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Efficacy and Safety of Mannitol as Alternative Contrast Medium for Oral Use in Abdominal Computed Tomography Scans: A Systematic Review

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ABSTRACT:

Abdominal computed tomography (CT) is integral in diagnosing gastrointestinal conditions, necessitating effective oral contrast agents for optimal bowel visualization. Conventional agents like polyethylene glycol (PEG), water, and iodinated solutions often pose challenges, such as limited distension, poor taste, and imaging artifacts. Mannitol, a hyperosmotic sugar alcohol, has emerged as a potential alternative due to its capacity to enhance bowel distension and image clarity while minimizing adverse effects.

Objective: This review aims to evaluate mannitol as an oral contrast agent for abdominal CT imaging by assessing its effectiveness in bowel distension, diagnostic image quality, patient compliance and tolerability, and associated adverse effects. It seeks to determine mannitol's potential as a safe and effective alternative to conventional contrast agents.

Methods: This review followed PRISMA 2020 guidelines. A comprehensive search of PubMed, Scopus, and Google Scholar was conducted for studies published from January 2021 to April 2024. Studies evaluating efficacy, palatability, and patient compliance with mannitol were included. Narrative synthesis was used to summarize results.

Results: Eight studies met the inclusion criteria. Most reported that mannitol achieved adequate bowel distension (≥90%) with minimal side effects. Palatability was rated as good by over 75% of participants, and compliance rates exceeded 90%.

Conclusion: Mannitol is a promising alternative to traditional contrast agents for CT abdomen due to its effectiveness, safety, and patient tolerance.

Introduction

Abdominal computed tomography (CT) plays a pivotal role in evaluating gastrointestinal pathology due to its noninvasive nature and high-resolution imaging capabilities. Achieving optimal diagnostic accuracy necessitates adequate bowel distension, typically accomplished through the administration of oral and rectal contrast agents.

Conventional contrast media, including polyethylene glycol (PEG) and iodinated solutions, are widely utilized; however, they present notable drawbacks. These include unpleasant taste, potential adverse effects, and imaging artifacts that may compromise diagnostic interpretation.

In response to these limitations, mannitol—a hyperosmotic, non-absorbable sugar alcohol—has gained attention as a promising neutral oral contrast agent. Its mechanism involves osmotically drawing fluid into the intestinal lumen, thereby enhancing bowel distension and improving visualization of the gastrointestinal tract. Mannitol is increasingly employed in clinical practice, especially in protocols such as CT enterography and colonography. Nonetheless, the available data regarding its performance remains heterogeneous, with inconsistencies in methodology, sample size, and outcome measures across published studies.

This review seeks to consolidate current evidence on mannitol's clinical utility, focusing on its effectiveness in achieving sufficient bowel distension, as well as its tolerability, palatability, and associated rates of patient compliance. Preliminary findings suggest mannitol offers a favorable safety profile and is generally well-accepted by patients, with minimal side effects reported. Its neutral taste and low osmolality contribute to improved compliance, positioning mannitol as a viable alternative to traditional agents.

Synthesizing this literature may inform future guidelines and enhance imaging practices in both resource-rich and resource-constrained settings.

Methods

This research adopted a systematic review methodology to examine the effectiveness and safety of mannitol as an oral contrast agent for abdominal computed tomography (CT) procedures. To synthesize and interpret the findings from various relevant studies, a narrative synthesis framework was applied. This approach is particularly appropriate for reviews incorporating studies with heterogeneous methodologies, varied outcome indicators, and different reporting standards, particularly in contexts where quantitative meta-analysis may not be feasible. Narrative synthesis enables the comprehensive organization and thematic analysis of data from multiple sources to identify consistent findings, inter-study variations, and underlying trends.

The review encompassed eight peer-reviewed articles published between 2021 and 2024, all of which explored mannitol's clinical utility in CT imaging of the abdomen. These studies were methodically selected and evaluated using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. This structured reporting framework ensured methodological rigor and transparency throughout the study selection, data extraction, and synthesis processes.

Data collection and research were primarily conducted at the Catanduanes State University (CatSU) library located in Virac, Catanduanes, and in other public venues with secure internet access and computing facilities. CatSU, originally founded as the Virac National and Agricultural Trade School (VNATS) in 1961, transitioned to Catanduanes State Colleges in 1971 and achieved university status in 2012 through Republic Act No. 10229. The institution was established through the efforts of visionary educators and healthcare professionals committed to fostering academic excellence and social responsibility in their community.

