A systematic review of water-soluble contrast use in videofluoroscopic examination of dysphagia

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ABSTRACT

Introduction: The Videofluoroscopic Swallow Study (VFSS) is a key diagnostic tool for evaluating swallowing function, providing dynamic visualization of bolus transit and swallowing mechanism. Traditionally, barium is used as the contrast medium due to its effectiveness in highlighting anatomical and functional aspects of swallowing. However, water-soluble contrast (WSC) agents, which differ in osmolarity, viscosity, and iodine atom-particle ratio, have emerged as alternatives and their optimal use in VFSS remains unclear. This systematic review investigates the utilization of WSC agents in VFSS.

Materials and Methods: This systematic review was conducted following the PRISMA 2020 guidelines, extensively analyzing WSC agents use in VFSS. Searches were conducted across PubMed, Scopus, and Google Scholar using keywords "Water-Soluble Contrast, Videofluoroscopic, High-Osmolar Water-Soluble Contrast, and/or Low-Osmolar Water-Soluble Contrast". A total of 574 papers were initially identified.

Results: Nine studies (2013–2021) investigated the use of WSC agents in VFSS. The studies varied in methodology and WSC agents used, with no standardized protocols identified. Findings indicated that low-osmolar WSCs may reduce the risk of complications, such as aspiration and pulmonary edema, compared to barium sulfate. WSC agents were utilized in high-risk populations, such as those with head and neck surgeries or neurological conditions.

Conclusion: WSC agents may serve as a viable alternative to barium sulfate in VFSS, particularly for high-risk patients. However, further research is needed to compare their diagnostic accuracy, patient outcomes, and safety profiles, as well as to establish standardized protocols for their use in dysphagia evaluation.

KEYWORDS:
Videofluoroscopic Swallow Study (VFSS), water-soluble contrast (WSC) agents, dysphagia, osmolarity, contrast media, systematic review.

INTRODUCTION

Dysphagia evaluation is a critical component of clinical practice for speech-language pathologists (SLPs), and it involves both instrumental and non-instrumental assessments to diagnose and manage swallowing disorders accurately. Non-instrumental assessments, such as questionnaires, water swallow tests, and clinical bedside examinations, provide valuable preliminary insights into swallowing difficulties.[1] Instrumental assessments, including Fiberoptic Endoscopic Evaluation of Swallowing (FEES) and Videofluoroscopic Swallow Study (VFSS), provide a detailed and objective examination of the swallowing process.[2] VFSS employs radiological imaging to assess swallowing mechanics.[3] By using VFSS to analyze anatomical landmarks from the oral cavity to the esophagus, SLPs can accurately diagnose swallowing dysfunction and develop appropriate rehabilitation strategies.[4]

Central to the VFSS procedure is using contrast agents to enhance visualization of the bolus within the upper digestive tract. The gold standard contrast is Barium Sulfate, which is odorless, white, and poorly soluble in water.[4] Barium Sulfate is preferred for its superior mucosal coating, high contrast, and attenuation properties, which facilitate the detection of subtle leaks.[5] However, the use of Barium Sulfate poses significant risks, including intestinal infarction in patients with gastrointestinal perforations and increased mortality rates in individuals with esophageal fistulas, particularly in pediatric populations.[6] In contrast, water-soluble contrast (WSC) agents offer an alternative with varying osmolarity levels. WSCs are categorized into four types: ionic monomeric, nonionic monomeric, ionic dimeric, and nonionic dimeric.[7] The distinguishing features of these agents include osmolality, viscosity, and the iodine atom-to-particle ratio. Osmolality refers to the concentration of solute particles in the contrast medium, while viscosity describes the fluid's density and internal resistance to motion. For example, Gastrografin, a high-osmolar contrast, has an iodine concentration of 367 mg/mL and is administered in doses of 30-100 mL, whereas Omnipaque 350 (Iohexol) contains 350 mg/mL iodine and is given in doses of 50-150 mL.[8] High-osmolar contrasts like Gastrografin may cause pulmonary edema due to fluid shifts into the lungs upon aspiration.[9] In contrast, low-osmolar WSCs such as ioxaglate sodium have not been associated with pulmonary edema (9).

