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practices in speech-language pathology

USING THICKENED LIQUIDS TO IMPROVE
SWALLOWING PHYSIOLOGY IN INFANTS WITH
DYSPHAGIA: A REVIEW OF EXTERNAL EVIDENCE

CAITLIN A. CUMMINGS, MA, CCC-SLP
MELANIE STEVENS, MS, CCC-SLP
NANCY BATTERSON, OT/L, SCFES
KATHLEEN CIANCA, MHS, OTR/L
NATIONWIDE CHILDREN'S HOSPITAL

EBP Briefs

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Cite this document as:

Cummings, C. A., Stevens, M., Batterson, N., & Cianca, K. (2018).
Using thickened liquids to improve swallowing physiology in
infants with dysphagia: A review of external evidence. *EBP Briefs*,
12(5), 1–10. Bloomington, MN: NCS Pearson, Inc.

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Produced in the United States of America.

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Acknowledgments

The authors would like to acknowledge and thank all members of the interdisciplinary infant dysphagia clinical outcome group at Nationwide Children's Hospital who assisted with formation of the clinical question, literature search and review, final summary of the evidence, and hospital-wide education regarding results and recommendations.

Structured Abstract

Clinical Question: For infants with oropharyngeal dysphagia, does thickening liquids decrease laryngeal penetration and/or aspiration when compared to not thickening liquids and continuing with thin liquids alone?

Method: Literature Review

Study Sources: MEDLINE via Ovid, CINAHL, Google Scholar, ClinicalTrials.gov, and Scopus

Search Terms: The following terms were used individually and in several different combinations: infant, infant food, infant formula, infant nutrition disorders, deglutition, deglutition disorders, thickener, enterocolitis, necrotizing, thicken*, cereals, baby cereal, gastroesophageal reflux, rice cereal, thick it, simply thick, thicken up, xanthan gum, carob gum, swallowing, all infant (birth to 23 months), dysphagia, aspiration, videofluoroscopic study, videofluoroscopic swallow study, VSS, fiber optic endoscopic evaluation of swallowing, FEES, nutrition

Number of Studies Included: 10

Primary Results: There are a limited number of studies that examine the effect of thin vs. thickened liquids on swallowing physiology in infants. Thickened liquids have been associated with slower bolus pharyngeal transit timing and improved swallowing physiology when compared to thin liquids for certain groups. However, relevant studies present mixed results and include a range of medical diagnoses, sample sizes, research methodologies, dysphagia rating approaches, and clinical scenarios that make it difficult to generalize to larger populations.

Conclusions: There is limited and low-quality evidence to support the recommendation of thickened liquids as an intervention that consistently improves swallowing physiology in the infant population. More high-quality controlled studies with larger sample sizes are needed. Successful management of dysphagia in infants may require a variety of interventions that include changes to liquid consistency as well as other compensatory strategies.

Using Thickened Liquids to Improve Swallowing Physiology in Infants With Dysphagia: A Review of External Evidence

Caitlin A. Cummings, MA, CCC-SLP
Melanie Stevens, MS, CCC-SLP
Nancy Batterson, OT/L, SCFES
Kathleen Cianca, MHS, OTR/L
Nationwide Children's Hospital

Clinical Scenario

Molly is a speech-language pathologist (SLP) and works at a hospital evaluating and treating adults who have dysphagia, a disorder characterized by difficulties with the oral, pharyngeal, and/or esophageal phases of swallowing (ASHA, 2017a). She has extensive experience performing videofluoroscopic swallow studies (VFSSs) and evaluating, in consultation with a radiologist, whether patients exhibit laryngeal penetration and/or aspiration when swallowing liquids and solids. Thickening liquids is a common intervention that Molly recommends to facilitate safer and more efficient swallowing in adults (Steele et al., 2015) across a range of diagnoses including head and neck cancer and dementia (Alagiakrishnan, Bhanji, & Kurian, 2013; Barbon & Steele, 2015).

