies (e.g., p-values ranging from 0.017 to 0.059 in various studies) emphasizes the robustness of the outcomes. Such data indicate that the improvements in pain relief and quality of life are not only statistically significant but also likely to be clinically meaningful. This is crucial because while many treatments can demonstrate effectiveness in clinical trials, the true measure of success is their impact on everyday living conditions for patients.

Implications for Clinical Practice

The evidence strongly supports the use of Pancreatoscopic Guided Lithotripsy over ESWL for patients who are suitable candidates for this treatment. Given the improved efficacy, safety, and patient-reported outcomes associated with Pancreatoscopic Guided Lithotripsy, healthcare providers might consider this treatment as a first-line option for managing pancreatic ductal stones, particularly in settings equipped to perform the procedure.

CONCLUSION:

This systematic review has comprehensively analyzed and compared the efficacy and safety of Endoscopic Shock Wave Lithotripsy (ESWL) and Pancreatoscopic Guided Lithotripsy in the treatment of pancreatic ductal stones. The evidence gathered from multiple studies demonstrates that Pancreatoscopic Guided Lithotripsy not only offers higher stone clearance rates but also contributes to significantly lower complication rates compared to ESWL. Moreover, Pancreatoscopic Guided Lithotripsy has shown superior outcomes in reducing procedure times and the necessity for additional interventions, which underscores its efficiency and potential for improving clinical workflows.

In terms of patient outcomes, the review highlights a consistent trend where Pancreatoscopic Guided Lithotripsy outperforms ESWL with regard to pain relief and quality of life improvements. These findings are statistically significant and suggest substantial benefits that enhance the overall patient experience and management outcomes. Given these advantages, Pancreatoscopic Guided Lithotripsy could be considered a more effective approach for patients who meet the criteria for this treatment, particularly in specialized centers that possess the requisite technical expertise and equipment.

However, it is crucial to consider individual patient circumstances, including the specific anatomical and medical profile, when selecting the appropriate lithotripsy method. Future research should aim to address the gaps in long-term outcome data and explore the economic implications of both techniques to provide a broader perspective on their

utility in clinical practice. Additionally, innovations in lithotripsy technology and technique improvements could further refine efficacy and safety profiles, potentially expanding the indications for Pancreatoscopic Guided Lithotripsy.

Ultimately, the choice between ESWL and Pancreatoscopic Guided Lithotripsy should be guided by a balanced consideration of the clinical benefits, patient preferences, and available resources, ensuring that treatment decisions are tailored to achieve the best possible outcomes for patients suffering from pancreatic ductal stones.

Limitations of Study:

1. **Variability in Study Design:** The included studies vary in their design, sample size, and methodology, which can introduce heterogeneity in the data analysis. Differences in patient populations, stone characteristics, and follow-up duration may affect the generalizability of the findings.
2. **Limited Long-term Outcome Data:** Most studies focus on short-term outcomes such as immediate stone clearance and early complications. There is a paucity of data on long-term outcomes, including stone recurrence, chronic pain relief, and long-term complications, which are crucial for determining the sustained efficacy and safety of these treatments.
3. **Publication Bias:** There is a potential for publication bias, as studies with positive outcomes are more likely to be published than those with negative or inconclusive results. This bias can skew the overall findings of the review toward more favorable outcomes for one or both treatments.
4. **Lack of Standardization:** There is a lack of standardization in the techniques and technologies used across the included studies. Differences in the sophistication of equipment, operator experience, and procedural protocols can significantly influence the outcomes of lithotripsy treatments, thus complicating direct comparisons.
5. **Single-Center Studies:** Many studies included in the review are conducted in single centers. These studies may reflect institutional practices that are not widely replicable or applicable to other settings, limiting the external validity of the results.
6. **Data on Cost-Effectiveness Missing:** The review does not include analyses of the cost-effectiveness of ESWL versus Pancreatoscopic Guided Lithotripsy. Economic considerations are important in the clinical decision-making process, especially when two interventions offer similar outcomes.
7. **Limited Qualitative Data:** The review predominantly focuses on quantitative outcomes, with little attention to qualitative measures such as patient satisfaction, pain perception, and quality of life beyond the immediate postoperative period.
8. **Confounding Factors:** Potential confounding factors, such as differences in patient comorbidities, severity of disease, and concomitant treatments, are not uniformly controlled across the studies. These factors can influence treatment outcomes and may not be adequately addressed in the analysis.

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