NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section

In late pregnancy, if the cervix does not dilate fully, several methods can be used to encourage the cervix to open and induce labour. In this procedure, a thin plastic tube (catheter) is passed through the cervix from the vagina to the uterus. Two small balloons on the catheter are inflated either side of the cervix, 1 inside the uterus and 1 in the vagina, with the aim of causing the cervix to dilate and inducing labour.

Introduction

The National Institute for Health and Care Excellence (NICE) has prepared this interventional procedure (IP) overview to help members of the Interventional Procedures Advisory Committee (IPAC) make recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This IP overview was prepared in November 2014.

Procedure name

- Insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section

Specialist societies

- Royal College of Obstetricians and Gynaecologists
- Royal College of Midwives.

Description

Indications and current treatment

Induction of labour is the most commonly performed obstetric intervention. It occurs in up to 20% of pregnancies in the UK and is generally carried out when the risks of continuing pregnancy outweigh the benefits. It is usually more painful than spontaneous labour, and epidural analgesia and assisted delivery are more likely to be needed. Maternal and fetal indications for induction of labour include pregnancy-induced hypertensive disorders, diabetes, post-term pregnancy, estimated large-for-date fetus, thrombophilia, intra-uterine fetal growth restriction, oligohydramnios, non-reassuring fetal status and fetal death.

Various methods are used to ripen and dilate the cervix and successfully induce labour in women when the cervix is unfavourable for induction. These include pharmacological methods (prostaglandins in the form of vaginal gels or tablets, or pessaries, and oxytocin as a slow intravenous infusion), surgical methods (amniotomy, alone or with oxytocin) and mechanical methods (laminaria tents and balloon catheters introduced through the cervix into the cervical canal and the extra-amniotic space). The aim of mechanical interventions is to ripen and dilate the cervix and promote onset of labour by applying pressure on the internal cervical os by indirectly increasing local secretion of prostaglandins and oxytocin, or both. Also, mechanisms which involve neuroendocrine reflexes may promote the onset of uterine contractions. A standard Foley urinary catheter is commonly used, with the balloon inflated in the extra-amniotic space and the catheter then put under tension to pull back against the cervical os. Sometimes saline solution is also infused in the extra-amniotic space as an adjunct.

What the procedure involves

Insertion of a double balloon catheter for induction of labour at term in pregnant women aims to facilitate induction through causing dilation of the cervix when the cervix is unfavourable for induction. The double balloon is claimed to stimulate local prostaglandin release, which leads to cervical ripening, through the 2 balloons squeezing the cervix.

The procedure is usually done with the woman in a lithotomy or supine position. A sterile speculum is inserted into the vagina to gain access to the cervix. The cervix is then prepared by cleaning with an appropriate antiseptic solution before inserting the device. A double balloon catheter (with a uterine balloon and a vaginal balloon) is inserted through the cervical canal and into the uterus, so that the tip of the catheter lies in the extra-amniotic space. The uterine balloon is then inflated with a small amount of saline and the catheter is gently pulled back until the uterine balloon lies against the internal cervical os. The vaginal balloon is also inflated with saline so that it lies against the external cervical os. Both the balloons are inflated alternatively and incrementally with small amounts of saline.

Once the balloons are fully inflated and in place on both sides of the cervix, the speculum is removed. The external end of the device is loosely taped to the woman's inner thigh.

Following the insertion of the double balloon, a fetal non-stress test is done and sometimes extra-amniotic saline is infused at the same time. The mother and fetus are monitored and the device is left in place for up to about 12 hours. If labour begins, or spontaneous device expulsion or rupture of membranes have occurred, or if fetal distress is suspected, the balloons are deflated and the device is removed to facilitate labour management. If labour does not begin spontaneously, the membranes are ruptured artificially and oxytocin infusion is started.

Outcome measures

Bishop score

The Bishop score is a group of measurements based on the station, dilation, effacement (or length), position and consistency of the cervix. A score of 8 or more generally indicates that the cervix is ripe, or 'favourable' – when there is a high chance of spontaneous labour, or response to interventions made to induce labour.

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section. The following databases were searched, covering the period from their start to 27.11.2014: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches (see appendix C for details of search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The following selection criteria (table 1) were applied to the abstracts identified by the literature search. Where selection criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, or a laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising study methodology, unless they reported specific adverse events that were not available in the published literature.
Patient	Pregnant women without a previous caesarean section.
Intervention/test	Insertion of a double balloon catheter for induction of labour.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the IP overview

This IP overview is based on 2262 patients (of which1260 patients had a double balloon catheter) from 9 randomised controlled trials.

Other studies that were considered to be relevant to the procedure but were not included in the main extraction table (table 2) have been listed in appendix A.

Table 2 Summary of key efficacy and safety findings on insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section

Study 1 Salim R (2011)

Details

Study type	Randomised controlled trial
Country	Israel (single centre)
Recruitment period	2008–10
Study population and number	n=**302 pregnant women with unfavourable cervix at term needing induction of labour** 148 DBC versus 154 SBC
Age	DBC mean 29.2 years; SBC mean 28.8 years
Patient selection criteria	Women with fetal or maternal indication for induction of labour, viable singleton pregnancy, cephalic presentation, intact membranes, and Bishop score of 6 or less were included. Any contraindication for vaginal delivery, previous caesarean delivery, low-lying placenta, fetal malformations, intrauterine fetal death, clinical amnionitis, women with Hepatitis B or C, or HIV, and with a history of allergy to latex were excluded.
Technique	DBC: Cook cervical ripening balloon was inserted through the cervix and the balloons either side of the cervix were inflated with 80 ml saline. Catheter taped to the inner thigh without tension. SBC: 16F Foley catheter inserted and filled with 60 ml saline. Catheter strapped to 1 leg on slight tension. Catheter removed after 12 hours if spontaneous expulsion had not occurred. Fetal heart rate monitoring done before and for 60 minutes after catheter insertion. All patients were managed identically and membranes ruptured artificially and oxytocin infused if labour did not commence spontaneously or after catheter removal.
Follow-up	**24–48 hours**
Conflict of interest/source of funding	No conflicts of interest.

Analysis

Follow-up issues: Six women in the DBC group (1 chose to stop, 2 had spontaneous progression, 1 requested catheter removal because of discomfort and 2 delayed catheter removals) and 3 women in the SBC group (2 chose to stop during insertion and 1 delayed catheter removal) were excluded from the analysis.