Recently, Molly started a new job at a children's hospital. At her new institution, SLPs and occupational therapists (OTs) work collaboratively with children who have feeding and swallowing disorders, and they perform VFSSs together. One of Molly's first patients is a 4-month-old female with a history of prematurity, wheezing, and vomiting. The patient's parents have noticed recently that she coughs sometimes during bottle feeds with thin formula, her eyes water, and she has had recurrent upper respiratory infections. The patient's physician recommended further evaluation of her swallowing via a VFSS. Molly and her colleague Samantha, an OT, are scheduled to perform the VFSS together, along with a radiologist. During the evaluation, Samantha places the patient in a semi-reclined position and offers her thin barium via her normal bottle and standard-flow nipple. Molly observes on the fluoroscopy monitor that after a few normal swallows, sometimes the barium enters the larynx and passes below the vocal folds. She records these observations as aspiration (passage of material below the level of the true vocal folds and into the trachea; Arvedson, 2008). Sometimes the patient coughs

and the liquid is cleared from the larynx, but in 3 out of 10 swallows, silent aspiration is observed as well. The infant does not cough, choke, or demonstrate any other overt reaction to this event (Arvedson, 2008). Molly and Samantha change the barium to nectar-thick and observe no laryngeal penetration or aspiration when they watch an additional 20 swallows.

Based on these observations, Molly initially wants to recommend changing the formula viscosity to nectar-thick. At her institution, the standard mixing equation for this thickness is 1.5 teaspoons of pulverized infant rice cereal for every ounce of liquid. The mother, however, is nervous about mixing the formula and wants to know why it is necessary if her daughter only aspirates a "little every now and then." Molly realizes that she is not as familiar with the evidence base behind this intervention when it involves the infant population. Following department protocol, Molly recommends that since there was no evidence of oral or pharyngeal dysphagia with thicker formula, the parents should discuss with their pediatrician Molly's instructions to give their daughter only formula thickened to nectar-thick for now. Molly also schedules the patient for an outpatient feeding evaluation follow-up appointment with her in 1 month and advises the mother to call her if concerns arise before that time. Molly explains that in 1 month they can reassess how well the patient is swallowing nectar-thick liquids and decide if there are any next steps in the treatment plan.

After this VFSS, Molly and Samantha decide that thickening liquids for infants with dysphagia would make a good topic for an interdisciplinary clinical outcome group (COG) involving various professionals across the hospital who work with this population and their families. Learning and coming to a consensus as an interdisciplinary group was designated as an important professional goal because "children [with feeding and swallowing disorders]

and families are better served by an interdisciplinary team than by a single discipline in isolation” (Arvedson, 2008, p. 118). A group of interested colleagues consisting of six SLPs, five OTs, one developmental pediatrician, and one dietician was formed. The goal of the group was to compile and review external evidence for the use of thickened liquids as an intervention to improve swallowing safety in infants with dysphagia.

Clinical Question

Molly first went to the American Speech-Language-Hearing Association (ASHA) website to review its evidence-based practice (EBP) resources. ASHA recommends writing the clinical question within the PICO framework (population, intervention, comparison, outcome) as the first step in the EBP process to help guide a literature search (ASHA, 2017b; Bothe, 2010; Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000; Straus, Richardson, Glasziou, & Haynes, 2005). Molly explained the PICO structure to her COG. In an effort to perform a literature review that was as targeted and organized as possible, the group decided to narrow the age range to 0–12 months. Based on the PICO model, the COG finalized its clinical question as the following: for infants ages 0–12 months with oropharyngeal dysphagia (P), does thickening liquids (I) lead to decreases in laryngeal penetration and/or aspiration risk (O) when compared to not thickening liquids and continuing with thin liquids alone (C)?

Search for the Evidence

Molly and Samantha met with their hospital’s research librarian to develop a search plan. The following electronic databases were used to find appropriate research articles that addressed their clinical question: MEDLINE via Ovid, CINAHL, Google Scholar, ClinicalTrials.gov, and Scopus. In order to try to capture all relevant literature, the following search terms were used individually and in a variety of combinations in the database searches: infant, infant food, infant formula, infant nutrition disorders, deglutition, deglutition disorders, thickener, enterocolitis, necrotizing, thicken*, cereals, baby cereal, gastroesophageal reflux, rice cereal, thick it, simply thick, thicken up, xanthan gum, carob gum, swallowing, all infant (birth to 23 months), dysphagia, aspiration, videofluoroscopic study, videofluoroscopic swallow study,

VSS, fiber optic endoscopic evaluation of swallowing, FEES, and nutrition. All articles had to be written in English, published after 2000, treatment studies, and peer-reviewed articles. Additional parameters were set for the targeted age depending on what categories each database offered (e.g., 0–12 months, birth to 23 months, child).

