**Single Compared With Double Balloon Catheters for Labor Induction. A Meta-analysis of Randomized Controlled Trials**

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**ABSTRACT**

**OBJECTIVE**: To examine the efficacy of the single compared to the double balloon catheters in women undergoing induction of labor.

**DATA SOURCES:** Together with a clinical librarian, we searched computerized databases, references in published studies and textbook chapters without language restriction. Searches were performed in MEDLINE, PubMed, ClinicalTrials.gov, and the Cochrane Library from inception through June 2016. MeSH headings used included the terms “single balloon catheter,” “Foley catheter,” “double balloon catheter,” “Cook catheter,” “Atad catheter,” “induction,” “induce,” “ripening,” and “ripen.”

**METHODS OF STUDY SELECTION**: We identified peer reviewed randomized and quasi-randomized trials that compared head to head between single and double balloon catheters for cervical ripening or labor induction. Eligible studies’ populations consisted of women with singleton pregnancies that had any indication for labor induction and were randomly allocated into induction with a single or with a double balloon catheter. Selected studies examined time from catheter insertion to delivery and mode of delivery. 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 of labor or ripening were also excluded. The primary outcome was time from catheter insertion until delivery and mode of delivery. Secondary outcomes included intrapartum fever or chorioamnionitis, and neonatal Apgar score.

**TABULATION, INTEGRATION, AND RESULTS:** Of all 520 records identified, 5 randomized trials (996 women; 491 with single balloon and 505 with double balloon catheters) were deemed eligible and were considered in the meta-analysis. The results show that time from catheter insertion to delivery did not differ between the two types of the catheters (*p*=0.527; WMD -0.87; 95% CI -3.55, 1.82). The incidence of cesarean delivery did not differ as well (*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 the catheters. Sub-analysis according to parity did not show significant differences between the two types of catheters as well. 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 catheters

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

**INTRODUCTION**

Labor induction is one of the most frequently used interventions in obstetrics (1,2), hence, selected methods for induction should be safe for both the mother and fetus, have minimal maternal discomfort, and if possible incur a low cost. Methods for labor induction may be divided into pharmacological and mechanical methods (2,3). Mechanical methods, particularly the single or the double balloon catheters, have been shown to be safe and as effective as pharmacological methods. In addition, mechanical methods have the potential advantages of ease of storage reversibility, stability at room temperature and fewer side effects such as decreased uterine hyperstimulation, when compared to pharmacologic methods (3–7). Additionally, despite the mechanical effect applied on the cervix, both the single and the double balloon catheters did 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. While induction of labor is a common and usually a necessary intervention, the associated risks including labor length, maternal and neonatal effects (9-11) and the related costs (12,13) make the selection of the best method a crucial issue. Except for the lower costs of the single balloon catheter (14,15), the results of the existed data that compared between the two catheters in terms of time from insertion to delivery, maternal complications, and cesarean delivery rate are mixed (14-18).

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

**SOURCES**

We prospectively developed a protocol with clearly defined objectives, criteria for selection, statistical methods, and approach to analyzing and assessing study quality. We registered the review with the PROSPERO International Prospective Register of Systematic Reviews (Registration No. CRD42016047605). Together with a clinical librarian, we attempted to identify all relevant RCTs that directly compared the use of a single balloon catheter with double balloon catheter for cervical ripening and induction of labor. We searched electronic databases: MEDLINE, PubMed and Ovid, ClinicalTrials.gov and the Cochrane Library from inception through June 2016. 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, we manually searched textbook chapters to locate additional studies and reviewed abstracts from main international meetings. We did not limit our search to publications published in English only.

**STUDY SELECTION**

Precise and prospectively defined inclusion criteria were used to determine which studies would be included in the meta-analysis. Only peer reviewed randomized and quasi-randomized trials that compared head to head between the two types of catheters in terms of time from catheter insertion to delivery and mode of delivery were eligible for inclusion. Eligible studies’ populations consisted of women with singleton pregnancies that had any indication for labor induction and were randomly allocated into one of the two treatment groups: induction with a single balloon catheter or with 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 as in the case of treating postpartum hemorrhage were also excluded.

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

Primary and secondary outcomes were defined before data extraction. The primary outcomes were time from catheter insertion until delivery and mode of delivery. 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 less than 7 at 5 minutes (yes/no) and Intrapartum fever or chorioamnionitis (yes/no). All procedures followed the guidelines for systematic review and meta-analysis of clinical trials outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (19).

Quality scores based on the CONSORT checklist (20) were evaluated 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 single balloon catheter and women induced with double balloon catheter. For continuous variables (time from catheter insertion to delivery [hours] and time from catheter insertion to vaginal delivery [hours]) we used the means and standard deviation in each study arm. The effect sizes were calculated using weighted mean difference (WMD). In studies that reported only the median and the interquartile range (IQR), where the latter is the range between the 25th percentile (Q1) and the 75th percentile (Q3) we implemented the following calculations, in order to estimate the mean and standard deviation for these studies (21): ; For approximated standard deviation, the following calculation was performed: .

Relative risk (RR) was used as the measure of association for the discrete variables (type of delivery, vaginal delivery within 24 hours from catheter insertion, intrapartum fever/chorioamnionitis and Apgar<7).