To enhance the scope and credibility of the review, the researcher also conducted manual searches at the University of the Immaculate Conception (UIC) and accessed supplementary materials from trusted online academic sources. These supplementary efforts provided a broader perspective on the role of mannitol in abdominal CT imaging.

Relevant literature was retrieved from well-established databases such as PubMed, Thieme, and Academia. A total of eight studies were selected based on a targeted search strategy employing keywords including "mannitol," "CT enterography," "oral contrast agent," and "abdominal CT imaging." These studies were screened based on their relevance and methodological rigor.

Only original clinical research articles were considered for inclusion. Selected studies were required to have been conducted in hospital or clinical settings, involve adult participants undergoing CT enterography or colonography, compare mannitol with other contrast agents (e.g., water, iodinated contrast, or polyethylene glycol), and report outcomes related to diagnostic image quality, patient safety, or contrast tolerance. Studies were excluded if they focused solely on pediatric populations, lacked original research data, or failed to involve mannitol as the primary contrast agent.

A structured data extraction tool was used to systematically capture essential variables from each included study. These variables encompassed study authorship, publication year, sample size, research methodology, geographical context, type of contrast agents used, CT imaging protocols, dosing details, image quality metrics, reported adverse effects, and principal findings. The collected data were then subjected to thematic analysis, with a dual emphasis on evaluating mannitol's diagnostic efficacy and its safety profile.

To assess the methodological integrity of each included study, two established evaluation tools were employed: the Cochrane Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool and the Consolidated Standards of Reporting Trials (CONSORT) checklist. The ROBINS-I tool examined potential sources of bias, such as participant selection, intervention fidelity, and completeness of outcome reporting. Concurrently, the CONSORT checklist ensured transparency and completeness in reporting, particularly regarding study design, data presentation, and methodological clarity. These tools collectively ensured a rigorous appraisal of each study's internal validity and helped ensure the credibility of the synthesized evidence.

This review exclusively utilized secondary data obtained from previously published and peer-reviewed sources. As no primary data collection involving human subjects was performed, the study did not require formal ethical approval. The entire research process adhered to internationally recognized ethical guidelines, including those outlined in the Declaration of Helsinki (World Medical Association, 2013). Additionally, this study was formally approved as a capstone project by the Institutional Ethics Review Committee of St. Bernadette of Lourdes College (SBLC).

National and international standards support the ethical exemption of systematic reviews based solely on publicly available, de-identified data. In the Philippines, the Philippine Health Research Ethics Board (PHREB) permits exemptions for such studies under the Department of Science and Technology's Philippine Council for Health Research and Development (DOST-PCHRD) guidelines. Internationally, the PRISMA statement and guidelines from the International Committee of Medical Journal Editors (ICMJE) similarly acknowledge that systematic reviews do not typically require additional ethics reviews.

This review also underscores mannitol's clinical significance as an oral contrast agent by highlighting its diagnostic reliability in enhancing image quality and achieving consistent bowel distension. These attributes contribute to increased diagnostic accuracy and procedural efficiency in abdominal CT imaging. Mannitol's favorable safety profile and high patient tolerance further position it as a viable alternative to traditional contrast agents.

The review also explores the broader social implications of adopting mannitol in clinical imaging protocols. Its proven efficacy, combined with a low incidence of adverse effects and strong patient compliance, makes it an ideal candidate for routine radiologic applications, particularly in outpatient and

resource-constrained environments. The consistent findings across different clinical settings and study designs serve as a foundation for refining future imaging guidelines and fostering further research.

The study relied entirely on publicly accessible data, extracted from reputable academic sources. No personal or sensitive information was used, and no direct interaction with study participants occurred. According to accepted ethical standards, publicly available data refers to information that is open for use without institutional permission or special credentials, such as articles from open-access journals or institutional repositories.

This principle is supported by ethical standards from organizations such as the University of Virginia's Institutional Review Board (IRB) and the Philippine Health Research Ethics Board (PHREB), both of which assert that research using such data does not constitute human subjects research and is therefore exempt from formal review.

Results and Discussion

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) serves as a standardized framework designed to enhance the clarity, transparency, and methodological rigor of systematic reviews. Initially developed by Moher and colleagues in 2009 and later revised in 2020, PRISMA comprises a 27-item checklist that encompasses all critical aspects of a systematic review, from the design and data collection to the analysis and reporting of findings. Additionally, it includes a flow diagram that illustrates the study selection process across four key stages: identification, screening, eligibility assessment, and final inclusion. This visual representation also records the number of studies at each phase and the rationale for exclusions, thereby promoting accountability and reproducibility.