Searching databases was completed over four distinct rounds. MEDLINE was searched first; CINAHL, Google Scholar, and ClinicalTrials.gov were searched second; Scopus was searched third; a repeat search of Google Scholar was completed last. This repeat search was conducted after the reference librarian educated COG members on the “related article” search feature available on the Google Scholar database. After each search round, articles were divided equally amongst the 13 COG members with instructions to skim titles and abstracts and to record whether each article appeared to address the PICO question and inclusion criteria (see Table 1). Depending on the search round, each COG member skimmed anywhere from 5 to 20 titles/abstracts at one time.

Searching five databases resulted in an initial yield of 1,173 articles. The first review excluded 1,037 articles that clearly were not relevant to the PICO question (i.e., they did not address infants, thickening, or dysphagia; they were published outside of the year range; and/or they were not treatment studies). The remaining 136 articles were given a “maybe” rating. Molly reviewed this list of articles and removed 19 duplicates. The remaining 117 articles were divided equally amongst COG member pairs who read the full texts to determine if they met inclusion criteria. Group members were paired so that each article was read by two people from different disciplines; any disagreement regarding adherence to inclusion criteria was discussed in full group meetings and a decision to include or exclude an article was made based on group consensus. The group initially rejected 100 articles and selected 17 articles for critical appraisal. If an article was designated for critical appraisal, the COG members that had initially read it were required to outline the participants, design, procedures, and outcomes of the study in a literature review matrix housed within an online shared drive at their hospital. Once the group met again and gave detailed reports of each article, 6 articles were deemed not to be treatment studies and 1 was found to not include thickening liquids in its procedures. These 7 articles were excluded, leaving 10 articles that adhered to the PICO question and were included in the final analysis (see Figure 1).

Evaluating the Evidence

In pairs, the COG members rated the 10 selected articles. The Oxford Centre for Evidence-Based Medicine's 2011 Levels of Evidence table (OCEBM Levels of Evidence Working Group, 2011) was used to rate each article's treatment benefits (see Tables 2 and 3).

Two systematic reviews closely approximated the COG's PICO question. Gosa, Schooling, & Coleman (2011) investigated the effect of thickened liquids on swallowing physiology in children. Of 22 studies that met the authors' inclusion criteria, six involved a total of 162 participants with some degree of dysphagia, and the majority of subjects were younger than 1 year old. Two investigations reported elimination of laryngeal and/or tracheal penetration in 71–100% of subjects when thickened compared to thin liquids were used (Khoshoo, Ross, Kelly, Edell, & Brown, 2001; Mercado-Deane et al., 2001), but only 50% of the participants across five studies showed elimination of aspiration. In addition, one study reported no increased incidence of aspiration across thin vs. thickened liquid trials. Authors concluded, though, that findings should be interpreted with caution. Most of the infants involved in the studies were relatively healthy and typically developing, and the majority of studies used small sample sizes, nonexperimental research designs, and yielded mixed results. Gosa, Schooling, & Coleman (2011) highlighted that definitive conclusions about the efficacy of thickening liquids in decreasing penetration/aspiration risk in infants are unable to be made without additional research.

The second systematic review, by Steele et al. (2015), investigated the effect of thickening liquid consistency on swallowing function and identified 36 studies that met their inclusion criteria. In total, articles suggested a reduction in the risk of penetration/aspiration during swallowing as thin liquids progress to thicker consistencies. The value of these conclusions was limited for Molly and her COG's PICO question, however, because only one of the articles in Steele et al. (2015) addressed the infant population (Goldfield, Smith, Buonomo, Perez, & Larson, 2013). Steele et al. (2015) also highlighted that because Goldfield et al. (2013) used a lower quality of research design with no control group comparison, claims regarding the consistent efficacy of thickened liquids to facilitate safer swallowing conditions should be limited to the adult population at this time.