Guidelines from professional bodies, such as the Royal College of Speech and Language Therapists (RCSLT) in the United Kingdom, recommend the use of WSCs for initial testing in patients suspected of being at high risk of

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aspiration.[10] Similarly, the Western Australia Country Health Services advocates for the use of WSCs in patients with a risk of gastrointestinal perforation.[11] These recommendations underscore the importance of selecting the appropriate contrast agent, particularly for high-risk populations, to enhance patient safety and diagnostic accuracy. This systematic review aims to synthesize research from the past decade on the use of high- and low-osmolar WSCs in VFSS, highlighting their potential benefits and risks in dysphagia evaluation.

MATERIALS AND METHODS

Search strategy

PubMed, Scopus, and Google Scholar databases were searched to retrieve articles published between 2013 and 2023. The search strategy involved using a combination of key terms and their variations. The key terms included WSCs (WSC), Video-Fluoroscopy (VFSS), High-Osmolar Water-Soluble Contrast (HOWSC), and Low-Osmolar Water-Soluble Contrast (LOWSC). This approach guaranteed a thorough exploration of the relevant literature on using WSC agents in VFSS evaluations.

Eligibility criteria

The inclusion criteria for eligible studies included articles, books, clinical trials, randomized controlled trials, and systematic reviews. Exclusion criteria encompassed studies not published in English, those using WSCs for purposes other than VFSS, and studies that did not specifically utilize WSC agents.

Selection process

This systematic review followed the PRISMA 2020 Flow Chart (Figure 1) to ensure a structured and transparent process for documenting study selection, including identification, screening, eligibility assessment, and inclusion.

Data extraction and analysis

The first author independently screened the titles and abstracts according to the specified criteria. Full-text evaluations were then performed on the studies deemed eligible from this initial review. Following a comprehensive assessment of these full texts, the reviewer selected the studies for inclusion. Relevant data, including author(s), publication year, country of origin, methodology, and key socioeconomic factors, were extracted and thematically analyzed. All authors reviewed and double-checked the papers included in the final systematic review.

RESULTS

This systematic review analyzed nine studies assessing the efficacy and utility of WSC agents in evaluating and managing dysphagia across various patient populations and clinical contexts. The characteristics of the included studies are summarized in Table I. The study designs included three retrospective studies, two prospective cohort studies, two cross-sectional descriptive studies, one literature review, and one double-masked randomized controlled trial. The research spanned from 2013 to 2021 and encompassed diverse geographical locations, including the United States, Finland, Spain, India, Hong Kong, and Korea.

Detection of Aspiration and Leakage

Several studies have demonstrated the effectiveness of WSC agents in detecting aspiration and leakage during VFSS. Iohexol, a low-osmolar WSC, was shown to detect aspiration in 22% of examinations and was particularly effective in detecting extraluminal leakage in 58% of cases when used alone.[12] The study further emphasized that Iohexol had no adverse effects, making it a safer option compared to barium sulfate, especially in patients at risk of aspiration. In addition, Gastrografin, another WSC, was used to detect pharyngeal leaks post-laryngectomy.[13] The study found that small volumes of Gastrografin were effective in detecting leaks in 46% of cases, which helped prevent the development of pharyngocutaneous fistulas and aided in conservative management without the need for surgical intervention.

