Membrane sweeping in patients planning a trial of labor after cesarean: a systematic review and meta-analysis of randomized controlled trials

Odessa Hamidia\textsuperscript{a}, Johanna Quist-Nelson\textsuperscript{b}, Serena Xodo\textsuperscript{c} and Vincenzo Berghella\textsuperscript{b}

\textsuperscript{a}\textsuperscript{a}Department of Obstetrics and Gynecology, Penn State Milton S Hershey Medical Center, Hershey, Pennsylvania, USA; \textsuperscript{b}\textsuperscript{b}Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania, USA; \textsuperscript{c}\textsuperscript{c}Department of Gynecology and Obstetrics, School of Medicine, University of Udine, Udine, Italy

\textbf{ABSTRACT}

\textbf{Background:} Membrane sweeping has been shown to reduce time to the onset of labor in women at term but the effects of membrane sweeping in women with a prior cesarean delivery are largely unknown.

\textbf{Objective:} To determine the effects of membrane sweeping on promoting labor in patients undergoing a trial of labor after cesarean.

\textbf{Study design:} Searches were performed in Medline, Ovid, Scopus, ClinicalTrials.gov, and the Cochrane Central Register of Controlled Trials using a combination of keywords related to “membrane sweeping,” “membrane stripping,” “vaginal birth after cesarean,” and “trial of labor after cesarean” from inception of databases until April 2018. Study eligibility criteria: We included all randomized controlled trials (RCTs) of singleton or twin gestations at 36 weeks or greater that evaluated prophylactic or prelabor membrane sweeping in patients undergoing a trial of labor after cesarean. Exclusion criteria were trials that did not include patients with a prior uterine scar or cesarean delivery, or that were studies of membrane sweeping during initiation of induction of labor. Study appraisal and synthesis methods: the primary outcome was the rate of spontaneous labor. Meta-analysis was performed using the random-effects model of DerSimonian and Laird, to produce relative risk (RR) with 95\% confidence interval (CI).

\textbf{Results:} Two studies met inclusion criteria and were included in our meta-analysis (\textit{n} = 361). Membrane sweeping did not have an effect on the onset of labor (RR 1.05, 95\% CI 0.92–1.20). There was no significant difference for the rate of spontaneous vaginal delivery (RR 1.06, 95\% CI 0.84–1.34), operative vaginal delivery (RR 0.97, 95\% CI 0.25–3.78), or cesarean delivery (RR 1.00, 95\% CI 0.87–1.14).

\textbf{Conclusion:} Membrane sweeping in patients planning a trial of labor after cesarean was not found to be effective in promoting the onset of labor. This systematic review highlights the limited data addressing the utility of membrane sweeping for women with prior cesarean delivery.

\textbf{Introduction}

Due to the increasing rates of cesarean deliveries and their associated morbidity, there is an increasing focus on both prevention of the primary cesarean as well as on the benefits to vaginal birth after cesarean (VBAC) \cite{1}. Potential benefits of a VBAC as cited by the American College of Obstetrics and Gynecology (ACOG) include avoidance of major abdominal surgery and the associated risks of infection, hemorrhage, thromboembolism, as well as faster recovery from delivery. Avoiding the risks of repeat cesareans also prevents injury to other organs and abnormal placentation \cite{1}.

The most serious morbidity cited by providers when discussing a trial of labor after cesarean (TOLAC) includes that of uterine rupture or scar disruption. This risk increases in patients undergoing induction or augmentation with pharmacologic agents \cite{2}. Prostaglandins are not recommended for use as cervical ripening agents in the USA due to the increased risk of uterine rupture in a patient undergoing a trial of labor after cesarean, limiting the options available for a patient being induced while undergoing a TOLAC \cite{1,3–5}. Additionally, VBAC rates increase when a patient presents in spontaneous labor \cite{6–8}. Given these factors, there is a need to identify other
mechanisms to increase the rate of spontaneous labor and vaginal deliveries for women undergoing a TOLAC.

One technique that may benefit patients who plan a TOLAC is membrane sweeping. Membrane sweeping may be performed during a vaginal exam when a clinician’s finger is introduced into the cervical os and separates the amniotic membrane from the lower uterine segment using circular movements. This intervention has been shown to increase local production of prostaglandins and stimulate the onset of labor [9].