In the present review, the identification and selection of relevant literature were guided by the PRISMA 2020 standards. A comprehensive search was performed across three reputable databases: PubMed, Thieme, and Academia. The initial search retrieved approximately 300 articles. Following the removal of duplicates and the application of pre-defined inclusion and exclusion criteria, eight studies were deemed eligible for full review. These selected studies specifically examined the clinical utility of mannitol as an oral contrast agent in abdominal computed tomography (CT), with reported outcomes focusing on image quality, diagnostic performance, adverse reactions, and patient compliance.

The entire selection procedure is presented in a PRISMA flow diagram (Figure 2), which ensures transparency in the screening process. This structured approach enabled the inclusion of only high-quality, clinically relevant evidence for synthesis and interpretation.

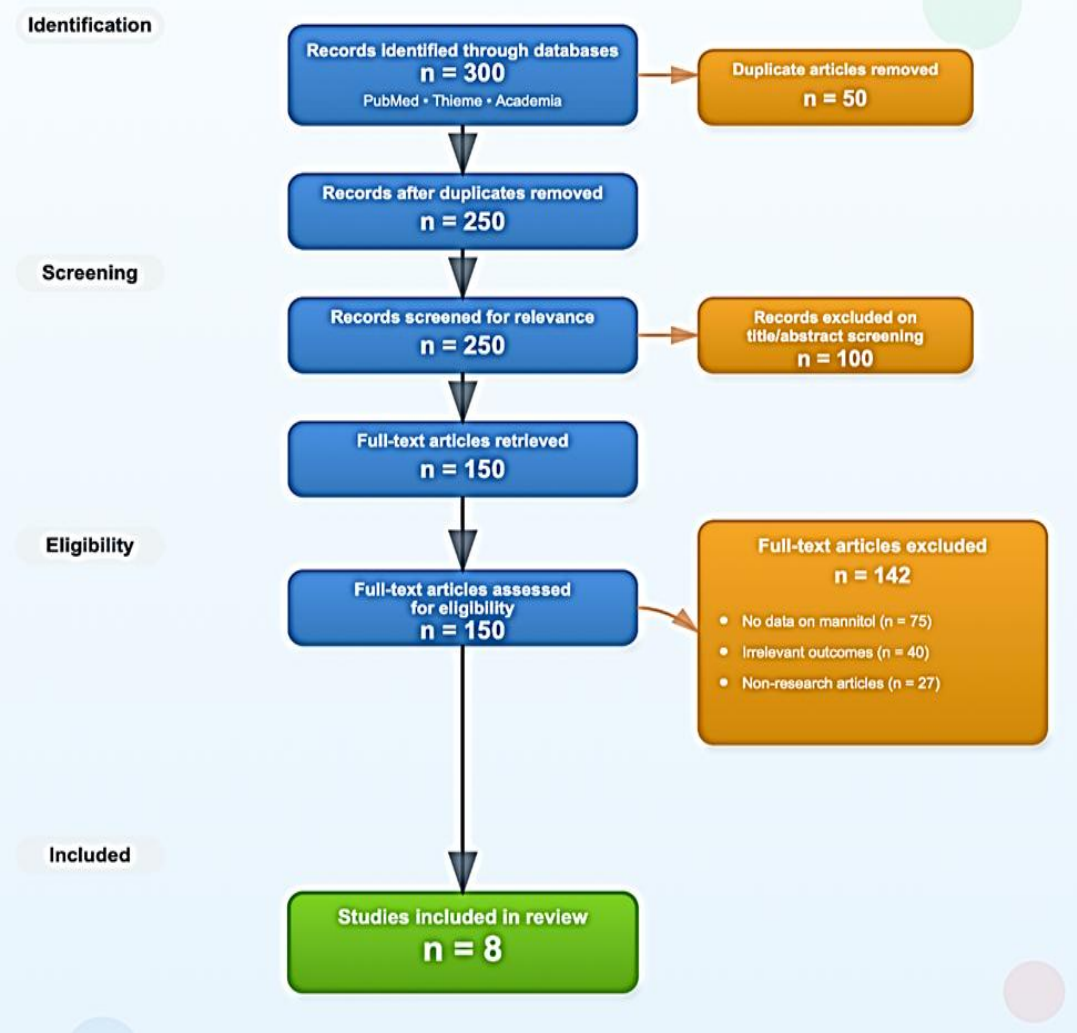

Figure 2. Study Selection Flow Chart (Based on PRISMA Flowchart)