Study design issues: Prospective study with large sample size, randomisation sequence generated in blocks of 10, concealed allocation, blinding was not performed. Management of induction of labour was standardised. Some women had prostaglandin oestradiol before catheter insertion.

Maternal and fetal indications included hypertensive disorders, diabetes, post-term pregnancy, thrombophilia, women's request, intra-uterine growth restrictions, oligohydramnios, non-reassuring fetal status, estimated large for date fetus.

Study population issues: Demographic and obstetric parameters were comparable between the 2 groups.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **293**

Delivery and neonatal outcomes

	DBC (n=148)	SBC (n=145)	p value
Time from catheter insertion to delivery (hours)*	**19.1±6.8**	**19.4±6.0**	**0.80**
Primiparous women	21.6±6.9 (n=78)	21.6±5.9 (n=77)	0.78
Multiparous women	16.4±5.6 (n=70)	16.8±5.1 (n=68)	0.63
Time from catheter insertion to vaginal delivery (hours)*	**17.8±6.1**	**18.9±5.8**	**0.22**
Primiparous women	20.2±6.4 (n=78)	21.1±5.7 (n=77)	0.79
Multiparous women	15.6±4.9 (n=70)	16.6±5.0 (n=68)	0.22
Vaginal delivery within 24 hours from catheter insertion % (n)	**84.4 (103)**	**80.8 (105)**	**0.44**
Primiparous women	64.1 (50/78)	64.9 (50/77)	0.91
Multiparous women	92.9 (65/70)	92.6 (63/68)	0.78
Mode of delivery % (n)			
Spontaneous vaginal delivery	74.3 (110)	85.5 (124)	0.02^
Assisted vaginal delivery	8.1 (12)	4.1 (6)	0.22
Caesarean section	17.6 (26)	10.3 (15)	0.09
Other			
Epidural use % (n)	52.7 (78)	45.5 (66)	0.24
Mean hospitalisation after delivery (days)	3.48	3.46	0.91
Birth weight (g)*	3166±483	3215±483	0.39

*Data are mean ± standard deviation

^Odds ratio 0.49 95% CI 0.26-0.92.

Spontaneous expulsion compared with planned removal of catheter

	Spontaneous expulsion (n=124)	Planned removal of catheter (n=169)	p value	Risk ratio (95% CI)
Time from insertion to delivery*	17.2±6.1	20.8±6.2	0.001	1.10 (1.06–1.15)
Operative deliveries % (n) (vacuum/ caesarean)	12 (15/124)	26 (44/169)	0.003	2.15 (1.26–3.69)

*Data are mean ± standard deviation

Safety

Adverse events

	DBC % (n=148)	SBC % (n=145)	p value
Total adverse events	**7.4 (11)**	**1.4 (2)**	**0.02^**
Intra-partum fever>38^0 C	5.4 (8)	1.4 (2)	0.10
Cord prolapse (emergency caesarean delivery done)	0.7 (1)	0	0.85
Fetal malpresentation after catheter removal (1 woman delivered vaginally after external cephalic version and 1 had a caesarean section)	1.4 (2)	0	0.70
Bleeding related to catheter insertion	0	0	
Admission to neonatal ICU	2.7 (4)	5 (7)	0.37
Culture proven sepsis in newborn	1	0	
Apgar score <7 at 5 minutes	0	0	

^Odds ratio 0.17 95% CI 0.04-0.80.

Abbreviations used: CI, confidence interval; DBC, double balloon catheter; SBC, single balloon catheter; ICU, intensive care unit.

Studies 2, 3, 4 Mei-Dan E (2012), Mei-Dan E (2014) – nested study within Mei-Dan E (2012), Walfisch A (2014) – secondary analysis

Details

Study type	Quasi RCT
Country	Israel (single centre)
Recruitment period	2007–11
Study population and number	n=**188 women at term with singleton pregnancy presented for induction of labour** 100 DBC without EASI versus 88 control (SBC+EASI)[2]. **Nested study:** n=186 (60 DBC+EASI versus 126 SBC+EASI)[3] **Secondary analysis:** n=160 (60 DBC+EASI versus 100 DBC without EASI)[4]
Age	DBC mean 27.7 years; SBC+EASI mean 29.2 years
Patient selection criteria	Women with singleton pregnancy in a vertex presentation with intact membranes at term (37 weeks or more), various indications for induction of labour, unfavourable cervix – Bishop score ≤4 were included. Women with contraindications for a vaginal delivery (placenta previa, non-vertex presentation), presence of ruptured membranes, presence of a uterine scar, and suspected fetal distress or non-reassuring fetal heart rate needing immediate intervention were excluded.
Technique	DBC group (2007–10): Cook's device was inserted through the cervix and the balloons either side of the cervix were inflated with 80 ml saline each. Catheter taped to the inner thigh without tension. Later in the course of study (2010–11), concomitant EASI at a rate of 50 ml/hour was given with DBC. SBC group (2001–11): 30ml Foley catheter (16 Fr) with concomitant EASI at a rate of 50 ml/hour was inserted. Balloon expulsion was monitored and, if not spontaneously expelled, it was removed after 12 hours. Induction of labour (either by intravenous administration of oxytocin or artificial rupture of membranes using standard protocols) commenced if Bishop score was increased by 2 or more points or cervical dilation of 3 cm. In case of failure of method of induction of labour, patient reassessed for a different method.
Follow-up	**48 hours**
Conflict of interest/source of funding	No conflicts of interest.

Analysis

Study design issues: Large sample size, systematic sampling used for quasi-random allocation – women who presented for induction of labour in even months were assigned to DBC group and those on odd months to SBC group, physicians were not blinded to intervention. Standard protocols for induction of labour and oxytocin were used and management was identical in both study groups, analysis on an intention to treat basis.

Three different analyses performed to compare different combinations of 2 mechanical cervical ripening devices with or without EASI. A nested study (Mei-Dan 2014), within this RCT (Mei-Dan 2012) compared women having a DBC plus EASI (2010–11) to women having a SBC plus EASI (2007–11). A secondary analysis of the same RCT (Walfisch 2014) compared women having a DBC plus EASI to women having a DBC without EASI.

Study population issues: There were no significant differences in baseline demographic, obstetric characteristics and indications for induction between groups; 49% (93/188) women were nulliparous or primiparous. Indications included post-term pregnancy, hypertensive disorders, diabetes, non-assuring fetal heart rate and oligohydramnios. Oligohydramnios was the most common indication for labour in the control group.