A Cochrane analysis that included 22 trials demonstrated that membrane sweeping at term does promote the onset of labor and reduce the need for formal induction of labor [9] but did not specifically address if these benefits are seen in women undergoing a TOLAC. Each primary article included in the prior Cochrane meta-analysis was reviewed and found to either exclude patients with a previous uterine scar or did not mention whether this was an exclusion criterion, so the TOLAC subpopulation information was unavailable from the previous meta-analysis performed on membrane sweeping [9]. The primary aim of this systematic review and meta-analysis of randomized controlled trials (RCTs) was to determine the efficacy of membrane sweeping on promoting the onset of labor in patients undergoing a TOLAC.

Materials and methods

Search strategy

The research protocol was designed a priori, defining methods for searching the literature, including and examining articles, and extracting and analyzing data. Searches were performed in Medline, Ovid, Scopus, ClinicalTrials.gov, and the Cochrane Central Register of Controlled Trials with the use of a combination of keywords and text words related to “membrane sweeping,” “membrane stripping,” “trial of labor after cesarean,” and “vaginal birth after cesarean” from inception of each database until April 2018 (see supplement 1 for search strategy). To locate additional publications, we reviewed bibliographies of identified studies and review articles. No restrictions for language or geographic location were applied.

Study selection

We included all RCTs of singleton or twin gestations that evaluated membrane sweeping in patients undergoing a trial of labor after cesarean. Exclusion criteria were trials that did not examine patients with a history of prior cesarean due to exclusion or did not mention these patients. Studies that provided membrane sweeping in the office prior to induction were included. We also excluded quasi-randomized trials (i.e. trials in which allocation was done on the basis of a pseudorandom sequence, e.g. odd/even hospital number or date of birth, alternation), and trials that included women with contraindications to vaginal delivery (e.g. placenta previa, placenta accreta, vasa previa). Before data extraction, the protocol was registered with Prospero (Registration number: CRD42018096260). The meta-analysis was reported following the Preferred Reporting Item for Systematic Reviews and Meta-analyses (PRISMA) statement [10].

Risk of bias

The risk of bias in each included study was assessed by two authors (OH and JQN) using the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions [11]. Seven domains related to risk of bias were assessed in each included trial since there is evidence that these issues are associated with biased estimates of treatment effect: (1) random sequence generation; (2) allocation concealment; (3) blinding of participants and personnel; (4) blinding of outcome assessment; (5) incomplete outcome data; (6) selective reporting; and (7) other bias. Review authors’ judgments were categorized as “low risk,” “high risk,” or “unclear risk” of bias.

Outcomes

Data abstraction was completed by two independent investigators (OH, JQN). Each investigator independently abstracted data from each study and analyzed data separately. The primary outcome was the rate of onset of spontaneous labor. The secondary delivery outcomes included rates of spontaneous vaginal delivery, operative vaginal delivery, and cesarean delivery. In addition, the indications for cesarean were included (i.e. maternal request, fetal distress, etc.), as well as rates of chorioamnionitis (Triple I), endometritis, fever, or uterine rupture. Secondary neonatal outcomes include admission to the neonatal intensive care unit, Apgar scores, and neonatal umbilical artery pHs when available. All analyses were done using an intention-to-treat approach, evaluating women according to the treatment group to which they were randomly allocated in the original trials.
**Statistical analysis**

The data analysis was completed independently by authors (OH, JQN) using Review Manager 5.3 (The Nordic Cochrane Centre, Cochrane Collaboration, 2014, Copenhagen, Denmark). The completed analyses were then compared, and any difference was resolved with discussion and involvement of a third party (VB). Data from each eligible study were extracted without modification of original data. Each outcome was assessed for the relative risk (RR); for continuous outcomes means ± standard deviation were imported into Review Manager v. 5.3 (The Nordic Cochrane Centre, Cochrane Collaboration, 2014, Copenhagen, Denmark), wherein the data analysis was completed.

Meta-analysis was performed using the random-effects model of DerSimonian and Laird, to produce summary treatment effects in terms of RR or mean difference (MD) with 95% confidence interval (CI). Heterogeneity was measured using I-squared (Higgins I²). The random effects model was chosen due to the potential significant differences between studies including implementation of the intervention, gestational age at recruitment and thus initiation of weekly membrane sweeping, Bishop score at recruitment, and previous vaginal delivery prior to TOLAC.

