Effectiveness of reduction maneuvers in the treatment of nursemaid’s elbow: A systematic review and meta-analysis

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1. Introduction

Nursemaid’s elbow is a common pediatric injury representing approximately 20% of upper extremity conditions\textsuperscript{1} with peak incidence being between two and three years of age\textsuperscript{2–4}. This condition typically occurs when axial traction is placed on the forearm, causing elbow extension and pronation. The applied forces and resulting arm movements permit subluxation of the radial head by partially tearing or entrapping the annular ligament between the radial head and capitellum\textsuperscript{3,5}. The most frequent causal mechanism is when an adult abruptly pulls while holding the hand of a child\textsuperscript{3,5,6}. Clinical presentation suggestive of nursemaid’s elbow includes typical mechanism of injury, limb in incomplete extension with a pronated wrist, and the child not wanting to use the arm or protecting it at their side. There is no edema, ecchymosis or deformity associated with the injury, and pain may be present on movement but usually not during palpation\textsuperscript{3,5}.

Various manipulative interventions can be performed to reduce nursemaid’s elbow\textsuperscript{7–10}. The traditional supination-flexion (SF) maneuver involves outward rotation of the forearm followed by elbow flexion\textsuperscript{11–13}. The hyperpronation (HP) maneuver, where the forearm is rotated inwards (child’s thumb pointing downwards) is gaining popularity, as studies have shown that it may be more effective\textsuperscript{7–10}.

The purpose of this systematic review and meta-analysis was to compare SF and HP in the treatment of nursemaid’s elbow reported in randomized controlled trials. The primary outcome was failure rate at the first reduction attempt. The secondary outcomes were pain during or after reduction, adverse effects, and recurrence rate.

2. Methods

2.1. Protocol

We reported our findings according to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines, including the PRISMA checklist and algorithm [14].

2.2. Selection Criteria

Studies eligible for inclusion were any quasi-randomized or randomized controlled trials that compared SF and HP for primary or recurrent nursemaid’s elbow in any healthcare setting. Quasi-randomization is an allocating method of patients to a specific intervention group that is not strictly random: e.g. date of birth, alternation, or hospital record number. Studies were excluded from the systematic review if children over the age of eight were the main participants or if trials included patients with a clinical presentation consistent with a complete dislocation or possible fracture. Papers not written in English or Dutch were only included if translation was possible.

2.3. Search Strategy

Two reviewers independently searched PubMed/MEDLINE, Embase, and Cochrane databases on June 6th, 2016. The PubMed search strategy (Table 1) was adjusted to fit the format for Embase and Cochrane databases. Two reviewers independently filtered the search results based on title and abstract to find all trials potentially eligible for inclusion. The trials that were deemed potentially eligible were evaluated via full text review. Eligible trials were chosen if they met the criteria and disagreement was resolved by discussion with the senior authors. The references of retrieved papers were manually searched for potential trials meeting the inclusion criteria.

2.4. Quality Assessment

Two reviewers independently appraised the methodological quality of included trials using the Joanna Briggs Institute-Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) [15]. This instrument has been widely used to increase methodological accuracy and to evaluate potential sources of bias and threats to validity. Critical appraisal included assessment of patient allocation, randomization, blinding, baseline characteristics, and completeness of outcome data (Table 2). Disagreements were resolved by discussion with the senior authors. Trials were not blinded for author, affiliation and source.

2.5. Outcome Measures

The primary outcome measure of this meta-analysis was failure rate of reducing nursemaid’s elbow at first attempt. The intervention was considered failure if another reduction attempt was deemed necessary or if the child did not demonstrate a fully functional and pain-free arm after the maneuver. Secondary outcome measures included pain during or after the maneuver, adverse effects (hematoma, infection, nerve injury, and subsequent surgery), and recurrence rate.

Table 1

Pulled elbow or radial head subluxation or nursemaid’s elbow or annular ligament displacement or RHFS or slipped elbow or toddler elbow or babysitter’s elbow Supination-flexion or supination flexion or hyper-pronation or hyperpronation or hyper pronation or forced pronation or manipulation or manipulative

1 and 2

2.6. Data Extraction

Two reviewers independently extracted the following study data: first author, year of publication, demographics, inclusion and exclusion criteria, interventions, and outcomes (failure rates, pain scores, adverse effects, and recurrence rates). Disagreements were resolved through discussion and if consensus could not be made, issue was taken to the senior authors. We intended to contact authors if additional information was needed.

2.7. Statistical Analysis

Individual and pooled data were reported as risk ratios with 95% confidence intervals (CI) for dichotomous outcomes (failure or success at first attempt) using the Mantel-Haenszel method. Continuous outcomes (e.g., pain scales) were reported as weighted mean differences (WMD) or if different scales were used as standardized mean differences (SMD).