Other issues: DBC with EASI system was commercially available only during the middle of this study period.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **188**

Obstetrical outcomes[2]

	DBC (n=100)	SBC+EASI (n=88)	p value
Time from insertion to expulsion (median, hours : minutes)	11:35 (10.07±4.40)	6:10 (6.56±4.13)	0.001
Time from insertion to active labour* (median, hours : minutes)	17:30 (19:56±16:03)	14:45 (15:50±7.57)	0.065
Time from insertion to delivery (median, hours : minutes)	20:45(23:25±15:32)	17:25 (19:37±11:22)	0.03
Time from removal to delivery (median, hours : minutes)	10:50 (14:49±14:45)	11:17 (14:01±10:58)	0.82
Ripening success** (%)	99	96.5	0.34
Use of analgesia (%)	90.9	87.8	0.62
Episiotomy (%)	24	46	0.09
Operative vaginal delivery (%)	13	20.7	0.12
Caesarean section (%)	20.0	20.7	>0.99
Birth weight (median, g)	3255 (3203±565)	3110 (3072±99)	0.09
Apgar score (0-10) at 5minutes+	9.8±0.4	9.8±5	0.77
Pain perception during catheter insertion (VAS, 0–10^^)+	3.4±2.3	3.3±2.3	0.77
Maternal satisfaction (Likert scale,1–10^)+	6.5±3.2	7±2.8	0.64

*Active labour defined as cervical dilation of 4 cm or more in the presence of regular uterine contractions.

**Defined as increase in Bishop score ≥2 points and/or cervical dilation of ≥3 cm)

^Higher scores indicating greater satisfaction, ^^ higher scores indicating worst pain.

+Data are mean ± standard deviation

Obstetrical outcomes (nested study, n=186)[3]

	DBC+EASI (n=60)	SBC+EASI (n=126)	p value
Spontaneous balloon expulsion % (n)	68.5 (37)	82.8 (101)	0.05
Time from balloon insertion to expulsion (hours, median)	8.5	6.5	0.17
Time from insertion to active labour* (median, hours : minutes)	**13:40 (00:10±23:05)**	**14:40 (01:20±52.25)**	**0.21**
Primiparous (median)	16:11	16:50	0.66
Multiparous (median)	11:40	11:50	0.34
Time from insertion to delivery (median, hours : minutes)	**14:19 (00:40±23:30)**	**15:50 (01:19 ±72:00)**	**0.04**
Primiparous (median)	16:35	19:00	0.1
Multiparous (median)	13:10	13:59	0.23
Time from removal to delivery (median, hours : minutes)	**08:15 (00:29±21:34)**	**11:20 (01:08±70:25)**	**0.002**
Primiparous (median)	10:56	13:10	0.006
Multiparous (median)	07:20	07:32	0.12
Ripening success % (n)**	96.4 (54)	92.7 (114)	0.55

Safety

Adverse events

	DBC+ EASI % (n=60)	SBC+ EASI % (n=126)	p value
Device insertion failure	1	1	-
Spontaneous balloon expulsion	68.5 (37)	82.8 (101)	0.05
Pain perception during catheter insertion (VAS, 0–10^^) (mean±SD)	3.7±2.7	3.1±2.3	0.19
Difficulty with catheter insertion (scale 1–5**)	22 (11)	23.3 (27)	1.0
Maternal fever	16 (4)	8 (3)	0.42
	DBC+EASI (n=60)	**DBC-EASI (n=100)**	
Maternal fever	8(5)	6 (6)	0.74

^^Higher scores indicating worst pain.

**Higher scores indicating extreme difficulty.

Spontaneous rupture of membranes	86.3 (44)	58.4 (59)	<0.0001
Oxytocin use	94.7 (54)	91.1 (112)	0.55
Epidural use	80 (44)	75.2 (82)	0.56
Delivery mode % (n)			
Spontaneous vaginal delivery	80 (48)	61.6 (77)	0.01
Operative vaginal delivery	11.7 (5)	17.6 (22)	0.12
Caesarean section	8.3 (5)	20 (25)	0.05
Birth weight (g)+	3129±505	3113±537	0.84
Apgar score (0–10) **at 5 minutes**+	9.9±1.4	9.8±0.5	0.30
Mean hospitalisation length(day)+	4.29±1.8	5.69±2.9	<0.001
Maternal satisfaction (Likert scale,1–10^)+	7.7±2.8	7.0±2.8	0.42

*Active labour defined as cervical dilation of 4 cm or more in the presence of regular uterine contractions.

**defined as increase in Bishop score ≥2 points and/or cervical dilation of ≥3 cm

^Higher scores indicating greater satisfaction

+Data are mean ± standard deviation

Obstetrical outcomes (secondary analysis of RCT, n=160)[4]

	DBC+EASI (n=60)	**DBC-EASI (n=100)**	**p value**
Spontaneous balloon expulsion %(n)	68.5 (37)	51 (51)	0.04
Time from insertion to expulsion (hours, median)	**08:30**	**11:35**	**0.01**
Primiparous (median)	10:20	12:32	0.002
Multiparous (median)	05:50	08:55	0.30
Time from insertion to active labour* (median, hours : minutes)	**13:40 (00:10±23:05)**	**17:30 (01:35±101.00)**	**0.001**
Primiparous (median)	16:11	21:0	<0.001
Multiparous (median)	11:40	14:25	0.06
Time from insertion to delivery (median, hours : minutes)	**14:19 (00:40±23:30)**	**20:45 (03:40±106:30)**	**<0.001**
Primiparous (median)	16:35	24:30	<0.001
Multiparous (median)	13:10	16:18	0.02
Time from removal to delivery (median, hours : minutes)	**08:15 (00:29±21:34)**	**10:50 (00:53±99:30)**	**0.01**
Primiparous (median)	10:56	12:50	0.03
Multiparous (median)	07:20	07:44	0.21
Ripening success % (n)**	96.4 (54)	99 (99)	0.29
Spontaneous rupture of membranes	86.3 (44)	41.7 (35)	<0.001
Oxytocin use	94.7 (54)	89 (89)	0.26
Epidural use	74.6 (44)	68.7 (68)	0.47
Delivery mode % (n)			
Spontaneous vaginal delivery	80 (48)	67 (67)	0.1
Operative vaginal delivery	11.7 (7)	13 (13)	0.57
Caesarean section	8.3 (5)	20 (20)	0.07

Birth weight (g)+	3129±505	3203±565	0.41
Apgar score (0–10) at 5 minutes +	9.9±1.4	9.8±0.	0.53
Hospitalization length (days)+	4.29±1.8	6.69±5.9	<0.001
Maternal satisfaction (Likert scale,1–10^)+	7.7±2.8	6.5±3.2	0.2

*Active labour defined as cervical dilation of 4 cm or more in the presence of regular uterine contractions.