Potential publication biases were assessed statistically by using Beggs’s and Egger’s tests. P-values < .05 were considered statistically significant. We planned the following subgroup analyses: by parity, any history of prior vaginal delivery or vaginal birth after cesarean, Bishop score < 5, and BMI < 30 and > 30.

**Results**

**Study selection and study characteristics**

A total of 320 records were screened, and 35 full-text articles were assessed for eligibility (Figure 1). Among these, 31 articles were excluded due to excluding patients undergoing TOLAC or not specifying. One article did not examine membrane sweeping, and one randomized control trial that was excluded was registered with clinicaltrials.gov and undergoing recruitment but not yet completed as of April 2018 [12]. Two randomized controlled trials comparing membrane sweeping versus no sweeping in patients undergoing TOLAC [13,14] were included. No trials were excluded for quasi-randomization or other methodologic exclusions.

Both studies had a low risk of bias in allocation concealment and selective reporting by the Cochrane Collaboration’s tool. Because of the nature of the technique, blinding was not considered possible and both trials were at high risk of performance bias (Figure 2).
**Synthesis of results**

The characteristics of the two included trials are summarized in Table 1 and details of the membrane sweeping intervention are summarized in Table 2. In both trials, patients who had a history of only one prior cesarean section were included. Patients in both studies underwent weekly membrane sweeping beginning at 36 weeks in the Hamdan et al. [13] trial and 39 weeks in the Ramya et al. [14] trial. The average bishop score at recruitment was higher in the Ramya et al. trial, reported as 2.4 ± 0.5 versus 3.0 ± 0.9 (mean ± standard deviation), sweeping versus no sweeping, respectively, versus the Hamdan et al. trial, reported as 1 [1] versus 1 [2] (data only available as median [IQR]) for the sweeping versus no sweeping groups, respectively.

Of 361 women, 182 (50.4%) were randomized to membrane sweeping whereas 179 (49.6%) were randomized to the control group of no membrane sweeping. One of these studies was conducted in Malaysia and one in India. Table 3 summarizes the baseline patient demographics in both included studies. In both studies, only patients who had a history of one prior cesarean were included. There were a total of 56 patients with a prior successful VBAC. The final results were not stratified by patients with a prior history of VBAC in either study.

Primary and secondary outcomes are summarized in Table 4. There was no significant difference between TOLAC patients undergoing sweeping of membranes versus no sweeping achieving onset of spontaneous labor (71.4 versus 68.7%; RR 1.05, 95% CI 0.92–1.20) (Figure 3). The results were not significant for secondary delivery outcomes including spontaneous vaginal delivery (RR 1.06, 95% CI 0.84–1.34), operative vaginal delivery (RR 0.97, 95% CI 0.25–3.78), or cesarean delivery (RR 1.00, 95% CI 0.87–1.14) (Table 4). There were also no differences in indications for those who underwent a repeat cesarean delivery. Only one study reported neonatal outcomes including intrapartum fever and neonatal umbilical artery pH as well as the maternal outcome of postpartum fever, and no differences were found in either group [13]. Notably, there were no reports of uterine rupture in either study, and there was one uterine dehiscence in the control group of the Ramya et al. [14] study (RR 0.33, 95% CI 0.01–8.05).

We were unable to perform our planned subgroup analyses regarding analysis by parity, any history of
prior vaginal delivery, Bishop score < 5, and BMI < 30 and > 30 due to a lack of available data. These parameters were each included by either one or both studies as baseline characteristics but results were not stratified by these parameters and thus we were unable to analyze these outcomes in our meta-

Table 1. Characteristics of included studies.

|                         | Hamdan (1) 2009 | Ramya (2) 2015 | Totals |
|-------------------------|-----------------|----------------|--------|
| Total patients          | 211 (107 versus 104) | 150 (75 versus 75) | 361 (182 versus 179) |
| Study Design            | RCT             | RCT            | –      |
| Gestational ages        | 36–41 weeks     | 39–41 weeks    | –      |
| Study Location          | Malaysia        | India          | –      |
| Inclusion criteria      | > 36 weeks, one prior transverse lower segment cesarean scar, singleton pregnancy, cephalic, intact membranes, agreeable to VBAC | One previous cesarean section with nonrecurrrent indications, singleton pregnancy, cephalic, intact membranes | –      |
| Exclusion criteria      | Contraindications to VBAC | Multiple gestations, medical comorbidities, gestational age < 39 weeks, history of prema-ture rupture of membranes, contraindications to VBAC | –      |
| Mode of induction       | Up to delivery provider: (vaginal PGE₂, oxytocin) | NR              | –      |
| Definition for spontaneous onset of labor | Regular painful contractions resulting in dilation of ≥ 3 cm or prelabor rupture of membranes | NR            | –      |

Data are presented as total number (n sweeping group/no sweeping control group) as number (percentage) or as mean ± standard deviation. NR: not reported; PGE₂: prostaglandin E₂.