Risk of Pulmonary Complications

The safety profile of WSC agents, particularly in pediatric and high-risk populations, was consistently highlighted across studies. In pediatric patients, Iohexol demonstrated greater sensitivity than barium in detecting aspirations without increasing the risk of pulmonary complications such as pulmonary edema or aspiration pneumonia.[14] Additionally, no allergic reactions or chemotoxicity were reported following WSC use, nor was there any prolongation of discharge intervals, suggesting that WSC is a safer alternative for vulnerable populations.[14]

Impact on Dysphagia Management

The use of WSC in VFSS poses significant implications for dysphagia management particularly in complex clinical populations. In pediatric patients with neurological impairments, Visipaque enabled more accurate identification of swallowing difficulties, which led to the implementation of individualized treatment strategies.[15] The study reported that 70% of the children had dysphagia, with 58% being moderate to severe cases, underscoring the importance of accurate and safe contrast agents in the management of dysphagia in complex cases. Supporting these findings, a broader review highlighted the adaptability of WSC agents across various clinical scenarios, reinforcing their role in comprehensive dysphagia evaluation.[18] Furthermore, in a clinical protocol involving subacute stroke patients, respiratory muscle training was associated with reduced aspiration risk. In that setting, Visipaque was incorporated into the diagnostic process, contributing to improved management outcomes.[16]

Special Considerations in Post-Surgical and Neurological Patients

In patients with specific conditions, such as post-surgical or neurological impairments, selecting the appropriate contrast agent is crucial. Risk factors for aspiration and penetration were identified in individuals with acute traumatic cervical spinal cord injuries using Omnipaque, a WSC agent, emphasizing the value of WSC for evaluating severity in patients with higher PAS scores and facilitating early intervention.[17] Comparisons of diagnostic tools in patients with motor neuron disease revealed that while screening questionnaires like the EAT-10 offer initial assessment, VFSS with WSC remains essential for accurate diagnosis and management.[18] Additionally, in patients with chronic aspiration following radiotherapy for head and neck cancer

Table I: Summary of the articles reviewed

Title	Study details	Research Objectives	Population	Methodology
The Use of Low-Osmolar Water-Soluble Contrast In Video-fluoroscopic Swallowing Exams	Authors: Julie A. Harris et al. Year: 2013 Country: USA Design: Prospective cross-sectional study.	1) To document usage of non-ionic water-soluble contrast, mainly Iohexol and barium contrasts, in adults who underwent fluoroscopic examination. 2) To provide the clinical use indication of using both contrasts.	Adult patients undergoing fluoroscopic exams of the pharynx and esophagus Experimental Group: Iohexol: 36 patients Iohexol and Barium: 197patients Control group: Barium: 206 patients (Total: 1978 VFSS)	Four experienced gastrointestinal radiologists and 12 SLP's rated the fluoroscopic exams. VFSS analyses were based on leakage detection and leakage percentage for each type of contrast used.

Outcomes:

Aspiration occurred in 22% of exams. Vestibular penetration occurred in 38% of exams. Extraluminal leakage of contrast was observed in 4.6% of exams. In aspiration cases, iohexol was used alone (8%), iohexol and barium were used together (45%), and barium was used alone (47%). In extraluminal leakage cases: iohexol alone (58%), iohexol and barium (31%), and barium alone (11%).
No adverse effects were observed with iohexol use. Small amounts of aspirated barium and extraluminal barium were noted.

Review:

Iohexol is effective and safe as a screening contrast agent. It reduces the risk of large-scale aspiration and leakage of barium. Barium remains useful but can lead to complications in some cases; thus, iohexol may be preferred to mitigate risks.

Title	Study details	Research Objectives	Population	Methodology
Risk factors for laryngeal penetration-aspiration in patients with acute traumatic cervical spinal cord injury (TCSCI).	Authors: Tiina Ihalainen et al. Year: 2017 Country: Finland Design: A prospective cohort study.	1) To inspect the risk factors of patients with acute traumatic cervical spinal cord injury for aspiration-penetration	37 adult patients with acute traumatic cervical spinal cord injury (TCSCI) (mean age: 61.2 years).	Ominpaque 350mgl/ml. Three different volumes: 5ml,10ml,20 ml. A clinical swallowing trial and VFSS were performed within 28 days post-injury. Patients were divided into two groups based on the Rosenbek Penetration-Aspiration Scale (PAS) score (range 1-8) of each patient. Group 1-penetrator/aspirators (PAS score ≥3) and Group 2-non-penetrator/aspirators 15 (PAS score ≤2).

