**Comparison of Single- and Double-balloon Catheters for Labor Induction. A Meta-analysis of Randomized Controlled Trials**

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**ABSTRACT**

***Objective***: To compare the efficacy of single- and double-balloon catheters in women undergoing the induction of labor.

***Methods*:** Together with a clinical librarian, we searched computerized databases, references in published studies, and textbook chapters without language restrictions. Searches were performed in MEDLINE, PubMed, ClinicalTrials.gov, and the Cochrane Library from inception through June 2016. The MeSH headings used included the terms “single-balloon catheter,” “Foley catheter,” “double-balloon catheter,” “Cook catheter,” “Atad catheter,” “induction,” “induce,” “ripening,” and “ripen.”We identified peer-reviewed randomized and quasi-randomized trials that compared single- and double-balloon catheters head-to-head for cervical ripening or labor induction. Eligible study populations consisted of women with singleton pregnancies that had any indication for labor induction and were randomly allocated to undergo induction with a single- or a double-balloon catheter. Selected studies examined the time from catheter insertion to delivery and mode of delivery. Observational studies, abstracts only, and studies in which the two catheters were not compared directly were excluded. Additionally, studies that examined indications other than labor induction or ripening were also excluded. The primary outcome was time from catheter insertion to delivery and mode of delivery. Secondary outcomes included intrapartum fever or chorioamnionitis and neonatal Apgar score.

***Results*:** Of the 520 records identified, five randomized trials (996 women; 491 with single-balloon and 505 with double-balloon catheters) were deemed eligible and were included in the meta-analysis. The time from catheter insertion to delivery did not differ between the two types of catheter (*p*=0.527; WMD –0.87; 95% CI –3.55, 1.82). The incidence of cesarean delivery also did not differ (*p*=0.844; RR 0.97; 95% CI 0.69, 1.35). Secondary outcomes, including time from catheter insertion to vaginal delivery, delivery within 24 hours, mode of delivery, Apgar score, and intrapartum fever did not differ between the two types of catheter. Sub-analysis according to parity also revealed no significant differences between the two types of catheter. Additionally, a sub-group analysis according to the geographic origin of the study (Middle East countries vs. other) did not reveal significant differences between the two types of catheter.

***Conclusion***: Time from catheter insertion to delivery and mode of delivery were comparable between the two types of catheter, regardless of parity.

**INTRODUCTION**

Labor induction is one of the most frequently used interventions in obstetrics (1,2). Therefore, the methods selected for induction should be safe for both the mother and fetus, cause minimal maternal discomfort, and if possible incur a low cost. The available methods for labor induction can be either pharmacological or mechanical (2,3). Mechanical methods, particularly single- or double-balloon catheters, are safe and as effective as pharmacological methods. In addition, mechanical methods have potential advantages including ease of storage, reversibility, stability at room temperature, and fewer side effects such as decreased uterine hyperstimulation when compared with pharmacologic methods (3–7). Additionally, although the mechanical effect is applied to the cervix, both the single- and double-balloon catheters do not lead to an increase in the incidence of preterm births in subsequent pregnancies (8).

There is a paucity of head-to-head randomized trials that compared single- and double-balloon catheters in terms of labor length and mode of delivery. Although labor induction is a common and usually necessary intervention, the associated risks including labor length and maternal and neonatal effects (9-11) and related costs (12,13) make selecting the best method crucial. There are lower costs associated with the use of a single-balloon catheter (14,15), but the results of the available data comparing the two catheters in terms of time from insertion to delivery, maternal complications, and cesarean delivery rate are mixed (14-18).

A systematic search of the literature did not reveal any published meta-analyses that compared the two types of catheter head-to-head. Therefore, the objective of this meta-analysis of randomized controlled trials (RCTs) was to compare the efficacy of single- and double-balloon catheters in women undergoing labor induction. Our hypothesis was that women who undergo labor induction with either of the catheter types will have a similar labor length and delivery mode.

**METHODS**

A protocol with clearly defined objectives, criteria for selection, statistical methods, and approach to analyzing and assessing study quality was developed prospectively. The review was registered with the PROSPERO International Prospective Register of Systematic Reviews (Registration No. CRD42016047605). Together with a clinical librarian, an attempt was made to identify all relevant RCTs that directly compared the use of a single- and double-balloon catheter for cervical ripening and labor induction. The following electronic databases were searched from inception through June 2016: MEDLINE, PubMed, Ovid, ClinicalTrials.gov, and the Cochrane Library. The MeSH headings used included combinations of the terms [“randomized” OR “randomised” OR “randomize”] AND [“single-balloon catheter” OR “Foley catheter” OR “double-balloon catheter,” OR “Cook catheter,” OR “Atad catheter,” OR “Induction,” OR “induce,” OR “ripening,” OR “ripen,”] in the title or abstract. All reference lists from eligible reports and relevant articles were manually searched for additional eligible studies. Additionally, textbook chapters were searched manually to locate additional studies and abstracts from major international meetings were reviewed. The search was not limited to publications in English only.