*aContraindications listed: placenta previa, suspected macrosomia, suspected cephalopelvic disproportion, abnormal fetal lie, obstructive pelvic masses.

*bGestational diabetes, chronic or gestational hypertension, preeclampsia.

*cContraindications listed: malpresentation, placenta previa, abruptio, suspected cephalopelvic disproportion, vasa previa, congenital anomalies, any previous abortions, more than one transverse lower segment scar, classical incision or gynecologic uterine surgeries.

Table 2. Detail of intervention – membrane sweeping.

|                         | Hamdan (1) 2009 | Ramya (2) 2015 |
|-------------------------|-----------------|----------------|
| Timing of membrane sweeping | Weekly membrane sweeping from the time of recruitment between 36 weeks and delivery | Weekly membrane sweeping between 39 and 41 weeks |
| Median number of sweep sessions | 2 | NR |
| Method/technique of sweeping | Finger placed as high as possible past the internal cervical os, and the membranes were swept off the lower pole of the uterus by a complete circular sweep of the finger, once clockwise and once counterclockwise. In the event of a closed internal or external cervical os, the cervical canal or external cervix was swept with 2 circular motions. | Fetal membranes separated from the cervix and lower uterine segment as far as possible by sweeping a finger 360 degrees. If cervix closed, attempts to stretch the cervix open or cervical massage was performed |
| Technique performed in the control group | Weekly gentle vaginal examination for Bishop score | Gentle vaginal exam at 39 weeks once for Bishop score |

NR: not reported.

Table 3. Patient demographics.

|                         | Hamdan (1) 2009 | Ramya (2) 2015 | Totals (%) |
|-------------------------|-----------------|----------------|-------------|
| Age (years)             | 30.7 ± 3.5 versus 31.5 ± 3.9 | 26.7 ± 3.3 versus 26.8 ± 3.5 | 28.7 versus 29.2 |
| Body mass index         | 29 ± 5 versus 29 ± 5 | NR | – |
| Gestational age at recruitment (weeks) | 37.3 ± 0.4 versus 37.3 ± 0.4 | NR | – |
| Parity                  | NR              | 2.1 ± 0.3 versus 2.1 ± 0.3 | – |
| One prior cesarean      | 213 (100)       | 150 (100)      | 363 (100)   |
| More than one prior cesarean | 0 (0)         | 0 (0)          | 0 (0)       |
| Any prior vaginal delivery | 36/108 (33.3) versus 37/105 (35.2) | NR | – |
| Prior vaginal birth after cesarean | 23/108 (21.3) versus 23/105 (21.9) | 3/75 (4.0) versus 7/75 (9.3) | 26/183 (14.2) versus 30/180 (16.7) |
| Bishop score at recruitment | 1 [1] versus 1 [2] | 2.4 ± 0.5 versus 3.0 ± 0.9 | – |
| Indication for previous cesarean | Failure to progress | 33/108 (30.6) versus 32/105 (30.5) | NR | – |
| Nonreassuring fetal status | 33/108 (30.6) versus 30/105 (28.6) | NR | – |
| Malpresentation | 25/108 (23.1) versus 13/105 (22.8) | NR | – |
| Other                   | 17/108 (15.7) versus 17/105 (16.2) | NR | – |
| Interval since cesarean (y) | 3.5 ± 2.3 versus 3.7 ± 2.6 | NR | – |

Data are presented as total number (n sweeping group/no sweeping control group) as number (percentage) or as mean ± standard deviation. NR: not reported.

*aData only available as median [IQR].
Attempts were made to contact authors of both studies for all missing data with no response. 