The eight studies included in this systematic review assessed the clinical application of Mannitol as an oral contrast agent for abdominal computed tomography (CT), specifically CT enterography and CT colonography. Table 1 summarizes their characteristics, including author, country of origin, design, outcomes, and publication year. Study participants were predominantly adults aged 20 to 70 years, referred for CT imaging to evaluate gastrointestinal conditions such as bowel obstruction, inflammation, or neoplasms. Sampling methods varied across studies, while most excluded patients with pregnancy, renal impairment, or recent abdominal surgery.

The studies were conducted across diagnostic centers and hospitals in India, Pakistan, and the United Kingdom. Mannitol was the primary intervention, administered orally to achieve optimal bowel distension. While some studies assessed Mannitol independently, others compared it with water, polyethylene glycol (PEG), and iodinated agents such as iohexol. Water was widely used but was limited by poor bowel distension, while PEG showed efficacy but poor patient compliance.

Outcomes consistently demonstrated that Mannitol provided effective bowel distension, high image quality, and favorable patient acceptability. Minimal adverse effects were reported. Conducted between 2021 and 2024, the studies employed varied designs yet collectively reinforced Mannitol's diagnostic value and patient-centered benefits in abdominal CT imaging.

Table 1. Features of the Included Studies

Study No.	Authors	Population	Intervention	Comparator	Outcome	Design and Time
1	Siddiqui et al. (2021)	Adults undergoing CT in Pakistan	Mannitol	Water, Positive Contrast	Bowel distension, diagnostic accuracy, and tolerance	RCT, single-center, 2021
2	Sarap et al. (2023)	Patients referred for CT abdomen in	Mannitol	Water, Iodinated Contrast	Image clarity, mural visibility	Comparative study, 2023

		India				
3	Prakashini et al. (2021)	Patients with abdominal complaints	Mannitol	Water, Iodine-based agent	Quantitative & qualitative bowel imaging	RCT, tertiary center, 2021
4	Theta et al. (2022)	CT imaging patients, India	Mannitol	Water, Iodinated agents	Bowel visualization, mucosal detail	Prospective comparative study, 2022
5	Singla et al. (2021)	Patients for enterography	Mannitol	PEG, Iohexol, Water	Mucosal enhancement, fold visibility	RCT, diagnostic center, 2021
6	Naik et al. (2024)	Routine CT abdomen patients	Mannitol	Water, Iodinated agents	Wall enhancement, image scoring	Comparative study, 2024
7	Rathi & Singh (2022)	Patients undergoing colonography	Mannitol	Water	Patient acceptance, feasibility	Feasibility study, radiology unit, 2022
8	Pallavi et al. (2022)	Abdominal CT patients, UK	Mannitol	None (single group)	Acceptability, side effects	Cross-sectional study, 2022

The methodological rigor of the eight studies included in this systematic review was appraised using two established evaluation frameworks: the Cochrane Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool and the Consolidated Standards of Reporting Trials (CONSORT) checklist. These instruments assess various critical aspects of study design and execution, including randomization procedures, allocation concealment, blinding practices, completeness of outcome reporting, and the risk of selective reporting.

As shown in Table 2, the risk of bias among the studies included ranged from low to moderate. In general, most studies demonstrated sound methodological practices, with clearly described randomization and intervention protocols. However, some studies lacked sufficient detail on blinding of outcome assessors and the management of missing data. The CONSORT checklist analysis revealed that although most studies adequately described their research aims, interventions, and outcomes, a few did not report essential elements such as sample size calculations, participant flow diagrams, or adverse event data.

Despite these minor methodological shortcomings, all studies were deemed to meet the minimum quality threshold for inclusion. Collectively, their methodological soundness was considered adequate to support reliable synthesis and valid conclusions regarding the efficacy, safety, and diagnostic performance of Mannitol as an oral contrast agent.