Based on these systematic reviews, the COG decided that there appears to be a moderate quality of evidence supporting a reduction in risk of aspiration/penetration with

thickened liquids in adults, but there is inconsistent and limited evidence in children, especially infants. The COG rated these studies as OCEBM Level 2 evidence because they were systematic reviews that addressed the effect of thickening liquids on swallowing physiology in children, but the papers' parameters were not restricted specifically to the infant (birth to 12 months) population.

Four individual studies discussed thickened liquids as a treatment for dysphagia in infants who have anatomic deficits and/or more critical medical diagnoses. A study by Ongkasuwan et al. (2014) included four children under the age of 12 months with multiple congenital anomalies and tracheostomies. SLP raters noted improvement in laryngeal penetration and aspiration when given pureed solids vs. thin liquid with barium in three of the infants when using a speaking valve and/or sham valve. Marques, Prado-Oliveira, Leirião, Jorge, & de Souza (2010) investigated swallowing in 11 children with isolated Robin sequence and airway obstruction/respiratory difficulties. The majority of infants (7/11) demonstrated aspiration risk with thin liquids via fiberoptic endoscopic evaluation of swallowing (FEES), and the authors reported that this risk decreased with thickened milk. In one case study, laryngeal penetration and silent aspiration of thin liquids were eliminated in an infant with laryngeal cleft type I when given thicker milk (Rossi, Buhler, Ventura, Otoch, & Limongi, 2014.) In addition, a 5-month-old infant with history of acute ischemia in the occipital cortex and aspiration pneumonia demonstrated increased feed volumes, better oral coordination, and reduced overt signs of aspiration when given nectar-thick vs. thin liquid (Peck & Rappaport, 2013). A VFSS subsequently showed no aspiration or penetration of thin liquids as the subject was weaned from nectar, to half-nectar, to thin consistencies during feeding therapy.

These four studies suggest there is some evidence that thickened liquids improve swallowing physiology and safety in the infant population. However, the overall quality of research methodology is low (i.e., case studies, observational methods), one study discusses purees and not thickened liquids specifically (Ongkasuwan et al., 2014), and thickening liquids is included sometimes along with other compensatory strategies/interventions that could have affected swallowing skill development (Peck & Rappaport, 2013). In addition, the rigor of rating swallowing function was inconsistent across studies (Rossi et al., 2014; Marques et al., 2010), and aspiration risk was not always quantitatively defined or eliminated when using thickened

feeds (Marques et al., 2010). Finally, the variety of subject diagnoses makes the results difficult to generalize to larger groups of infants. Molly and her colleagues determined that there was limited and mixed evidence that thickened liquids improved swallowing safety in infants who have anatomic or structural defects contributing to their dysphagia. They designated these four studies as Level 4 evidence.

Three studies investigated swallowing and suspected dysphagia in infant groups who were otherwise previously healthy. Khoshoo et al. (2001) completed a prospective investigation of 15 infants with RSV bronchiolitis and dysphagia and found that the majority of those who demonstrated penetration and/or aspiration with thin liquids (8/9) demonstrated a “normal” swallow (i.e., no penetration or aspiration) when given thickened liquid. Mercado-Deane et al. (2001) studied swallowing function via upper gastrointestinal study and VFSS across infants with and without an underlying disease that would predispose them to dysphagia. Of 93 infants who demonstrated aspiration of thin liquids via VFSS, approximately 40% (37/93) improved when given thickened liquids. Furthermore, 67% (22/33) of infants who demonstrated laryngeal penetration of thin liquids showed normal swallowing when given thick liquids. Finally, Sheikh et al. (2001) completed a retrospective chart review of 13 typical infants with a new onset of choking/feeding concerns. VFSS was performed around age 5–6 months and revealed that all infants aspirated thin liquids, with six aspirating semi-thick and/or thick liquids as well. The nine infants that aspirated thin and semi-thick liquids were placed on a thickened-feed diet. At a 9-month follow-up, “aspiration and swallowing dysfunction had finally resolved” (p. 1193) in all infants.