Main findings

This meta-analysis of two randomized controlled trials was unable to show whether membrane sweeping increased the incidence of spontaneous labor in patients undergoing TOLAC. The results of secondary outcomes analyzed were not different between the two groups (membrane sweeping versus no sweeping). We were unable to determine whether membrane sweeping is an effective means of achieving spontaneous labor in patients undergoing a trial of labor after cesarean. This is due to a likely type II error as only 361 women were included in total, and the heterogeneity was high. There were no uterine ruptures, and only one incidence of uterine dehiscence in the control group (no sweep) of one included study [14].

Strengths and limitations

Strengths of this meta-analysis include the examination of a population of patients that have not been extensively studied in regards to membrane sweeping to promote the onset of spontaneous labor. Additionally, the two randomized controlled trials that were overall judged to be of low risk of selection bias.

Our study is inherently limited by the RCTs included in our review, which do not allow completion of subgroup analyses. Another limitation is the small number of patients available to review and the heterogeneity between the two studies. A major source of heterogeneity was the definition of the primary outcome of “spontaneous labor” in the two included studies. Hamdan et al. [13] clearly define spontaneous labor as

| Primary outcome | Hamdan (1) 2009 | Ramya (2) 2015 | Totals | RR (95% CI) |
|-----------------|-----------------|----------------|--------|-------------|
| Spontaneous onset of labor* | 84/107 (78.5) versus 75/104 (72.1) | 46/75 (61.3) versus 48/75 (64) | 130/182 (71.4) versus 123/179 (68.7) | 1.05 [0.92, 1.20] |
| Spontaneous vaginal delivery | 60/107 (56.1) versus 54/104 (51.9) | 13/75 (17.3) versus 14/75 (18.7) | 73/182 (40.1) versus 68/179 (38.0) | 1.06 [0.84, 1.34] |
| Operative vaginal delivery | 4/107 (3.7) versus 4/104 (3.8) | 0/75 (0) versus 0/75 (0) | 4/182 (2.2) versus 4/179 (2.2) | 0.97 [0.25, 3.78] |
| Cesarean delivery | 43/107 (40.2) versus 46/104 (44.2) | 62/75 (82.7) versus 61/75 (81.3) | 105/182 (57.7) versus 107/179 (59.8) | 1.00 [0.87, 1.14] |
| Uterine dehiscence | NR | 0/75 (0) versus 0/75 (0) | 0/75 (0) versus 0/75 (0) | 0.33 [0.01, 8.05] |
| Uterine rupture | 0/107 (0) versus 0/104 (0) | 0/75 (0) versus 0/75 (0) | 0/104 (0) versus 0/107 (0) | – |
| Indication for cesarean | Maternal request | 13/43 (30.2) versus 16/46 (34.8) | 21/62 (33.8) versus 23/61 (37.7) | 34/105 (32.4) versus 39/107 (36.4) | 1.05 [0.61, 1.81] |
| | Scar tenderness | NR | 20/62 (32.2) versus 19/61 (31.1) | 20/62 (32.2) versus 19/61 (31.1) | 0.87 [0.58, 1.30] |
| | Fetal distress | 15/43 (34.9) versus 15/46 (32.6) | 8/62 (12.9) versus 12/61 (19.7) | 23/105 (21.9) versus 27/107 (25.2) | 1.06 [0.50, 1.41] |
| | Malpresentation | 2/43 (4.7) versus 2/46 (4.3) | NR | 2/43 (4.7) versus 2/46 (4.3) | 0.97 [0.14, 6.77] |
| | Failure to progress | 12/43 (27.9) versus 9/46 (19.6) | NR | 12/43 (27.9) versus 9/46 (19.6) | 1.30 [0.57, 2.95] |
| | Other | 1/43 (2.3) versus 4/46 (8.7) | 13/62 (20.9) versus 7/61 (11.5) | 14/105 (13.3) versus 11/107 (10.3) | 0.86 [0.12, 6.09] |
| | Gestational age at delivery | 39.6 ± 1.0 versus 39.6 ± 0.9 | 40.00 ± 0.56 versus 39.92 ± 0.55 | – | Mean difference 0.05 (–0.09, 0.20) |
| | Received prostaglandins | 5/107 (4.6) versus 2/104 (1.9) | NR | NR | 2.43 [0.48, 12.25] |
| | Chorioamnionitis | NR | NR | NR | – |
| | Endometritis | NR | NR | NR | – |
| | Intrapartum fever ≥38°C | 2/90 (2.2) versus 3/82 (3.7) | NR | NR | 0.65 [0.11, 3.80] |
| | Postpartum fever ≥38°C | 10/101 (9.9) versus 6/99 (6.1) | NR | 8/62 (12.9) versus 12/61 (19.7) | 1.62 [0.61, 4.30] |
| | Postpartum hemorrhage | 21/99 (21.2) versus 23/98 (23.5) | NR | NR | 0.89 [0.52, 1.50] |
| Neonatal outcomes | Neonatal intensive care | NR | NR | NR | – |
| | Neonatal umbilical artery pH ≤ 7.1 | 7.31 ± 0.06 versus 7.30 ± 0.06 | NR | 1 (0) versus 0 (0) | 2.92 [0.12, 70.79] |