Outcomes:

VFSS results show that 51.4% of the patients scored higher than three on the aspiration penetration scale, while 48.6% scored two or less. Seventy-four percent had silent aspiration.
There was a statistical difference in the need for bronchoscopy between the two groups who aspirated or penetrated liquids. In addition, the group that showed aspiration and penetration had a higher number of vertebral fractures and cervical spine fractures.

Review:

The identified risk factors associated with penetration-aspiration in TCSCI patients were coughing, throat clearing, choking, and changes in voice quality; those risk factors should be considered for further evaluation of suspected pharyngeal dysfunction to avoid further complications. VFSS using WSC is a valuable complement in managing swallowing issues for these patients.

Evaluation of dysphagia. Results after one year of incorporating Video-Fluoroscopy into its study	Authors: Ruth García Romero et al. Year: 2018 Country: Spain study design: cross-sectional descriptive study	1) To analyze Video-Fluoroscopy results after prescribing an individualized treatment plan for patients after one year in the center	61 children with neurological disabilities	Visipaque with three different consistencies (thin and thick liquids and pudding) and three different volumes, 3ml, 5ml, and 10 ml, was used in VFSS. Additional variables that were measured include age, pathology, degree of neurological damage, type and severity of dysphagia (oral, pharyngeal, oesophageal), aspirations, prescribed treatments, and improvements in nutrition and respiration.

Table I: Summary of the articles reviewed

				Outcomes: 70% of the children's dysphagia was detected, and 58% of it was moderate to severe. Aspirations and/or penetrations were recorded in 59% of cases, of which 50% were silent. Nutritional and respiratory improvements were noted in patients after VFSS. Dysphagia was also effectively managed. **Review:** VFSS using WSC implementation led to high diagnostic accuracy and effective treatment for patients. The findings support the inclusion of VFSS in pediatric diagnostic protocols to improve patient outcomes in terms of nutrition and respiratory health.
ACR Appropriateness Criteria Dysphagia	Authors: Levy et al. Year: 2019 Country: USA study design: A literature review study	1) To extensively review the current medical literature from peer-reviewed journals and evidence-based methodologies used to create an appropriate procedure for imaging and treatment of specific cases of swallowing disorders.	Patients with symptoms of dysphagia.	The guideline was developed by a multidisciplinary team of experts using a thorough review of literature from peer-reviewed journals, the RAND/UCLA Appropriateness Method, and the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) to assess the suitability of imaging and treatment procedures for specific clinical situations.
				Outcomes: An evidence-based guideline - The American College of Radiology Appropriateness Criteria for Dysphagia. **Review:** Modified barium evaluation is the golden standard for assessing patients with swallowing disorders. However, in some special considerations, where swallowing needs to be assisted immediately post-operation for patients who underwent head and neck surgery, Diatrizoate meglumine and diatrizoate sodium solution, or Iohexol WSC, is preferable, especially if a leak is suspected due to a fistula.
Title	**Study details**	**Research Objectives**	**Population**	**Methodology**
Tubed Supraglottic Laryngeal Closure to Treat Chronic Aspiration After Radiotherapy for Head and Neck Cancer	Authors: Peter K. M. Ku et al. Year: 2020 Country: Hong Kong study design: A retrospective study	1) To investigate the long-term effect of surgical treatment on patients who suffer from chronic aspirationdue to radiotherapy on the head and neck	17 adult patients. - 15 with tubed supraglottic closure (TSLC) - 2 with total laryngectomy	Patients who had radiotherapy for head and neck cancer and subsequently required laryngectomy or TSLC for chronic aspiration pneumonia. Swallowing function assessed using the Functional Oral Intake Scale (FOIS) and the Swallowing Performance and Status Scale (SPSS). The type of WSC was unspecified.
				Outcomes: There was significant improvement on both swallowing scales after total laryngectomy or tubed supraglottic closure at 12, 24, and 36 months. However, the two patients with total laryngectomy continue to suffer from recurrent episodes of aspiration pneumonia after surgery. **Review:** The study provides evidence supporting TSLC as a preferable option over laryngectomy for managing chronic aspiration in patients with a history of radiotherapy for head and neck cancer. The type of WSC agent in VFSS was not specified.
Efficacy of small-volume gastrografin Video-fluoroscopic screening for detecting pharyngeal leaks following total laryngectomy	Authors: M Narayan et al. Year: 2020 Country: India Study design: A retrospective case-control study	1) To investigate the ability to use gastrografin contrast in detecting pharyngeal leaks after total laryngectomy	137 adult patients under 60 years of age Experimental Group (n = 52): - 48 males and four females Control group (n= 85): - 80 males and five females	3–5ml gastrografin water-soluble. The control group was assessed clinically for development of pharyngocutaneous fistulae, while the experimental group underwent small-volume (3-5 ml) post-operative gastrografin VFSS.