Collectively, these studies suggest that thickening liquids can be considered a safe, effective, and temporary intervention for reducing aspiration. One study, however, presented limited information regarding how the SLP rated the swallowing event, and failed to present any rater reliability data (Khoshoo et al., 2001). Another described normal swallowing only in very general terms as having the ability to swallow “satisfactorily” (Mercado-Deane et al., 2001, p. 425). Direct comparisons of swallowing thin vs. thicker consistencies with each subject were not always outlined (Sheikh et al., 2001). In addition, none of the studies reported a complete elimination of penetration/aspiration across their subjects when thickened liquids were used. Molly and her colleagues noted

these mixed results and methodological weaknesses and summarized the evidence as inconsistent and limited for the typically developing infant population. The investigations were rated as Level 4 evidence.

In the final paper, Goldfield et al. (2013) studied 10 premature infants with dysphagia by examining tongue movement, soft palate movement, and bolus transit time during the swallowing of thin and nectar-thick liquids during VFSS. Average transit time of the bolus head through the pharynx was significantly longer for the thicker consistency. Swallowing nectar-thick liquid also was associated with more coordinated tongue and soft palate movements that created a “pump-like” action for swallowing. The COG rated this article as Level 5 evidence: mechanism-based reasoning. Each infant aspirated during thin liquid trials, but the authors did not discuss whether penetration/aspiration resolved or continued with thicker liquids; the analysis was limited to bolus transit time, tongue movement, and soft palate movement.

The Evidence-Based Decision

Molly, Samantha, and their COG concluded that the overall empirical evidence for recommending thickened liquids as a consistent and effective intervention for infants who aspirate or penetrate thin liquids is limited and of low quality. This characterization of the evidence was found in other articles encountered during the broad literature review as well (Miller, 2011). However, the COG noted that none of the articles portrayed thickening liquids as unilaterally harmful or stated that it should never be used for dysphagia management. On the contrary, thickening liquids can be considered a “necessary and appropriate intervention” that reduces aspiration risk in some cases (Gosa, Schooling, & Coleman, 2011, p. 348) if it is used judiciously and in combination with continuous monitoring as a transitional strategy toward establishing more normalized swallowing function. Clinicians must carefully consider the heterogeneous nature of each subject case (Marques et al., 2010) and exhaust other adaptive strategies and techniques such as positioning changes, smaller bolus size, and pacing before pursuing thickened liquid recommendations (Peck & Rappaport, 2013). Thickening liquids also can be temporary, as infants sometimes progress to normal swallowing function over time (Sheikh et al., 2001) or are weaned successfully from thick to thinner liquids (Peck & Rappaport, 2013; Rossi et al., 2014).

Based on the limited evidence, the COG confirmed that if penetration and/or aspiration is observed during VFSS, alternative methods such as trialing different feeding positions and altering liquid flow rate should be explored by the SLP and OT prior to thickening liquids. If these modifications are ineffective in reducing laryngeal penetration/aspiration, the most appropriate clinical course of action is to increase liquid thickness in small increments until swallowing safety is demonstrated (Steele et al., 2015). The COG decided that patients should have an outpatient feeding follow-up assessment within 1–3 months of a VFSS, depending on the case, in order to continue monitoring swallowing status, provide further parent education, and decide if other evaluation and treatment measures are warranted, such as progressively weaning to thin liquids or repeating a VFSS in the future.

Molly met with her patient and the mother during their follow-up appointment and learned that she had been doing well with nectar-thick formula via her standard-flow nipple. The mother reported no observations of dysphagia symptoms over the last month and no new respiratory infections. Because of her patient's success with thickened liquids, Molly recommended weekly feeding therapy to trial weaning her incrementally back to a thinner consistency of formula. With the patient's referring doctor's approval, Molly explained that she could also use various modifications such as pacing (removing the nipple periodically), changing positioning (using a more upright or side-lying position), and reducing bolus size (using a slower flow nipple) to try to build safer swallowing skills in a controlled manner (Peck & Rappaport, 2013; Rossi et al., 2014). If these modifications were not successful, thickened liquids could continue with ongoing monitoring by a feeding therapist and her doctor. Molly explained that this approach adheres to the available evidence base because it acknowledges that thickening liquids has been shown in some cases to improve swallowing safety in infants, but that other intervention techniques and goals for resuming thin liquid feeds may be considered as well depending on the patient. The mother voiced understanding and was excited to start therapy in the next week.