**Defined as increase in Bishop score ≥2 points and/or cervical dilation of ≥3 cm

^Higher scores indicating greater satisfaction

+Data are mean ± standard deviation

Multivariate analysis found EASI to be an independent predictor of a shorter insertion to delivery time (p=0.03).

Summary of 3 studies above[4]

	Caesarean section rate %	**Insertion to delivery (median, hours)**
Study 2		
DBC	20	20.7*
SBC+EASI	20.7	17.4
Study 3		
DBC+EASI	8.3	14.3*
SBC+EASI	20	15.8
Study 4		
DBC+EASI	8.3	14.3
DBC-EASI	20	20.7*

*statistically significant differences between the arms (p≤0.05).

Abbreviations used: DBC, double balloon catheter; EASI, extra-amniotic saline infusion; RCT, randomised controlled trial; SBC, single balloon catheter; VAS, visual analogue scale.

Study 5 Pennell CE (2009)

Details

Study type	Randomised controlled trial
Country	Australia (single centre)
Recruitment period	2001–03
Study population and number	n=**330 nulliparous women with unfavourable cervix at term needing induction of labour** 107 DBC versus 110 SBC versus 113 PGE2 gel.
Age	DBC mean 27 years, SBC mean 26 years, PGE2 mean 27 years
Patient selection criteria	Nulliparous women over 36 weeks' gestation, singleton fetus in cephalic presentation, intact membranes and Bishop's score <4 were included. Women <16 years, with previous uterine surgery, low-lying placenta, any active or purulent infection of the lower vaginal tract, or an abnormal pre-induction fetal heart rate tracing were excluded.
Technique	DBC: Atad ripener device inserted through the cervix and the balloons either side of the cervix were inflated with 80 ml water. Catheter taped to the inner thigh without tension. SBC: 16F Foley catheter inserted and filled with 30 ml sterile water. Catheter strapped to 1 leg on slight tension. Catheters removed after 12 hours if spontaneous expulsion had not occurred. Fetal heart rate monitoring done before and for 60 minutes after catheter insertion. PGE2 gel (2 mg) was placed in the vagina, repeated 6 hourly, maximum 3 doses (mean 1.8 doses). Fetal heart rate monitoring done before and for 60 minutes after each PGE dose. Mechanical dilation patients were managed identically and membranes ruptured artificially and oxytocin infused if labour did not commence. In women with spontaneous labour, amniotomy done after cervical dilation of 3 cm, oxytocin augmentation started if there is inadequate progress 4 hours after membrane rupture.
Follow-up	**24–48 hours**
Conflict of interest/source of funding	No conflicts of interest. Study supported by a grant from the Women and Infants Research Foundation, Australia, and Adeza Biomedical Corporation supported the fetal fibronectin test kits.

Analysis

Follow-up issues: Loss to follow-up described. There were 11 protocol violations (1 woman in the PGE2 group had a Foley catheter inserted after 2 doses of gel, 6 women in SBC group had PGE2 gel after insertion difficulties (n=2) or unsuccessful cervical ripening (n=4), 3 had vaginal delivery and 3 caesarean delivery. Four women in the DBC group had PGE2 gel after catheter removal for maternal side effects (n=2), or unsuccessful cervical ripening (n=2). Two of them had vaginal delivery and 2 had caesarean sections).

Study design issues: Large sample size, randomisation was conducted after stratification by fetal fibronectin status, generation of randomisation sequence unclear, sealed opaque envelopes used (patients chose from a selection of 12 envelopes), blinding of participants and providers was not possible but research midwives were blinded to treatment allocation. Rate of caesarean section analysed on an intention-to-treat basis using the Chi-square test.

Prostaglandin dosage protocol used in the study is different to that recommended by the manufacturer and British Royal College of Obstetrics and Gynaecologists guidelines.

Study population issues: Homogenous group of women, no significant differences in baseline characteristics (gestation age, indications, pre-induction cervical assessment and Bishop scores) between groups. Only 5% of women were induced before 37 weeks of gestation. The majority of women had induction for prolonged pregnancy or hypertension. Indications for caesarean section were failed induction of labour, failure to progress in established labour or non-reassuring fetal status based on electronic fetal monitor (EFM) patterns.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **330**

Delivery outcomes

	DBC % (n=107)	SBC % (n=110)	PGE2 % (n=113)	p value
Mode of delivery %(n)				
Spontaneous vaginal delivery	36 (38)	41 (45)	38 (43)	0.715
Assisted vaginal delivery	22 (23)	23 (25)	25 (28)	0.845
Caesarean section	43 (46)	36 (40)	37 (42)	0.567
Indications for caesarean section				**0.168**
Non-reassuring FHR pattern	33 (15)	14 (35)	20 (47)	-
Failure to progress	21(46)	35 (14)	41 (17)	-
Failed induction of labour^	22 (10)	30 (12)	12 (5)	-
Indications for assisted vaginal delivery				**0.113**
Non-reassuring fetal heart rate pattern	7 (30)	12 (48)	15 (54)	-
Other indications	70 (16)	52 (13)	46 (12)	-
Other outcomes				-
Induction to delivery time (median, hours)*	24.5 95% CI 23.7–30.6	23.2 95% CI 20.8–25.8	23.8 95% CI 21.7–26.8	0.043
Time to active labour (median, hours)*	16.1	14.3	14.5	0.014
Length of labour (hours)	9.8	10.3	9.0	0.152
Vaginal delivery within 24 hours	37 (40)	48 (53)	43 (49)	0.274
Use of analgesia (epidural)	83 (89)	81 (90)	81 (92)	0.951

^Defined as inability to rupture the membranes after 3 doses of PGE2 or 12 hours of mechanical ripening or a cervical dilation of <4 cm after 8 hours of strong contractions

*Estimated from Kaplan–Meier survival analysis

Neonatal outcomes

	DBC % (n=107)	SBC % (n=110)	PGE2 % (n=113)	p value
Birth weight (g)	3540	3405	3440	0.035
Apgar score <7 at 5 minutes	0	2 (2)	3 (3)	0.378
Arterial blood gases				
pH	7.26	7.26	7.25	0.050