**Study Selection**

Precise and prospectively defined inclusion criteria were used to determine the studies included in the meta-analysis. Only peer-reviewed randomized and quasi-randomized trials that compared the two types of catheter head-to-head in terms of time from catheter insertion to delivery and mode of delivery were eligible for inclusion. The eligible study populations consisted of women with singleton pregnancies that had any indication for labor induction and were randomly allocated into one of two treatment groups: induction with a single-balloon catheter or a double-balloon catheter.

Observational studies, abstracts only, and studies in which the two catheters were not directly compared were excluded. Additionally, studies that examined indications other than induction or ripening, such as the treatment of postpartum hemorrhage, were also excluded.

All identified records were retrieved independently by two reviewers (RS and NS) who screened each record for eligibility. The full text of the articles assessed for eligibility were retrieved and assessed by the same reviewers; they screened each eligible full-text report and extracted and tabulated the relevant data. Data were extracted independently from the text, tables, and graphs of each of the selected studies on two separate occasions to confirm the accuracy of data collection. Disagreements between authors over the inclusion and exclusion of studies and data interpretation were resolved by consensus through discussion between the authors.

The primary and secondary outcomes were defined before data extraction. The primary outcomes were time from catheter insertion to delivery and mode of delivery. The secondary outcomes included intrapartum fever or chorioamnionitis and neonatal Apgar score.

The continuous outcome variables were time from catheter insertion to delivery and time from catheter insertion to vaginal delivery (hours). The categorical outcome variables were type of delivery (vaginal, vacuum, and cesarean), delivery within 24 hours from catheter insertion (yes/no), Apgar score less than seven at 5 minutes (yes/no), and intrapartum fever or chorioamnionitis (yes/no). All procedures followed the guidelines for the systematic review and meta-analysis of clinical trials outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (19).

**Statistical Analyses**

Quality scores based on the CONSORT checklist (20) were determined for all studies. The possible score ranged between 0–25 points (partial points were given for partial reporting).

In each study, comparisons were made between two parallel groups: women induced with a single-balloon catheter and women induced with double-balloon catheter. Continuous variables were compared by calculating the means and standard deviation in each study arm and the effect sizes were calculated using weighted mean differences (WMDs). In studies that reported only the median and the interquartile range (IQR; the range between the 25th percentile [Q1] and the 75th percentile [Q3]), the following calculations were used to estimate the mean and standard deviation and approximated standard deviation (21):

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Relative risk (RR) was used as a measure of association for discrete variables.

The heterogeneity of the studies was assessed using Cochrane’s Q test of heterogeneity (P<0.1 was considered statistically significant). Inconsistencies in the study results were assessed using I² tests, which describe the percentage of the total variation among studies that is due to heterogeneity rather than chance. A random effects model (DerSimonian and Laird) was chosen if Cochrane’s Q test P<0.1 or I² ≥50%. Otherwise, a fixed effects model (inverse variance methods) was used. The study quality scores were evaluated as a source of heterogeneity by ﬁtting meta-regression models to the individual study effect sizes (i.e., WMD and RR). Funnel plots and Egger tests were used to assess publication bias (P<0.1 was considered a statistically asymmetric funnel plot). Statistical analyses and graphical presentations were performed using Stata version 12.1 (Stata Corp., College Station, TX).

**RESULTS**

The study selection process is presented in Figure 1. Of the 520 records identified, five randomized trials were deemed eligible and were considered in the meta-analysis (14–18). Combining the data from these five trials resulted in a total of 996 women (491 single-balloon and 505 double-balloon catheters). A summary of the studies included in this meta-analysis is shown in Table 1. Four of the five studies included only pregnancies with viable fetuses (14-16,18). Three studies were performed in the Middle East (681 women), one was in the United States (98 women), and one was in Australia (217 women).

Meta-analyses were performed for each outcome. The time from catheter insertion to delivery did not differ between the two types of catheter (*p*=0.527; WMD –0.87; 95% CI –3.55, 1.82). There was also no difference in the incidence of cesarean delivery (*p*=0.844; RR 0.97; 95% CI 0.69, 1.35) (Table 2). Secondary outcomes including time from catheter insertion to vaginal delivery, delivery within 24 hours, mode of delivery, Apgar score, and intrapartum fever did not differ between the two types of catheter (Table 2). Figure 2 shows that there was no significant association between the type of catheter and mode of delivery (RR ~1).