Molly and Samantha realized that no infant patient in the future would likely present with the exact same oropharyngeal dysphagia case in the outpatient setting. In addition, they noted that the type of thickener, thickening recipes, and the benefits/drawbacks of different instrumental evaluation techniques were variables that needed further consideration in future appraisals of the evidence. Finally,

they acknowledged that their appraisal of the literature related to thickening liquids and infant dysphagia would have to be ongoing and that future COGs may need to narrow their clinical question and target more specific diagnostic groups in order to identify more consistent trends in recommendations and guidelines. McGrattan et al. (2017), for example, recently studied swallowing function via VFSS in infants with congenital heart disease. Although significantly fewer infants demonstrated aspiration with nectar-thick barium (8/30) compared to thin (18/30), the authors highlight that these results indicate mixed findings. Thickening liquids may have positive effects for some infants with dysphagia but may be limited in their benefit to others depending on the type and severity of their swallowing impairment. Because this article was published after completion of Molly and Samantha's COG, it was not included in the formal systematic search and review process. Nevertheless, they designated its results as highly relevant to their clinical practice and planned to include it in their next round of article reviews when the COG meets in 2 years to update the final list of evidence.

After the experience with their COG and literature review, Molly and Samantha both felt more confident with their knowledge of the evidence base for thickening liquids as a treatment strategy for infants with dysphagia. They were more prepared to educate families and collaborate with colleagues at all stages of the swallowing evaluation and treatment process.

Authors' Note

Caitlin A. Cummings, MA, CCC-SLP, is a speech-language pathologist and EBP coordinator for the Speech-Language Pathology Department at Nationwide Children's Hospital. She helps lead EBP initiatives and provides feeding evaluation and treatment primarily for children ages birth through 3 years as a member of the cleft lip and palate team. She is also a doctoral student at The Ohio State University specializing in speech disorders and bilingual development in children with cleft lip and palate and craniofacial anomalies.

Contact Information:
caitlin.cummings@nationwidechildrens.org
Phone: 614-722-3966
Nationwide Children's Hospital
700 Children's Drive
Columbus, OH 43205

Melanie Stevens, MS/CCC-SLP, BCS-S, is a speech-language pathologist with board certification in swallowing and a clinical supervisor in the Speech-Language Pathology Department at Nationwide Children's Hospital. Melanie has 17 years of experience specializing in pediatric dysphagia, FEES, and communication and swallowing care for children with tracheostomies. She currently practices across inpatient, NICU, and pediatric aerodigestive team settings and leads dysphagia EBP initiatives at the department and hospital level.

Nancy Batterson, OT/L, SCFES, is an occupational therapist with specialty certification in feeding, eating, and swallowing in the Clinical Therapies Department at Nationwide Children's Hospital. Nancy has over 29 years of experience in pediatric occupational therapy. Her areas of interest include childhood stroke/CVA, cerebral palsy, oral motor feeding development, and dysphagia.

Kathleen Cianca, MHS, OTR/L, is a pediatric occupational therapist with over 35 years of experience and the OT EBP coordinator at Nationwide Children's Hospital. She has advanced training in pediatric neurodevelopmental treatment, sensory integration, management of infants with feeding difficulties, and VFSSs. Kathleen has been a cofounding and active team member of two pediatric interdisciplinary feeding teams in Ohio (Cincinnati Children's Hospital Medical Center and Nationwide Children's Hospital) for 24 years.

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Table 1. Inclusion and Exclusion Criteria for Articles

Inclusion criteria	Exclusion criteria
Qualitative and/or quantitative data regarding swallowing physiology for at least one infant age 0–12 months Treatment study Use of thickened liquids with comparison to thin liquids Peer-reviewed journal article Published since the year 2000 Written in English	Published before 2000 No specific medical diagnoses were excluded

Table 2. Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence¹ to Assess Treatment Benefits (Does this intervention help?)

Level	Description
1	Systematic review of randomized trials or <i>n</i> -of-1 trials
2	Randomized trial or observational study with dramatic effect
3	Nonrandomized controlled cohort/follow-up study
4	Case-series, case-control, or historically controlled studies
5	Mechanism-based reasoning

¹ OCEBM Levels of Evidence Working Group. (2011). *The Oxford 2011 levels of evidence*. Oxford Centre for Evidence-Based Medicine.