Table I: Summary of the articles reviewed

		Outcomes: Pharyngeal leak was detected in 46% of the study group and 4 had pharyngocutaneous fistulae development after laryngectomy compared to 28% of patients in the control group with 6 requiring surgical correction. **Review:** The use of small volumes of gastrografin during VFSS facilitates the detection of even minor pharyngeal leaks, thereby reducing the risk of developing a pharyngocutaneous fistula and preventing wound dehiscence.		
Evaluation of Dysphagia in Motor Neuron Disease. Review of Available Diagnostic Tools and New Perspectives	Authors: Elisabet Romero Gangonells et al. Year: 2020 Country: Spain Study design: A transversal, unicentric observational study	1) To investigate the sensitivity and Specificity of the EAT-10 and SwalQoL questionnaires and the ALS-SS and FOIS scales compared to the gold standard technique, VFSS.	45 adult patients with motor neuron disease.	Nectar, thin liquid, and pudding consistencies in 5ml, 10 ml, and 20ml volumes, mixed with an unspecified type of WSC in VFSS. Results were compared to Eating Assessment Tool (EAT-10), and SwalQoL questionnaires, as well as the ALS-SS and FOIS scales.
		Outcomes: Of the 45 patients, 37 patients were diagnosed with dysphagia while 8 had no dysphagia based on VFSS and Dysphagia Outcome and Severity Scale. Only 28 patients were diagnosed with dysphagia based on the ALS-SS and EAT-10 questionnaires and 12 patients based on the FOIS scale. **Review:** None of the evaluated questionnaires demonstrated superior sensitivity, but the SwalQoL revised FS stood out for its perfect specificity. With modifications to its symptom frequency section, the SwalQoL revised FS may be a valuable tool for clinically assessing dysphagia, particularly in accurately identifying patients without the condition. The ALS-SS exhibited the highest validity as a severity scale for dysphagia. The type of WSC agent in VFSS was not specified.		
Swallowing study using water-soluble contrast agents may increase aspiration sensitivity and antedate oral feeding without respiratory and drug complications: A STROBE-compliant prospective, observational, case-control trial.	Authors: Chang Ho Hwang Year: 2020 Country: Korea Study design: prospective, observational, case-control cohort trial	1) The objective of this study was to evaluate the feasibility of a Water-soluble Contrast Application into Dysphagia Evaluation	All patients >3 years old who were referred to for swallowing study from September 2015 to November 2017 at a tertiary medical center/university teaching hospital were recruited. In total, 755 evaluations were analyzed, 365 of which were by WSS and 390 by MBSS.	Clinical trial: High-risk patients were evaluated by WSCA (iohexol)-based swallowing study (WSS) and others by MBSS. The specific dose is as follows: Iohexol 350 (Omnipaque [osmolarity 541 mOsm/L, viscosity 10.4 centipoise at 37°C, specific gravity of 1.406], Barium sulfate (BaSO4 40% [osmolarity 233 mOsm/L, viscosity 2.3 centipoise at 25°C]
		Outcomes: The most common underlying condition was brain lesion, followed by aspiration pneumonia. Aspiration was more frequent in WSS (40.3%) compared to MBSS (9.2%). However, no significant differences were found between the groups in aspiration volume, radiographic alterations, or the correlation between iohexol intake and radiologic changes ($p > .05$). Patients who underwent WSS more frequently transitioned to oral feeding (44.9%), with no increase in aspiration pneumonia. WSS did not delay discharge or cause allergic reactions or chemotoxicity within one week. **Review:** This study supports the use of WSC compared with MBSS because there were no aspiration-induced complications or adverse drug effects, along with increased sensitivity in detecting aspiration and facilitating an earlier transition to oral feeding.		