Sub-analysis according to parity, i.e., nulliparous (Table 3) and multiparous (Table 4), did not reveal any significant differences between the two types of catheter in any of the primary or secondary outcomes examined. Additionally, a sub-group analysis according to the geographic origin of the study (Middle East countries vs. other) was performed. Again, no significant differences were found between the two types of catheter and the primary or secondary outcomes examined (data not shown).

As part of sensitivity analysis, WMD estimations were performed again (time from catheter insertion to delivery [hours] and time from catheter insertion to vaginal delivery [hours]) after excluding the studies that did not report the means and standard deviations in each group (16, 18); approximations of the means and standard deviations were considered in the analysis. The results remained comparable, since significant differences were found in the time from catheter insertion to delivery (*p*=0.184; WMD -2.15; 95% CI -5.33, 1.02) and time from catheter insertion to vaginal delivery (*p*=0.159; WMD 1.1; 95% CI -0.37, 2.57) between catheter types.

Publication bias was examined using the Egger test for asymmetry funnel plot. No significant asymmetry was found in all of the analyses (*p*>0.2).Meta regression analysis between the study effects (RR, WMD) and the study quality scores also revealed no significantly different results (data not shown).

**DISCUSSION**

This meta-analysis of RCTs examined the efficacy of single- compared with double-balloon catheters in women undergoing labor induction. The results revealed that the time from catheter insertion to delivery or vaginal delivery and delivery within 24 hours was comparable between the two types of catheter, regardless of parity. The mode of delivery was also comparable regardless of parity. The incidence of intrapartum fever or chorioamnionitis and a neonatal Apgar score <7 at 5 minutes also did not differ between the two types of catheter. There were also no differences according to the geographic location where the study was performed.

Single-balloon catheters have been recognized as a safe and effective mechanical method for labor induction for several decades (22,23). In 1991, the double-balloon catheter, which added a second cervico-vaginal balloon to the existing single uterine balloon, was introduced as a novel technique and promising results were initially reported (24,25). Subsequently, only a small number of RCTs have directly compared single- and double-balloon catheters. Additionally, inconsistent results have been reported among the existing trials in terms of labor length, delivery mode, and peripartum complications.

Labor length is one of the major outcomes examined among the various methods used for labor induction. In addition to the positive effects on patient satisfaction (26), the ability to shorten the length of time women spend in labor and in hospital has significant clinical and financial implications given the known maternal and perinatal consequences associated with prolonged labor (9-13). The results of the RCTs that compared the two catheters were inconsistent and range from a shorter labor with the use of the single-balloon catheter (15-17) to comparable results (14,15). The results of this meta-analysis showed that the time from catheter insertion to delivery was comparable between the two types of catheter.

In terms of mode of delivery, recent RCTs did not show an increased risk of cesarean delivery in women undergoing induced labor compared with similar groups of women without induction (27,28). Nevertheless, different rates of cesarean delivery have been reported with the two types of catheter. Hoppe et al. reported that among nulliparous women, the incidence of cesarean delivery was almost two-times greater in women with a single- compared to a double-balloon catheter (60.0% vs. 32.0% respectively; *p*=0.047) (18). Salim et al. (14) reported an increased incidence of operative deliveries among women with double- compared with single-balloon catheters, whereas others did find a significant difference. Differences between the study results could be attributed to different populations and also probably to different intrapartum management strategies, as in case of Hoppe et al. (18), since a 60% rate of cesarean delivery was considerably higher than the rates reported in the other four trials included. Salim et al. inflated the single-balloon catheter to 60 mL (14), whereas the single-balloon catheter was inflated to 30 mL in the other studies. Previous studies reported that inflating a transcervical single-balloon to 60 mL or 80 mL to induce labor is a more effective method of labor induction compared with inflating to 30 mL (29-31). Nevertheless, this meta-analysis of five RCTs showed a comparable rate of cesarean delivery between the two types of catheter. Similarly, despite inconsistent outcomes regarding other maternal and neonatal outcomes, this meta-analysis revealed comparable results between the two catheters.

The current meta-analysis has a number of limitations. Although we analyzed all RCTs published in the literature according to the search engine used, the relatively small number of trials found may affect the external validity of the results. In addition, differences in the trials with respect to parity, the use of additional interventions (as in the case of saline infusion in the study by Mei-dan et al. (15)), and the inclusion of a study that reported cases of fetal death (17) may affect the results. Finally, blinding of the trials was not possible because of the nature of the catheter intervention, which could have introduced bias into the studies.

**Conclusion**

This is the first meta-analysis of RCTs that compared single- and double-balloon catheters head-to-head in women undergoing labor induction. Overall, the findings of this meta-analysis provide reassurance that both catheters used for the induction of labor have comparable efficacy and safety. The fact that the single-balloon catheter costs much less than the double-balloon catheter makes the single-balloon catheter a more cost-effective method for labor induction.

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