Table 3. Article Summaries Ranked by OCEBM Level

Reference	Type of study	Participants and method	Major findings	OCEBM Level
Gosa, Schooling, & Coleman (2011)	Systematic review	6 of 22 studies investigated the effect of thickened liquids on swallowing physiology in children/infants; 1 study investigated increased aspiration as an adverse effect of thickening	Mixed results; some studies found elimination of laryngeal/tracheal penetration and aspiration; discussion did not specify ages of the children included in the final articles; 1 study found no increase in aspiration with the use of rice cereal for thickening	2*
Steele et al. (2015)	Systematic review	1 of 36 studies included infants with suspicion of aspiration	Limited availability of studies and evidence regarding swallowing, oral processing, and thickened liquids in children	2**
Khoshoo et al. (2001)	Prospective case series	15 previously healthy infants 3–12 months old with RSV bronchiolitis and suspected dysphagia; subjects underwent VFSS with thin and thick liquids	9 infants demonstrated penetration/aspiration with thin liquid; normal swallowing was observed for 8 of these infants when liquid was thickened	4
Marques, Prado-Oliveira, Leirião, Jorge, & de Souza (2010)	Prospective case-control	11 infants under the age of 2 months with Pierre Robin sequence and cleft palate; swallowing was evaluated across nipple sizes, nasopharyngeal intubation, and thin vs. thickened liquid via FEES	7 infants showed risk of aspiration (reflux of liquid into nasopharyngeal intubation tube, milk residue on vocal folds) when given thin liquid; risk decreased with thickened liquid	4
Mercado-Deane et al. (2001)	Prospective case control	Part of the study included analysis of 126 infants < 1 year of age that underwent a modified barium swallow study	Of 93 infants that demonstrated tracheal aspiration of thin liquids, 37 were able to swallow normally when given thick liquids; of 33 that showed laryngeal penetration of thin liquids, 22 were able to swallow normally when given thickened liquids	4
Ongkasuwan et al. (2014)	Prospective case control	4 of 12 subjects with tracheostomies younger than 12 months; laryngeal penetration/aspiration of thin liquids and purees was rated during a modified barium swallow study with and without wearing a Passy Muir® Valve (PMV)	Mixed results; 3 infants showed improved average ratings of swallowing physiology when purees were given with and without a PMV in comparison to thin liquids; 1 infant showed no change in ratings across both consistencies	4
Peck & Rappaport (2013)	Case study	1 of 2 case studies involved an infant with dysphagia and aspiration pneumonia who underwent feeding intervention with thin vs. thickened liquids	Subject showed improved feeding volumes, reduced overt signs of aspiration, and was able to transition to oral feeds when given nectar-thick liquids vs. thin liquids; no aspiration was viewed during modified barium swallow study with thin liquids after weaning from nectar-thick	4
Rossi et al. (2014)	Case study	1 infant with laryngeal cleft type I; underwent VFSS	Laryngeal penetration and aspiration were eliminated when given thicker milk; infant was weaned over 11 months to accepting thin liquids	4
Sheikh et al. (2001)	Retrospective chart review	13 previously healthy infants presenting with respiratory symptoms and/or choking during feeding; VFSS performed at mean 5.9 months of age and repeated at 3-month intervals	All infants demonstrated aspiration of thin liquids; thickening liquids temporarily improved swallowing function for 9 infants; all eventually demonstrated normal swallowing function within a year	4
Goldfield, Smith, Buonomo, Perez, & Larson (2013)	Prospective case series	10 premature infants under the age of 12 months; authors examined tongue and soft palate movement and bolus transit timing of nectar-thick compared to thin liquids via VFSS	Pharyngeal transit time for nectar-thick boluses was significantly longer than thin; tongue dorsum and soft palate showed greater coordination in moving in opposite directions from each other (i.e., approaching antiphase) at the same time with nectar-thick vs. thin liquids, thus creating a more “pump like-action” for swallowing	5

** This study was graded down per OCEBM recommendations as the authors highlighted that most studies included a small number of participants, used nonexperimental research designs, and found mixed results.