Heterogeneity was calculated with the $\chi^2$ test and inconsistency in study effects across trials was quantified by $I^2$. The values of individual trials were pooled using a fixed-effect model in case of homogeneity across trials ($I^2 \leq 25\%$) and using a random-effect model in case of heterogeneity ($I^2 \geq 25\%$). Statistical analyses were performed with the use of Stata® 13.0 (StataCorp LP, College Station, TX, USA).

3. Results

3.1. Baseline Characteristics

Seven trials published between 1998 and June 6th, 2016 met the criteria and were included in this systematic review [7-10,16-18] (Fig. 1). There were a total of 701 patients (62% female), of which 350 patients were treated with the HP maneuver and 351 patients underwent the SF maneuver. All included studies were (quasi-)randomized controlled trials which were performed in either the emergency department or outpatient clinic. Detailed findings of study characteristics are displayed in Table 3.

3.2. Critical Appraisal

A summary of the critical appraisal of included trials is displayed in Table 4. The total MASTARI score ranged from 4 to 6 (out of 10), with a mean of 5.7 points. No trials fulfilled all criteria to be considered as a high-quality trial. As the method of group assignment was not truly random or not mentioned in 5 studies [7,9,10,16,17], and allocation concealment was not reported or not implemented in 6 studies [8-10,

Table 2

<table>
<thead>
<tr>
<th>Critical appraisal tool question</th>
<th>Potential bias</th>
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</thead>
<tbody>
<tr>
<td>1. Was the assignment to treatment group truly random?</td>
<td>Selection bias</td>
</tr>
<tr>
<td>2. Were participants blinded to treatment allocation?</td>
<td>Selection bias</td>
</tr>
<tr>
<td>3. Was allocation to treatment groups concealed from the allocator?</td>
<td>Selection bias</td>
</tr>
<tr>
<td>4. Were the outcomes of people who withdrew described and included in the analysis?</td>
<td>Attrition bias</td>
</tr>
<tr>
<td>5. Were those assessing outcomes blind to treatment allocation?</td>
<td>Ascertainment bias</td>
</tr>
<tr>
<td>6. Were the control and treatment groups comparable at entry?</td>
<td>Design bias</td>
</tr>
<tr>
<td>7. Were groups treated identically other than the named intervention?</td>
<td>Systematic difference/contamination bias</td>
</tr>
<tr>
<td>8. Were outcomes measured in the same way for all groups?</td>
<td>Psychometric veracity of instruments</td>
</tr>
<tr>
<td>9. Were outcomes measured in a reliable way?</td>
<td>Detection/instrument/measurement bias</td>
</tr>
<tr>
<td>10. Was appropriate statistical analysis used?</td>
<td>Performance/detection bias</td>
</tr>
</tbody>
</table>


16-18], there was a high risk of selection bias. In addition, as studies lacked blinding of patients, treating physicians, and outcome assessors, this resulted in a high risk of ascertainment bias in all studies [7-10, 16-18].

3.3. Reduction of Nursemaid’s Elbow

Given the fact that in all 7 trials the reduction maneuvers were performed in a similar study population and setting [7-10,16-18], we decided to pool the data on reported failures at first attempt. Meta-analysis using a fixed-effect model showed that HP was more effective than SF for treatment of nursemaid’s elbow (risk ratio, 0.34; 95% CI, 0.23 to 0.49; I², 35%) (Fig. 2). Absolute risk difference between maneuvers was 26.4%, which results in a number needed to treat of 3.8. This signifies that for every 4 children treated with HP rather than SP for nursemaid’s elbow, there will be one less failure at first reduction attempt.

3.4. Secondary Outcomes

Five of seven studies reported pain perception related to the reduction maneuver [8-10,16,18], however, assessment across studies varied widely. Therefore, we were not able to pool the data for further analysis. McDonald and colleagues [8] reported less physician-perceived pain at first attempt in the HP group (p = 0.013) using an ordinal pain scale (0 to 3). This is in line with Bek and colleagues [10] who found that subjective physician-perceived pain for the HP technique was less painful (p = 0.003). In contrast, Gunaydin and colleagues [16] and Guzel and colleagues [18] found no difference in physician-perceived pain related to reduction maneuver. In addition, Green and colleagues [9] found no difference in physician-perceived pain using a visual analogue scale (0 to 10), whereas both nurses (p = 0.03) and parents (p = 0.04) distinguished HP technique as the less painful maneuver. Assessors were not blinded in all 5 studies.

Other secondary outcomes such as adverse events after manipulation (e.g., hematoma, infection, nerve injury, subsequent surgery) and recurrence rate were not reported in any of the included trials.