Table I: Summary of the articles reviewed

The Retornus-2 study impact of respiratory muscle training in subacute stroke patients with dysphagia, study protocol of a double-blind randomized controlled trial	Authors: Guillen-Sola et al. Year: 2021 Country: Spain Study design: a double-masked randomized controlled trial	1) To evaluate the efficacy of an 8-week IEMT program on respiratory muscle strength and swallow dysfunction severity in patients who suffer ed from subacute stroke with dysphagia	Fifty stroke patients with oropharyngeal dysphagia.	Dysphagia severity was assessed using VFSS, FEES, the Penetration-Aspiration Scale, and the Bolus Residue Scale (BRS). 50 ml Visipaque Water-soluble contrast with a thickener (ThickenUp) in three different consistencies, liquid, nectar, and pudding, and three different volumes: 5-10- and 20 ml were used in VFSS. The strength of respiratory muscles was measured using PImax and PEmax. The voluntary peak cough flow (measured using a PEFR meter) and tongue strength (measured with the IOPI® system) were also measured. All data was collected at baseline, end-treatment, and 6-month follow-up.

Outcomes:

An improvement in respiratory muscle strength and might be associated with relevant benefits in dysphagia patterns. A reduction in aspiration events was confirmed by video-fluoroscopy or fiberoptic endoscopic evaluation of swallowing.

Review:

The results show a reduction in aspiration for those patients, which might be due to the effectiveness of the training program on muscles. However, the trial group's results or outcomes are not included yet.