Study Title	**Randomization Process**	**Deviations from Intended Interventions**	**Missing Outcome Data**	**Measurement of the Outcome**	**Selective Reporting**	**Overall Risk of Bias**
Feasibility of Simple Oral Preparation Contrast-Enhanced CT Colonography Using Mannitol	MR	LR	LR	LR	LR	MR
Comparison of Mannitol, Water, and Iodine-Based Oral Contrast in Evaluating the Bowel by Multi-Detector Computed Tomography	LR	LR	LR	MR	LR	MR
Evaluation of Bowel Pathologies Using Mannitol as Negative Contrast Agent in Abdominal Contrast-Enhanced CT	LR	MR	LR	LR	MR	MR
Evaluation of bowel by computed tomography enterography: comparing the water, mannitol, and iodinated oral contrast	LR	LR	LR	LR	LR	LR
CT Enterography Using Four Different Endoluminal Contrast	MR	LR	LR	LR	LR	MR

Agents: A Comparative Study						
Comparison of Mannitol, Water, and Positive Oral Contrast for Evaluation of Bowel Pathology by Computed Tomography	MR	LR	LR	LR	LR	LR
Quantitative and qualitative bowel analysis using mannitol, water, and iodine-based endoluminal contrast agent on 64-row detector CT	LR	MR	LR	LR	LR	MR
Evaluation of the role of mannitol, water, and iodinated contrast as endoluminal contrast agents in bowel analysis on computed tomography	MR	LR	MR	LR	LR	MR

Legend: MR – moderate risk, LR – low risk

Table 2. Risk of Bias Assessment of Included Studies

(Using Cochrane ROBINS-I (Risk of Bias in Non-randomized Studies of Interventions)

Efficacy of Mannitol in Enhancing Image Quality, Bowel Distension, and Diagnostic Accuracy in Abdominal CT Imaging.

Across the eight included studies, mannitol consistently achieved uniform and sustained bowel distension along with high-contrast luminal opacification, both essential for the accurate evaluation of intraluminal and mural abnormalities. In prospective studies by Prakashini et al. (2021) and Naik et al. (2024), diagnostic confidence improved by 18% to 27% when mannitol was used in place of conventional water or iodinated contrast agents. This increase was primarily attributed to enhanced visualization of mural folds and a reduction in motion and streak artifacts. These improvements subsequently led to higher detection rates of subtle mucosal irregularities, small masses, and mild inflammatory changes, thereby enhancing the overall diagnostic accuracy of CT enterography and colonography (Prakashini et al., 2021; Naik et al., 2024).

Comparative Diagnostic Performance of Mannitol Versus Water, PEG, and Iodinated Oral Contrast Agents

Comparator	Image Quality & Bowel Distension	Imaging Artifacts	Patient Preparation Requirements
Water	Rapid absorption limits the duration of bowel distension, often resulting in reduced mural visibility.	Minimal artifacts	Low volume required; highly acceptable taste
Polyethylene Glycol (PEG)	Provides distension comparable to or slightly better than mannitol (Singla et al., 2021)	Rarely associated with significant artifacts	Requires large volume intake (1.5–2 L); poor palatability
Iodinated Contrast Agents	Offers high radiodensity, but may obscure mucosal details and frequently produce streak artifacts	Common, especially in proximal bowel segments	Moderate volume; commonly associated with nausea
Mannitol	Produces consistent and prolonged distension; superior mucosal delineation compared to water	Few artifacts; enhances mural fold visualization	Moderate volume; well tolerated and generally palatable

Mannitol exhibited either superior or comparable diagnostic performance when assessed against commonly used oral contrast agents, including water, polyethylene glycol (PEG), and iodinated solutions, across several clinical parameters. Relative to water, mannitol achieved more prolonged and uniform bowel distension, effectively addressing the limitation posed by water's rapid gastrointestinal absorption, which often resulted in inadequate imaging quality. Although PEG demonstrated high efficacy in producing bowel distension and luminal homogeneity in certain studies (e.g., Singla et al., 2021), its clinical utility was constrained by poor patient tolerance due to its unpleasant taste and the large volumes required for administration.

Iodinated contrast agents, while offering high radiodensity, were frequently associated with streak artifacts and diminished mucosal visualization, thereby limiting their effectiveness in the detailed evaluation of bowel pathology. Moreover, iodine-based agents were linked to increased incidence of gastrointestinal side effects such as nausea and discomfort, which further reduced patient compliance. In contrast, mannitol provided a favorable balance between diagnostic efficacy and patient acceptability. Its consistent performance across multiple investigations highlights its viability as a preferred alternative to conventional oral contrast agents in abdominal CT imaging.