4. Discussion

In this systematic review, data were pooled from 7 randomized controlled trials to compare the effectiveness of two primary manipulative maneuvers for reduction of nursemaid’s elbow in young children. The hyperpronation maneuver had a significantly lower failure rate at first attempt compared to the supination-flexion maneuver (risk ratio 0.34; 95% CI 0.23 to 0.49; I² = 35%). Five of seven studies assessed pain perception and reported conflicting results regarding this issue. Due to lack of homogeneity of pain measures between studies, data was unable to be pooled for further analysis.

Our findings were consistent with the systematic review conducted by Krul and colleagues [19] who found that the HP maneuver had a significantly lower failure rate than the SF maneuver (risk ratio 0.45; 95% CI 0.28 to 0.73). The results of our meta-analysis indicated that the addition of the studies from Gunaydin [16], Guzel [18], and Garcia and colleagues [17] strengthened the evidence that HP is more effective in comparison to SF. Our findings were also in line with the conclusions of Neven and colleagues [20], however, they included the study by Taha [21], whereas we excluded this trial because it lacked a control group.
Results of methodological appraisal.

Table 4
Study characteristics.

<table>
<thead>
<tr>
<th>First author (year)</th>
<th>Participants</th>
<th>Interventions</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macias et al. (1998)</td>
<td>Mean age, 27.7 months; boys, 34; girls, 51</td>
<td>Hyperpronation versus supination-flexion</td>
<td>Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver)</td>
</tr>
<tr>
<td>McDonald et al. (1999)</td>
<td>Age range, 3 months to 6 years; boys, 58; girls, 77</td>
<td>Rapid pronation and flexion versus rapid supination and flexion</td>
<td>Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver)</td>
</tr>
<tr>
<td>Green et al. (2006)</td>
<td>Mean age, 26.7 months; boys, 29; girls, 41</td>
<td>Forced pronation versus supination-flexion</td>
<td>Pain before, during, and 1 min after successful reduction measured by parent, nurse and physician</td>
</tr>
<tr>
<td>Bek et al. (2009)</td>
<td>Mean age, 28.6 months; boys, 26; girls, 40</td>
<td>Hyperpronation versus supination-flexion</td>
<td>Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver)</td>
</tr>
<tr>
<td>Gunaydin et al. (2013)</td>
<td>Mean age, 27.3 months; boys, 51; girls, 99</td>
<td>Hyperpronation versus supination-flexion</td>
<td>Pain before, during, and after reduction measured by assisting physician using mCHEOPS scale</td>
</tr>
<tr>
<td>Garcia-Mata et al. (2014)</td>
<td>Mean age, 25 months; boys, 33; girls, 82</td>
<td>Hyperpronation versus supination-flexion</td>
<td>Success rate at 1st attempt; then, success rate at 2nd attempt (original maneuver)</td>
</tr>
<tr>
<td>Guzel et al. (2014)</td>
<td>Mean age, 30 months; boys, 38; girls, 40</td>
<td>Hyperpronation versus supination-flexion</td>
<td>Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver)</td>
</tr>
</tbody>
</table>

NE, nursemaid's elbow; mCHEOPS, modified Eastern Ontario Children's Hospital pain scale; WBFPSS, Wong-Baker Faces Pain Rating Scale; FLACCS, Face, Legs, Activity, Cry, Consolability Scale.

* Sex of two patients not mentioned.

Studies included in this review report conflicting data regarding pain evaluation of manipulative interventions for reduction of nursemaid's elbow [8-10, 16, 18]. In two out of five studies [8,10], the HP maneuver was less painful than SP maneuver according to the subjective observation of the treating physician. Additionally, Green and colleagues reported a difference in pain evaluation by nurses and parents in favor of HP [9], whereas no difference in physician-perceived pain was reported in 3 studies [9,16,18]. Knowing that pain assessment in young children can be very difficult and the fact that assessors were not blinded in the included studies, makes it difficult to draw conclusions on this topic.

Overall, our systematic review strengthens the evidence supporting the HP maneuver as the preferred technique for reduction, but our studies had limitations and was susceptible to bias. Although trial setting and study population were very similar across the included studies, we were not able to pool data on pain perception due to heterogeneity of pain measures. Furthermore, the quality of evidence was low in all of the studies due to the impossibility of blinding subjects, providers, and assessors after allocation of treatment intervention. Implications for future research include completely randomized controlled clinical trials with larger study populations and subpopulations, longitudinal outcome studies comparing recurrence rates between HP and SF groups, creating a gold-standard pain scale adapted to young children, and incorporating blinding if possible, to minimize potential bias.

5. Conclusion

We conclude that the hyper-pronation technique is more effective than the supination-flexion maneuver to manually reduce nursemaid’s elbow in young children. The included studies, however, were low in quality and susceptible to bias due to the inability to blind physicians and study participants after treatment intervention allocation. Future research with larger study populations and a universal, child-specific pain scale is needed to strengthen the evidence supporting our finding.

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Fig. 2. The risk ratio on the failure rate at first attempt is shown between supination-flexion and hyperpronation.

References