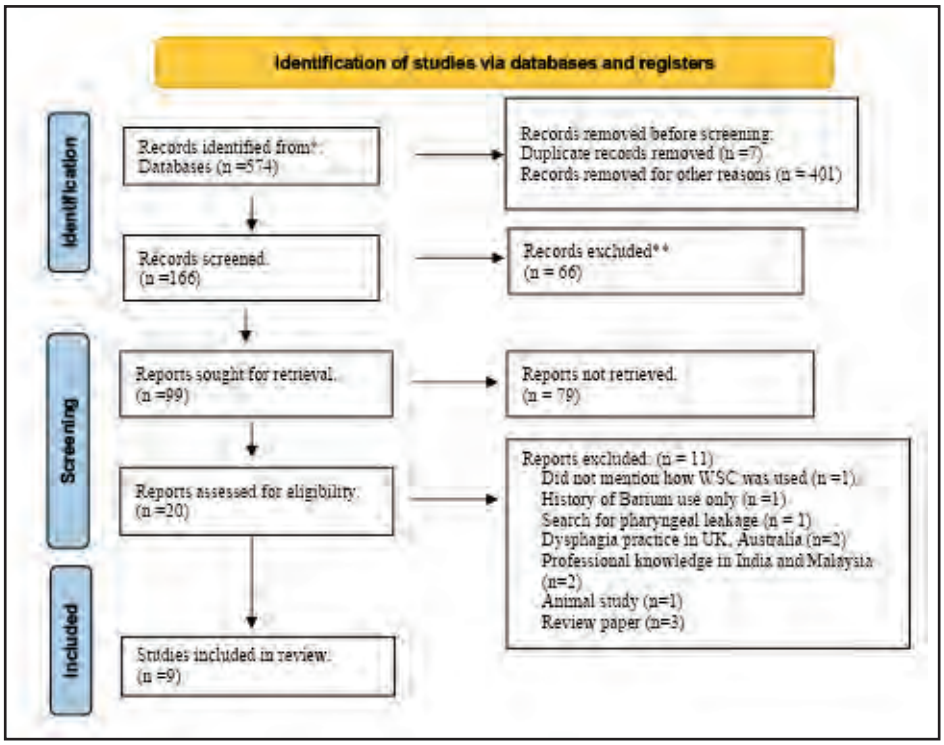

Fig. 1: Prisma flowchart diagram of the screening process

found that the use of WSC in VFSS combined with surgical approaches such as supraglottic closure significantly improved swallowing function, reduced aspiration pneumonia risk, and enhanced overall quality of life.[19]

DISCUSSION

This systematic review synthesizes findings from nine studies over the past decade, offering critical insights into the use of WSCs in VFSS. The discussion centers on the variability of WSC agents and their clinical applications and the implications for healthcare professionals, specifically radiologists and SLP's in the management of dysphagia.

Variability of WSC agents in VFSS

Due to their safety and diagnostic efficacy, WSC agents are increasingly used in VFSS. The primary agents discussed in the reviewed studies include Iohexol, Omnipaque, Visipaque, and Gastrografin. These agents are preferred due to their lower risk of aspiration and ease of use than barium, particularly in patients at risk for aspiration pneumonia. Iohexol was commonly used in VFSS to evaluate pharyngeal and esophageal function in a large patient population.[15] Omnipaque (350 mg/mL) was used in Finland to investigate laryngeal penetration-aspiration in patients with spinal cord injuries.[17] Although WSCs have proven effective in detecting aspiration, clear guidelines on the optimal concentration and volume remain undefined.[15] Variability in WSC application is evident, as seen in a study exploring its use in head and neck surgical patients and esophageal assessments, which highlighted the benefits of low-osmolar agents such as Iohexol.[20] Their findings, alongside updates from the American expert panel in 2019, underscored the potential benefits of WSC, deficient osmolar variants like Iohexol.[4] Visipaque was employed in both pediatric and adult populations however, the concentration was not specified, and there was a noted lack of comparative analysis with other contrasts in pediatric patients.[15] Gastrografin (3-5 mL) was used in India in the Amrita Institute's Department of Head and Neck due to its lower reactivity with tissues in cases of extravasation to detect pharyngeal leaks post-laryngectomy.[13] While effective, the study did not address potential long-term complications associated with its use. Geographical differences in WSC use further illustrate the inconsistency in practice. For example, in Australia, the Western Australia Country Health Service recommended undiluted Iohexol (350 mg I/mL) in 50–100 mL volumes for thin fluid trials, which was tested in post-radiotherapy patients without adverse effects.[11] Similarly, a Korean study involving 762 patients reported no cases of pulmonary edema or aspiration pneumonia linked to Iohexol use complications typically associated with agents like Gastrografin.[22] The lack of standardized recommendations for concentration and volume continues to pose challenges for clinical practice.