Safety

Adverse events

	DBC % (n=107)	SBC % (n=110)	PGE2 % (n=113)	p value
Induction/intrapartum adverse event – discomfort (unable to void in 2 women, decreased balloon volume in 2 women, device removed in1 woman)	5 (5)	0	17 (15)	<0.001
Uterine hyperstimulation with/without FHR changes*	-	-	14 (16)	
Abruption placenta (emergency caesarean done)	-	-	1 (1)	
Readmission to hospital	**4 (4)**	**6 (6)**	**10 (10)**	**0.455**
Endometritis	1	2	2	-
Wound infection	1	2	3	-
UTI, increased vaginal loss and infected perineum	2	2	5	-
Other events				
Postpartum haemorrhage >1000 ml	5 (5)	5 (5)	11 (12)	0.143
Maternal temperature during labour (>37.5 C)	17 (18)	17 (19)	18 (20)	0.999
Antibiotics during labour	24 (26)	24 (26)	17(19)	0.316

*Defined as either the occurrence of 5 or more contractions in 10 minutes for 2 consecutive 10-minute periods or a contraction lasting at least 2 minutes, with or without changes in FHR patterns.

pO_2	15.4	17.5	14.7	0.003
pCO_2	55.3	53.2	57.8	0.003
Neonatal admissions	21 (20)	29 (27)	33 (29)	0.245

Patient satisfaction (assessed using questionnaires 24–48 hours after delivery) (VAS 0–10, with maximum pain or satisfaction scoring 10)

	DBC % (n=107)	**SBC % (n=110)**	**PGE2 % (n=113)**	**p value**
Pain during insertion of ripening device (pain score >4)	NR	NR	NR	0.002
Pain during cervical ripening (pain score >4)	55	36	63	<0.001
Overall satisfaction with induction of labour (median score 8)	NR	NR	NR	0.179

Multivariate regression analysis showed that caesarean section (OR 4.66, 95% CI 2.84–7.65), oxytocin infusion (2.20, 1.08–4.52), gravidity >1 (0.44, 0.25–0.75) were associated with low satisfaction with induction of labour (VAS <8).

Abbreviations used: CI, confidence interval; DBC, double balloon catheter; FHR, fetal heart rate; NR, not reported; OR, odds ratio; PGE2, prostaglandin E2; SBC, single balloon catheter; UTI, urinary tract infection; VAS, visual analogue scale.

Study 6 Kehl S (2014)

Details

Study type	Randomised controlled trial
Country	Germany (5 centres)
Recruitment period	2011–12
Study population and number	n=**326 pregnant women with an unfavourable cervix undergoing induction of labour at term** 168 DBC + OM sequentially versus 158 OM alone.
Age	Mean 30 years in both groups
Patient selection criteria	Pregnant women with singleton pregnancies and a fetus in cephalic presentation at term (>259 days of gestation) with a clinical need for induction of labour were included. Women with a favourable cervix (Bishop score >8), premature rupture of membranes, previous caesarean section, structural or chromosomal fetal malformation, intrauterine fetal death, placenta previa or any other contraindication to vaginal delivery were excluded.
Technique	DBC: on the first day, Cook's device was inserted through the cervix and the balloons either side of the cervix were inflated with 80 ml saline each. Catheter taped to the inner thigh without tension. If DBC did not fall out spontaneously, it was removed 12 hours after placement. If labour did not start after mechanical ripening, then on second day, 50 mg of OM was given 4 hourly, maximum 3 times. A dose of 100 mg was given up to 3 times after 24 hours if needed, and vaginally 4 hourly, maximum 3 times after 48 hours (on the third day). OM alone group had the regimen described above from first day. Artificial rupture of membranes or routine oxytocin administration were not used in this study.
Follow-up	**48 hours**
Conflict of interest/source of funding	No conflicts of interest.

Analysis

Follow-up issues: In the DBC plus OM group, 6 were excluded from analysis because DBC could not be placed successfully in 4 women and 2 women deviated from the study protocol. In the OM alone group, 7 were excluded as labour started before induction in 4 women and 3 women deviated from the study protocol.

Study design issues: Prospective study with large sample size, study conducted in academic and non-academic hospitals, randomisation sequence generated using a computer generated randomisation scheme with 1:1 allocation for each arm of the study, sealed opaque envelopes used to conceal allocation, blinding of participants and providers was not possible. A standardised Bishop score was used in the study.

Study population issues: Homogenous group of women, no significant differences in baseline between groups. Majority of women had induction because the pregnancies were at or beyond 41 weeks of gestation.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **313**

Maternal and neonatal outcomes

	DBC + OM % (n=162)	**OM % (n=151)**	**p value**
Mode of delivery % (n)			
Normal vaginal delivery	67.9 (110)	59.5 (90)	0.13
Surgical vaginal delivery	10.5 (17)	10.6 (16)	0.98
Caesarean section	21.6 (35)	29.8(45)	0.10
Induction to delivery interval (hours, median)	**32.4**	**22.5**	**0.004**
Nulliparous	34.1	31.6	0.19
Parous	31.1	16.1	0.06
Other			
Vaginal delivery within 48 hours	79.5 (101/127*)	84.9 (90/106*)	0.29
Number of applications of misoprostol (median, range)	2 (0–11)	3 (1–23)	<0.001
Total dose of misoprostol (micrograms; median, range)	100 (0–850)	200 (50–1950)	<0.001
Neonatal outcomes			
Umbilical arterial pH	7.24±0.07	7.24±0.08	0.56
Apgar score <7 at 5 minutes	**4.9 (8)**	**0.7 (1)**	**0.04**
Nulliparous	6	1	0.06
Parous	2	0	0.50
Other			
Epidural anaesthesia	29 (47)	25.2 (38)	0.44
Oxytocin	44.4 (72)	44.4 (67)	1.00
Meconium stained amniotic liquor	15.4 (25)	17.2 (26)	0.67

*includes normal and surgical vaginal deliveries

Safety

	DBC (n=162)	**OM (n=151)**	**p value**
Chorioamnionitis	0	1	0.23
Postpartum endometritis	0	2	-
Infection of the new-born	4	1	-

Abbreviations used: DBC, double balloon catheter; OM, oral misoprostol.