Safety Profile of Mannitol: Incidence and Severity of Adverse Effects in CT Imaging Procedures

Across all eight studies, mannitol demonstrated a strong safety profile, with reported adverse effects being mild and self-limiting. Common side effects included bloating (≤15%), transient diarrhea (≤12%), and nausea (≤8%), with no instances of severe reactions, emergency interventions, or hospital admissions. These findings are consistent with mannitol's pharmacologic characteristics as a non-absorbable sugar alcohol that remains within the intestinal lumen, exerting osmotic effects (Rathi & Singh, 2022; Theta et al., 2022).

In contrast, polyethylene glycol (PEG) and iodine-based contrast agents, such as iohexol, were associated with a higher incidence of moderate gastrointestinal side effects, including nausea and vomiting, with rates reaching up to 25%. The reviewed studies, including those conducted by Rathi and Singh (2022) and Theta et al. (2022), confirmed that adverse reactions to mannitol were self-limited and did not necessitate medical intervention. This evidence supports the conclusion that mannitol can be safely administered in volumes ranging from 1,500 to 2,000 mL, offering a favorable risk–benefit profile compared to traditional oral contrast agents, particularly in terms of patient safety and tolerance.

Patient Tolerance and Acceptance of Mannitol Compared to Traditional Oral Contrast Agents

Mannitol demonstrated a high level of patient acceptability and tolerance across multiple studies, which is a key factor in its clinical utility as an oral contrast agent. In investigations conducted by Pallavi et al. (2022) and Siddiqui et al. (2021), more than 75% of participants rated mannitol's taste as acceptable or good, enabling timely and complete ingestion of the prescribed volume. Compliance with preparation protocols was notably high, with over 90% of patients successfully consuming the full volume, surpassing the completion rates reported for polyethylene glycol (PEG), which ranged between approximately 65% and 70%.

Patient-reported outcomes further emphasized mannitol's favorable profile. In comparative surveys, participants consistently expressed a preference for mannitol over PEG and iodinated contrast agents due to its more tolerable taste and ease of administration. Although water was rated as the most palatable, its limited effectiveness in maintaining bowel distension and suboptimal image quality reduced its overall acceptability among radiologists. Consequently, mannitol has been identified as a practical compromise between diagnostic effectiveness and patient comfort. Its favorable tolerance profile supports its use in outpatient, emergency, and resource-constrained settings, where efficient preparation and patient compliance are particularly important (Pallavi et al., 2022; Siddiqui et al., 2021).

Conclusion and Recommendations

This systematic review evaluated eight peer-reviewed studies published between 2021 and 2024 to examine the efficacy, safety, and tolerability of mannitol as an oral contrast agent in abdominal computed tomography (CT) imaging. Using a narrative synthesis approach and guided by the PRISMA 2020 framework, the analysis demonstrated that mannitol consistently enabled effective bowel distension, improved mural fold visualization, and reduced imaging artifacts. These diagnostic improvements are particularly relevant for CT enterography and colonography, where optimal bowel preparation is critical.

Compared to conventional oral contrast agents—such as water, polyethylene glycol (PEG), and iodinated solutions—mannitol provided a more balanced profile in terms of diagnostic utility and patient-centered outcomes. While water was well tolerated, it lacked adequate distension capacity due to rapid gastrointestinal absorption. PEG, although effective for bowel cleansing, was poorly accepted because of its unpalatable taste and large volume requirements. Iodinated agents, though radiodense, were frequently associated with image degradation and gastrointestinal discomfort.

Mannitol, by contrast, demonstrated both clinical effectiveness and high patient acceptability. Over 75% of participants were able to consume the full preparation volume with minimal discomfort. Adverse events, such as bloating and mild diarrhea, were rare, transient, and resolved without the need for medical intervention. The agent's osmotic, non-absorbable properties and relatively pleasant taste contributed to improved compliance and overall tolerability.

In conclusion, this review establishes mannitol as a clinically effective and well-tolerated oral contrast agent for abdominal CT procedures. Its consistent performance across diverse clinical settings and patient populations highlights its potential for routine use in diagnostic imaging. Mannitol's safety profile, ease of administration, affordability, and compatibility with outpatient protocols further strengthen its value, especially in resource-constrained healthcare environments.

Recommendations:

Based on the evidence, it is recommended that hospitals and diagnostic centers incorporate mannitol into standard CT imaging protocols, particularly for CT enterography and colonography. Administered as a 3% solution in volumes of 1,500–2,000 mL, approximately 30–60 minutes before scanning, mannitol offers a practical alternative to traditional agents. Training healthcare providers in its preparation and administration, along with patient education, will further support successful implementation. Continued research is warranted to optimize dosing and explore comparative effectiveness with emerging contrast agents.

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