Comparison to Barium

While barium remains a standard contrast agent in VFSS, WSCs offer distinct advantages, particularly in patients at risk of aspiration. The usage of barium can cause significant complications if aspirated[21], in contrast to WSC agents like Iohexol and Gastrografin, which are absorbed more readily by the body, reducing the risk of severe complications.[22] However, the reviewed studies did not extensively compare WSC to barium in terms of diagnostic accuracy, patient outcomes, or safety profiles. This lack of direct comparison is a notable limitation; more studies are needed to reduce the ability to make informed decisions about the most appropriate contrast agent in different clinical scenarios.

Implications for dysphagia management

The implications of using WSCs in VFSS extend beyond diagnostics to the management of dysphagia. As highlighted by this review, the use of WSCs in pediatric patients with neurological disabilities allowed for a more accurate diagnosis of dysphagia, leading to more individualized and effective treatment plans.[15] This is a critical consideration for SLP's who rely on precise diagnostic information to develop interventions that address the specific needs of their patients. Additionally, long term application of WSCs in VFSS, when combined with surgical interventions, has been associated with improved swallowing function in individuals experiencing chronic aspiration after radiotherapy for head and neck cancer.[14] These findings highlight the potential for WSCs to not only improve immediate diagnostic outcomes but also contribute to better long-term management of dysphagia, ultimately enhancing the quality of life for patients.

Clinical Considerations and Recommendations

For healthcare professionals, particularly those in radiology and speech-language pathology, integrating WSCs into VFSS protocols presents both opportunities and challenges. The evidence supports using low-osmolar WSCs in specific patient populations, particularly those at high risk for aspiration or pulmonary complications. However, the choice of contrast agent should be guided by a thorough assessment of the patient's overall health, swallowing function, and specific risk factors. Given the benefits and safety profile of WSCs, it is recommended that clinicians consider these agents as part of a comprehensive VFSS approach, particularly in cases where barium sulfate may be contraindicated. Continued research is also necessary to further refine the use of WSCs in VFSS and to explore their application in broader patient populations.

LIMITATIONS

This systematic review focuses on the application of WSC agents in VFSS examinations. There are several notable limitations in this review that impact the generalizability and strength of its findings. First, the inclusion of only nine studies may not fully capture the breadth of available evidence, limiting the overall representativeness. The studies analyzed also varied significantly in design, patient populations, and methodologies, leading to challenges in synthesizing results and drawing definitive conclusions. Additionally, the lack of standardized outcome measures across studies introduced variability, complicating the comparison of efficacy and safety outcomes. Potential publication bias, where studies with positive outcomes are more likely to be published, further skews the review's conclusions. Most studies focused on immediate rather than long-term outcomes, leaving a gap in understanding the

chronic implications of WSC use. Geographical and population-specific limitations may restrict the applicability of findings across diverse clinical settings. Moreover, several studies lacked critical methodological controls such as blinding and randomization, which could introduce bias and affect the reliability of results. Inconsistent reporting of adverse effects also limits the ability to fully assess the safety profile of WSCs. These limitations underscore the need for more rigorous, standardized research to validate the role of WSCs in VFSS better and improve clinical practice.

RECOMMENDATIONS FOR FUTURE RESEARCH

Despite these advancements, a significant practice gap persists regarding the optimal concentration and volume of WSC. This gap underscores the need for standardized guidelines and protocols for using WSC in dysphagia assessments. Future research is essential to establish the most effective WSC concentrations for various food and liquid consistencies, thereby enhancing the efficacy and safety of dysphagia evaluations through VFSS.

CONCLUSION

This systematic review shows that research into using WSC agents in VFSS is still emerging, with limited scientific and experimental studies available. Nevertheless, the current review suggests that WSC agents offers a viable alternative to Barium Sulfate in VFSS, particularly for patients at high risk of aspiration or penetration. There remains a lack of standardized guidelines regarding the type, concentration, and volume of WSC for optimal use in dysphagia evaluation. Further research is needed to establish definitive protocols to optimize the use of WSC in dysphagia evaluation and ensure consistent, safe practices across different clinical settings.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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