* This study was graded down per OCEBM recommendations because only 1 of 36 studies in this systematic review was relevant to the specific PICO question and search parameters addressed in this review. The overall quality of the study was also low (arising from case-series, posttest or pretest, and posttest studies with no control group comparison).

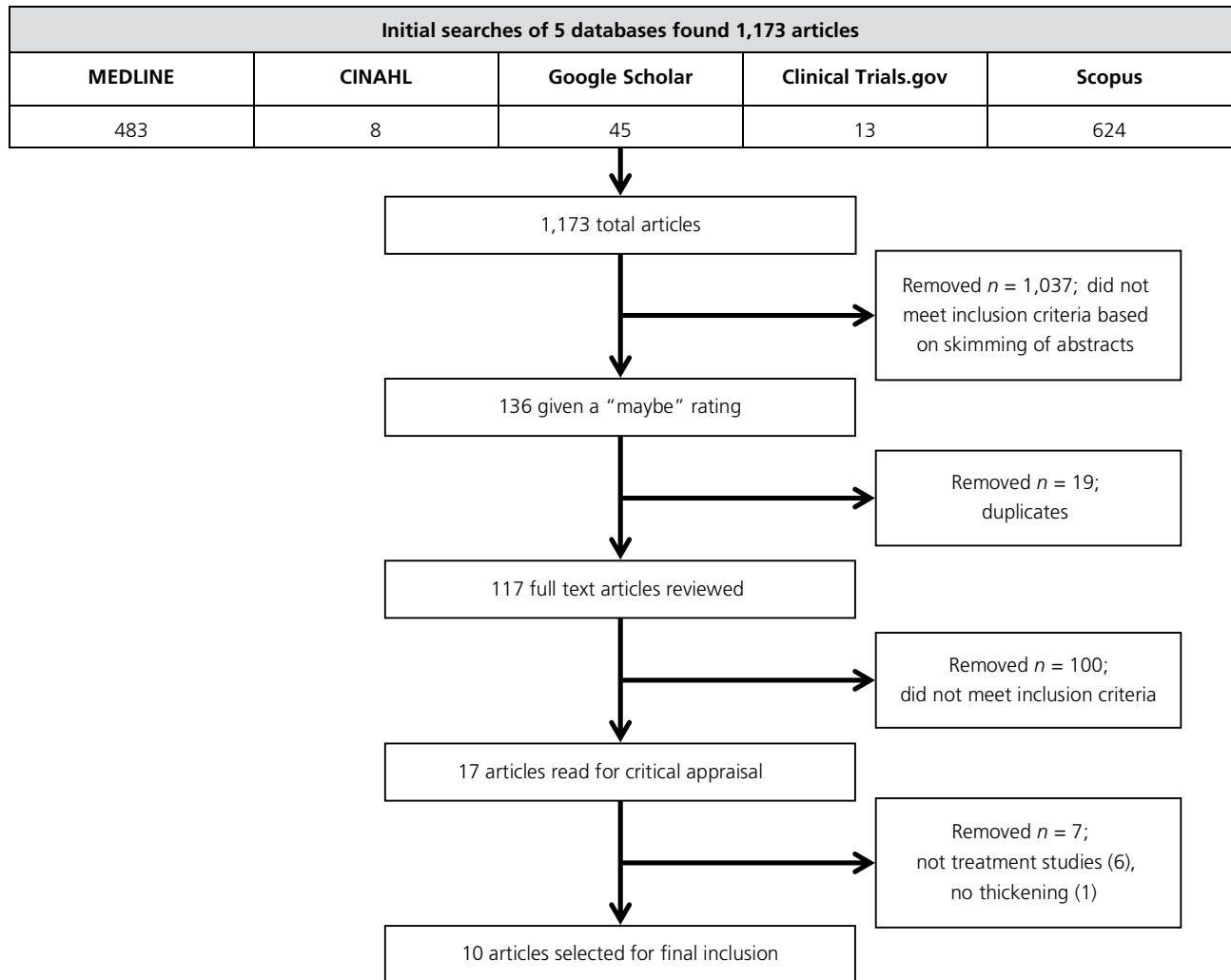


Figure 1. Article search and evaluation process.