Heterogeneity of the studies was assessed using Cochrane’s Q test of heterogeneity (P<0.1 was considered statistically significant). Inconsistency in the studies' results was assessed by I² which describes the percentage of total variation across studies that is due to heterogeneity rather than chance. Random effects model (DerSimonian and Laird) was chosen if Cochrane’s Q test P<0.1 or I²≥50%. Otherwise, the fixed effects model (inverse variance methods) was chosen. The role of the studies quality score was evaluated as a source of heterogeneity by ﬁtting meta-regression models to the individual study effect sizes (i.e. WMD and RR). The funnel plot and the Egger test were used to examine publication bias (P<0.1 considered statistically asymmetric funnel plot). The statistical analysis and graphical presentation were performed using Stata version 12.1 (Stata Corp., College Station, TX).

**RESULTS**

The study selection process is presented in Figure 1. Of all 520 records identified, 5 randomized trials (14–18) were deemed eligible and were considered in the meta-analysis. Combining the data in 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 listed in Table 1. Except for one study (17), all other four studies (14-16,18) included only pregnancies with viable fetuses. The studies' characteristics are presented in Table 1. Three of the studies were performed in the Middle East (681 women), one study in the United States (98 women) and one study in Australia (217 women).

Meta-analyses were performed for each outcome. The results show that time from catheter insertion to delivery did not differ between the two types of the catheters (*p*=0.527; WMD -0.87; 95% CI -3.55, 1.82). The incidence of cesarean delivery did not differ as well (*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 catheters` types (Table 2). Figure 2 shows that there were 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) separately, did not show significant differences between the two types of catheters in primary or secondary outcomes that were examined. Additionally, a sub-group analysis according to the geographic origin of the study (Middle East countries vs. other) was performed. Yet again, no significant differences were found between the two types of catheters and primary or secondary outcomes that were examined (data are not shown). As part of sensitivity analysis, we performed the WMD estimation again (time from catheter insertion to delivery [hours] and time from catheter insertion to vaginal delivery [hours]), excluding the studies that did not report the mean and standard deviation in each group (16, 18), and approximations of the mean and standard deviation were considered in the analysis. The results remained comparable as no significant differences were found in time from catheter insertion to delivery (*p*=0.184; WMD -2.15; 95% CI -5.33, 1.02) and in time from catheter insertion to vaginal delivery (*p*=0.159; WMD 1.1; 95% CI -0.37, 2.57).

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

**DISCUSSION**

This meta-analysis of RCTs that examined the efficacy of the single compared to the double balloon catheters in women undergoing induction of labor found that the time from catheter insertion to delivery or to vaginal delivery and delivery within 24 hours was comparable between the two types of catheters regardless of parity. Additionally, mode of delivery was also comparable regardless of parity. The incidence of intrapartum fever or chorioamnionitis, and the incidence of neonatal Apgar score < 7 at 5 minutes did not differ as well between the two types of catheters. The results did not differ according to geographic location where the study was performed.

Single balloon catheter is 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). Since then, only a small number of RCTs compared directly the single with the double balloon catheters. Additionally among the existing trials, inconsistent results have been reported in terms of labor length, delivery mode and peripartum complications.

Labor length is one of the major outcomes that are examined among the various methods used for labor induction. In addition to the positive effect on women satisfaction (26), the ability to shorten the length of time women spend in labor, and in hospital, has large clinical and financial implications given the known maternal and perinatal consequences associated with prolonged labor (9-13). The results of the RCTs that compared between the two catheters were inconsistent and range from 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 were comparable between the two types of catheters.

In terms of mode of delivery, though recent RCTs did not show an increased risk for cesarean delivery among women undergoing induction of labor compared to similar group of women without induction (27,28), still, within the two types of catheters, different rates of cesarean delivery have been reported. Hoppe et al. (18), reported that among nulliparous women, the incidence of cesarean delivery was almost 2 times greater in women with single compared to double balloon catheter (60.0% versus 32.0% respectively; *p*=0.047). Salim et al. (14) reported an increased incidence of operative deliveries among women with double compared to single balloon catheters while others did find a significant difference. Differences between the studies` results may be attributed to different populations and probably to a different intrapartum management, 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. On the other hand, Salim et al. (14), used 60 mL to inflate the single balloon catheter (14), while in the remainder four trials the single balloon catheter was inflated with 30 mL. It has been reported from previous studies that inflation of a transcervical single balloon for induction of labor to 60 mL or 80 mL is a more effective method of labor induction as compared with inflation to 30 mL (29-31).

Nevertheless, this meta-analysis of the five RCTs showed a comparable rate of cesarean delivery between the two types of catheters.

Similarly, despite inconsistent outcome regarding other maternal and neonatal outcomes, this meta-analysis showed comparable results between the two catheters.

The current meta-analysis has a number of limitations. Though we analyzed all RCTs published in the literature according to the searching engine we used, the relatively small number of trials found may affect the external validity of the results.

Differences in the trials with respect to parity, use of additional interventions, as in the case of saline infusion in the trial of Mei-dan et al. (15), and inclusion a trial that involved cases of fetal death (17) may affect the results. Finally, as a result of the nature of the catheter intervention, blinding of trials was not possible, which may have introduced a bias into the studies.

**Conclusion**

This is the first meta-analysis of RCTs that compared head to head between single and double balloon catheters in women undergoing induction of labor according to the research engine that was performed. Overall, the findings of this meta-analysis provide reassurance that both catheters used for induction of labor have comparable efficacy and safety. The fact that the costs of the single balloon catheter is greatly lower than the double balloon, make the single-balloon catheter a more cost-effective method for labor induction.

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