Studies 7, 8 Kehl S (2011, 2013)

Details

Study type	Randomised controlled trial
Country	Germany (1 centre)
Recruitment period	2009–10
Study population and number	n=**122 women with term pregnancies with an indication for induction of labour** 59 DBC + OM sequentially versus 63 OM alone.
Age	Mean 30 years in both groups
Patient selection criteria	Women with singleton pregnancy at term >259 days of gestation; vertex presentation, indication for induction of labour, unfavourable cervix – Bishop score <8 were included. Women with previous caesarean section, structural or chromosomal fetal malformation, intrauterine fetal death, placenta previa were excluded.
Technique	DBC: on the first day, Cook's device was inserted through the cervix and the balloons either side of the cervix were inflated with 80 ml saline each. Catheter taped to the inner thigh without tension. If DBC did not fall out spontaneously, it was removed after 12 hours after placement. If labour did not start after mechanical ripening, then on the second day, 50 mg of OM was given 4 hourly, maximum of 3 times. A dose of 100 mg is given up to 3 times after 24 hours, if needed, and vaginally 4 hourly, maximum of 3 times after 48 hours (on the third day). In women with PROM, induction of labour started after 12 hours after PROM. If PROM occurred when DBC was place, then DBC was removed after 24 hours. OM alone group had the regimen described above from first day.
Follow-up	**48 hours**
Conflict of interest/source of funding	No conflicts of interest.

Analysis

Follow-up issues: There were 19 incomplete questionnaires from the study group and 25 from the control group, which were excluded from the analysis.

Study design issues: Small sample size, random assignment by physicians with 1:1 allocation for each arm of the study. Sealed opaque envelopes were used to conceal allocation. A standardised Bishop score was used in the study.

Another publication of the same study (Kehl 2013) focused on women's acceptance and satisfaction[8]. After childbirth, a standardised questionnaire was given to women to complete before discharge. Level of satisfaction with regard to delivery assessed on a 5-point scale (bad to very good, or not at all to very much) or with 'yes' or 'no'; birth experience was objectively evaluated using SIL-Ger, rated on a scale from 1–7, with a total score of 70 or above indicating a positive birth experience.

Study population issues: There were no significant differences in baseline between groups. Most of the inductions were because of post-date pregnancies or PROM. Many women in the study were wary of mechanical labour induction as pharmacological agents are well established for this indication.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **122**

Maternal and neonatal outcomes[7]

	DBC + OM (n=59)	OM (n=63)	p value
Mode of delivery % (n)			
Normal vaginal delivery	62.7 (37)	66.7 (42)	0.322
Surgical vaginal delivery	10.2 (6)	4.8 (3)	0.436
Caesarean section	27.1 (16)	28.6 (18)	0.10
Other			
Rate of failure for IOL* (%)	9.3	21.1	0.007
Rate of failure for IOL in women without PROM* (%)	10.8	28.2	0.002
Time for IOL (median, hours)	15.3	20.8	0.158
Time for IOL in women without PROM (median, hours)	15.8	32.6	0.024
Umbilical arterial pH <7	0	0	-
Apgar score <7 at 5 minutes	1.7 (1)	0	-

*Defined as no vaginal delivery within 48 hour

Satisfaction with IOL (n=78)[8]

	DBC + OM % (n=40)	OM % (n=38)	p value
Labour induction			
Satisfaction with labour induction (quite a lot to very much)	62.5 (25)	63.2 (24)	0.95
Bothered by swallowing tablets (not at all to moderately)	97 (34)	97 (37)	1.00
Bothered by placement of DBC (not at all to moderately)	70 (28)	0	0.017
Bothered by presence of DBC (not at all to moderately)	75 (30)	0	0.002
Would consider induced labour again and recommend it (quite a lot to very much)	75 (30)	53 (20)	0.040
Birth experience			
Birth experience (SIL-Ger score)	87.7±15.8	79±17.3	0.030
Satisfaction with childbirth (good/very good)	77.5 (31)	87 (33)	0.283

Multivariate analysis showed that 3 independent factors were associated with a positive birth experience: satisfaction with childbirth (p<0.001), involvement in decision-making after childbirth (p=0.041) and method of induction of labour (p=0.005).

Safety

Adverse events

	DBC (n=59)	OM (n=63)
Postpartum endometritis (after caesarean section)	1	0
Infection of the newborn	0	1
Nausea and emesis	0	8
Shivering	0	1
Bladder (urination) problems	2	0
Foreign body sensation	1	0
Pain	1	2

Abbreviations used: DBC, double balloon catheter; IOL, induction of labour, OM, oral misoprostol; PROM, premature rupture of membranes; SIL-Ger, German language version of Salmon Item List.

Study 9 Lokkegaard E, (2015)

Details

Study type	Randomised controlled trial
Country	Denmark (multi-centre)
Recruitment period	2002–5
Study population and number	n=**825 pregnant women with cephalic presentation and unfavourable cervices undergoing induction for conventional indications** 412 DBC versus 413 PGE2 vaginal insert (3mg dinoprostone). Median Bishop score 4.
Age	DBC mean 30 years, PGE2 insert mean 31 years
Patient selection criteria	Women undergoing induction of labour with intact fetal membranes, cephalic position and unfavourable cervix (Bishop score <6), prolonged pregnancy (>42 weeks' gestation), preeclampsia/hypertension, placenta insufficiency, gestational diabetes and twins were included. Women with previous caesarean section were also included. Women with spontaneous labour, rupture of membranes, placenta previa, acute fetal distress, intrauterine fetal death, vaginal/cervical infections, asthma, glaucoma, or latex allergy were excluded.
Technique	DBC: intervention performed in the evening. Atad device was inserted through the cervix with 80 ml saline installed stepwise in the uterine and the cervical balloons. The catheter is removed 12 hours after insertion and whenever possible induction continued by amniotomy, if not possible rectal enema was given to enable amniotomy. If amniotomy not possible within 2hours, oxytocin was administered for 2 hours and amniotomy attempted again. PGE2 vaginal insert (3 mg dinoprostone) placed high in the vaginal fornix in the morning on the day of induction (n=305). A second tablet instead after 4-5 hours if amniotomy was not possible at that time (n=179). If labour not induced on the first day, the procedure was repeated the following day (n=99). Primiparous and multiparous women were given the same dose. Simulation with additional oxytocin 2-3 hours after amniotomy was allowed.
Follow-up	**24–48 hours**
Conflict of interest/source of funding	No conflicts of interest.

Analysis

Study design issues: a large prospective study conducted at 7 labour wards. Planned sample size, sufficiently powered, random assignment by a telephone automated randomisation system to each arm of the study, randomisation was computer generated stratified for parity, no blinding of participants, intention to treat and per protocol analyses were performed. Subgroup analyses were done, but the study was not powered to detect differences among the subgroups.