Data are presented as total number (n sweeping group /no sweeping control group) as number (percentage) or as mean ± standard deviation. NR, not reported.

*Spontaneous onset of labor defined in Hamdan et al. [13] as “Regular painful contractions resulting in dilation of ≥3 cm or prelabor rupture of membranes,” not reported in Ramya et al. [14].

Some data missing as per Hamdan [13].
“regular painful contractions resulting in dilation of \( \geq 3 \) cm or prelabor rupture of membranes,” while Ramya et al. [14] did not provide a definition making us unable to determine the comparability of this important outcome.

**Comparison with existing literature and implication**

Many previous studies examining membrane sweeping have been conducted, some with conflicting results. Ultimately the 2005 Cochrane review demonstrated there was a benefit in decreasing the time to onset of spontaneous labor and reduced the need for formal induction of labor [15]. The Cochrane review showed that 1 out of 8 patients would go into spontaneous labor. The results of this study do not draw the same conclusions about the benefits of membrane sweeping in patients who are undergoing a TOLAC. Both of the included studies also had negative results concluding that membrane sweeping did not increase the rate of onset of spontaneous labor [13,14]. This may be due, in part, to the small number of participants identified in the two studies, and the heterogeneity between the studies, most notably the above-mentioned lack of clear criteria cited by Ramya et al. [14] to define the spontaneous onset of labor. There was also heterogeneity within each study in terms of including patients with prior successful vaginal delivery and VBAC as well as no prior VBAC, with the latter being at higher risk of undergoing a repeat cesarean delivery [16].

Due to these limitations, especially in the number of included studies, our current meta-analysis is at high risk of suffering from a Type-II error. Before adequate conclusions can be made regarding the efficacy of membrane sweeping in patients undergoing a TOLAC, additional studies are warranted. Women who are undergoing a trial of labor after cesarean are subject to a multitude of factors that increase their risk of repeat cesarean and are deserving of increased studies to determine efficacious and safe practices to increase their chances of a successful VBAC through achieving spontaneous labor. Larger studies with more power to detect differences are still needed.

The main purpose and potential benefit of membrane sweeping are promoting the onset of labor without formal induction methods such as oxytocin or prostaglandins, the latter of which is not recommended for use in patients with a prior cesarean [1]. In addition to this potential decrease in the need for pharmacologic agents being a preferable concept to some women, it also potentially eliminates the need for as long a period of formal electronic fetal monitoring and hospital stay as would be necessary with the administration of such induction agents and is a low-cost technique. Even more significant than the reduced need for pharmacologic agents, women who plan a TOLAC are highly motivated to achieve a vaginal delivery and their chance of success is known to be increased when they present in spontaneous labor [6–8]. The association between advanced dilation and the likelihood of TOLAC success has been shown in repeated studies [6–8]. Conversely, adverse effects of membrane sweeping include discomfort during the vaginal exam, bleeding, and irregular contractions [15].

The risks/benefits of this procedure should be carefully weighed with each individual patient. As there is a potential benefit shown in patients overall in previous studies, it is not unreasonable to offer membrane sweeping, however, patients should be aware that it may cause discomfort without increasing their chance of achieving onset of labor.

In conclusion, the limited available evidence does not demonstrate the benefit of membrane sweeping in patients planning a trial of labor after cesarean in promoting the onset of labor. This systematic review highlights the limited data addressing the utility of membrane sweeping for women with prior cesarean delivery and identifies an area that requires further investigation.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

**ORCID**

Odessa Hamidi http://orcid.org/0000-0002-6475-8238
Vincenzo Berghella http://orcid.org/0000-0003-2854-0239
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