Study population issues: There were several indications for induction of labour but the majority were those with prolonged pregnancy. There were no significant differences in baseline between groups.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **825**

Induction and intrapartum outcomes (intention to treat analyses)

	DBC (n=412)	PGE2 vaginal insert (n=413)	Relative risk (95% CI)
Primary outcome			
Failure % (n)*	43 (177/412)	34.4 (142/413)	1.25 (1.02-1.49)
Induction time, hours (median)^	27.3 91.0-16.9)	29.8 (4.3-23.2)	NS
Secondary outcome			
Vaginal delivery % (n)	72.3 (298/412)	74.1 (306/413)	0.98 (0.90-1.06)
Vaginal assisted % (n)	15.1 (45/412)	14.7 (45/413)	1.03 (0.70-1.50)
Caesarean section % (n)	27.7 (114/412)	25.9 (107/413)	1.07 (0.85-1.34)
Additional oxytocin % (n)	46 (188/413)	34 (141/412)	1.34 (1.16-1.54)
Apgar score (5 minutes)			
7-10 % (n)	99.2 (370/412)	99.2 (377/413)	
<7 % (n)	0.8 (3/413)	0.8 (3/413)	
Missing % (n)	9.5 (39/412)	8.0 (33/413)	
Admission to neonatal unit % (n)	13.6 (56/412)	17.6 (73/413)	0.77 (0.56-1.06)

*Failure is defined as women who went into labour spontaneously before the induction, had developed ripe cervix since randomisation, could not have the balloon catheter placed or regretted participation in the study and women in whom labour could not be induced.
^ Induction time is calculated from time of intervention or time of randomisation to time of birth.

After 24 hours 55.3% (235/412) women in DBC group had given birth compared to 54.3% (271/413) in the dinoprostone group.

Subgroup analyses based on parity

	DBC (n=235)	PGE2 vaginal insert (n=271)	Relative risk (95% CI)
Nulliparous women			
Induction of labour (n)	151	165	
Induction time, hours (median)^	23.3	22.2	
Caesarean section frequency % (n)	41.7 (63/235)	35.8 (59/271)	1.17 (0.88-1.54)
Admission to neonatal unit % (n)	11.9 (18/235)	15.8 (26/271)	0.76 (0.43-1.32)
Multiparous women			
Induction of labour (n)	84	106	
Induction time, hours (median)^	19.5	14.6	
Caesarean section frequency % (n)	20.2 (17/235)	17 (18/271)	1.19 (0.66-2.17)
Admission to neonatal unit % (n)	10.7 (9/235)	11.3 (12/271)	0.95 (0.42-2.14)

Subgroup analyses on indications for induction did not find any statistically significant differences with respect to outcomes.

Abbreviations used: CI, confidence interval; DBC, double balloon catheter; NS, not significant; PGE2, prostaglandin E2.

Study 10 Cromi A (2012)

Details

Study type	Randomised controlled trial
Country	Italy (single centre)
Recruitment period	2010–11
Study population and number	n=**210 pregnant women with unfavourable cervices undergoing labour induction** 105 DBC versus 105 PGE2 vaginal insert.
Age	DBC mean 34 years, PGE2 insert mean 33 years
Patient selection criteria	Women presented with a singleton gestation, vertex presentation, Bishop score <6, intact membranes, gestational age ≥34 weeks and reassuring fetal heart tracing on admission were included. Women with antepartum bleeding, intrauterine fetal death, prior uterine scars, positive vaginal or rectal group B streptococcus screening cultures, placenta previa, or any other contraindications to vaginal delivery were excluded.
Technique	DBC: Cook's device was inserted through the cervix and the balloons either side of the cervix were inflated with 50 ml saline each. Catheter taped to the inner thigh without tension. If DBC did not fall out spontaneously, it was removed 12 hours after placement. PGE2 vaginal insert (10 mg controlled-release dinoprostone) placed high in the vaginal fornix and monitored for at least 1 hour and then allowed to ambulate. Stopped after maximum dosing period (2 hours); onset of labour; uterine contractile abnormalities; or non-reassuring fetal heart rate patterns. Standard oxytocin dose administered to women not in labour after expulsion or removal of device or 1 hour after maximum dose of prostaglandin pessary. Standard intrapartum management according to protocols carried out.
Follow-up	**24–48 hours**
Conflict of interest/source of funding	No conflicts of interest.

Analysis

Follow-up issues: Two women in PGE2 insert group deviated from protocol and were withdrawn.

Study design issues: Random assignment with 1:1 allocation for each arm of the study, concealed allocation, planned sample size, intention to treat analysis performed.

Study population issues: There were no significant differences in baseline between groups.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **208**

Induction and intrapartum outcomes

	DBC (n=105)	PGE2 vaginal insert (n=103)	p value	Odds ratio (95% CI)
Improvement in Bishop score (median, range)	3 (0-9)	4 (0-10)	0.09	-
Onset of active labour % (n)	91.4 (96)	90.3 (93)	0.81	-
Time to onset of active labour, hour (mean±SD)	15.6±4.5	16.6±8.8	0.71	-
Mode of delivery (%, n)				
Vaginal delivery	76.2 (80)	73.8 (76)	0.75	-
Vacuum delivery	5.7 (6)	1.0 (1)	0.12	-
Caesarean section	23.8 (25)	26.2 (27)	0.75	0.88 (0.47–1.65)
Other				
Time to delivery, hour (mean±SD)	19.7±5.9	20.4±10.3	0.83	-
Time to vaginal delivery, hour (mean±SD)	18.8±5.4	19.9±9.6	0.86	-
Vaginal delivery within 24 hours % (n)	68.6 (72)	49.5 (51)	0.007	2.22 (1.26–3.91)
Oxytocin administration % (n)	85.7 (90)	54.4 (56)	<0.0001	5.04 (2.58–9.84)
Epidural rate % (n)	82.9 (87)	61.2 (63)	0.0006	3.07 (1.61–5.84)
Length of hospitalisation (days; median, range)	3 (2–6)	3 (2–7)	0.73	-
Neonatal outcomes				
Birth weight (mean±SD)	3268±582	3314±572	0.56	-
Apgar score <7 at 5 minutes % (n)	7.6 (8)	4.8 (5)	0.57	-
Umbilical artery blood pH<7.0 % (n)	0.9 (1)	0	1.0	-
ICU admission % (n)	7.6 (8)	4.8 (5)	0.57	-

Safety

	DBC (n=105)	PGE2 vaginal insert (n=103)	p value
Device insertion failure (as a result of closed cervix, PGE2 inserted)	2	0	
Accidental expulsion of device (new device reinserted)	2	0	
Uterine hypertonus* without fetal heart rate changes	0	3.9 (4)	0.002
Tachysystole ^ with associated fetal heart rate (2 needed emergency caesarean delivery due to persistent abnormal tracing after insert withdrawal)	0	5.7 (6)	
Postpartum haemorrhage (blood loss of >1000ml)	7.6 (8)	6.8 (7)	0.1

*Single contraction lasting at least 2 minutes

^>5 contractions per 10 minutes for at least 20 minutes.

Abbreviations used: CI, confidence interval; DBC, double balloon catheter; ICU, intensive care unit; OM, oral misoprostol; PGE2, prostaglandin E2; SD, standard deviation.

Study 11 Wang W (2014)

Details

Study type	Randomised controlled trial
Country	China (single centre)
Recruitment period	2010–11
Study population and number	n=**126 primiparous women with unfavourable cervices and oligohydramnios undergoing labour induction** 66 DBC versus 60 PGE2 vaginal insert (dinoprostone)
Age	DBC mean 27.9 years, PGE2 mean 27.8 years
Patient selection criteria	Women with AFI <5 cm, gestational age beyond 37 weeks, singleton pregnancy, vertex presentation, Bishop score<6, intact membranes, absence of documented uterine contraction, absence of prior caesarean section delivery history, reassuring antenatal fetal testing active and oxytocin challenge test negative were included. Women with antepartum bleeding, chorioamnionitis, placenta previa or any other contraindication to vaginal delivery were excluded from DBC insertion. Women with prostaglandin allergy, maternal asthma history, vaginitis, cervicitis at presentation or glaucoma history were excluded from pharmacological treatment.
Technique	DBC: Cook's device was inserted through the cervix and the balloons either side of the cervix were inflated with 80 ml saline each. Catheter taped to the inner thigh without tension. If DBC did not fall out spontaneously, it was removed 12 hours after placement. PGE2 vaginal tablets (10 mg controlled release dinoprostone) inserted into the posterior vagina fornix, removed after 24 hours or earlier if active labour or non-reassuring fetal heart rate monitoring. Both groups monitored, allowed to ambulate with heart rate monitoring every 2–4 hours, oxytocin used after 24 hours of unsuccessful ripening and also for augmentation in active labour.
Follow-up	**48 hours**
Conflict of interest/source of funding	No conflicts of interest. Study funded by health department in China.

Analysis

Follow-up issues: Two women in the DBC group were reassigned to the PGE2 group (1 due to catheter insertion failure and 1 refused placement), 3 women from the PGE2 group were reassigned to the DBC group because of non-reassuring fetal heart rate patterns.

Study design issues: Random allocation to either group. No allocation concealment and blinding reported.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **126**

Induction and intrapartum outcomes

	DBC % (n=67)	PGE2 vaginal insert % (n=59)	p value	OR (95% CI)
Improvement in Bishop score (mean±SD)	4±1.4	3.4±1.4	0.27	-
Bishop score <6 after 12 hours	19.4 (13)	32.2 (19)	0.10	0.51 (0.22–1.15)
Onset of active labour % (n)	34.3 (23)	50.8 (30)	0.61	0.51 (0.25–1.04)
Oxytocin infusion % (n)	64.2 (43)	22 (13)	0.00	6.34 (2.87–14.01)
Amniotomy (mean±SD)	73.1 (49)	40.7 (24)		3.97 (1.88–8.40)
Time to vaginal delivery, min (mean±SD)	1170±323	1122±537	0.54	-
Vaginal delivery within 24 hours	59.7 (40)	61 (36)	0.88	0.95 (0.46–1.94)
Caesarean section delivery	16.4 (11)	22 (13)	0.42	0.70 (0.29–1.70)
Neonatal outcomes				
Birth weight (mean±SD)	3157±317	3172±402	0.82	-
Apgar score <7 at 5 minutes	0	3.4 (2)	0.22	1.04 (0.99–1.09
Umbilical cord arterial pH (mean±SD)	7.2±0.6	7.1±0.1	0.06	-
Umbilical cord arterial pH <7.1	6 (4)	25 (15)	0.03	0.19 (0.06–0.60)
Neonatal ICU admission % (n)	0	3.4 (2)	0.22	1.04 (0.99–1.09)

Safety

Adverse events

	DBC % (n=67)	PGE2 vaginal insert % (n=59)	p value	OR (95% CI)
Excessive uterine activity (tachysystole)	4.5 (3)	16.9 (10)	0.04	0.23 (0.06–0.88)
Non-reassuring fetal heart rate	1.5 (1)	15.3 (9)	0.01	0.08 (0.01–0.69)
Birth canal injury	1.5 (1)	8.5 (5)	0.10	0.16 (0.02–1.44)
Precipitous delivery	1.5 (1)	5.1 (3)	0.34	0.28 (0.03–2.80)
Postpartum haemorrhage	1.5 (1)	3.4 (2)	0.60	0.43 (0.04–4.89)
Newborn asphyxia % (n)	4.5 (3)	5.1 (3)	1.00	0.88 (0.17–4.51)
Device replacement	2	1	-	-

No serious side effects such as maternal placental abruption and perinatal death reported in either group.

Abbreviations used: AFI, amniotic fluid index; DBC, double balloon catheter; ICU, intensive care unit; PGE2, prostaglandin E2; SD, standard deviation.

Study 12 Atad J (1996)

Details

Study type	Randomised controlled trial
Country	Israel (single centre)
Recruitment period	2010–11
Study population and number	n=**95 pregnant women with unfavourable cervices undergoing labour induction (53 primiparous, 42 multiparous)** 35 DBC versus 30 PGE2 vaginal insert versus 30 oxytocin
Age	DBC mean 27.3 years, PGE2 mean 28.5 years, oxytocin mean 27.8 years
Patient selection criteria	Women with singleton pregnancy, vertex presentation, intact membranes, Bishop score 4 or less were included. Women with previous caesarean delivery, abnormal fetal monitoring, and placenta previa were excluded.
Technique	DBC: Atad ripener device was inserted through the cervix and the balloons either side of the cervix were inflated with 100 ml saline each. Catheter taped to the inner thigh without tension. If DBC did not fall out spontaneously, it was removed after 12 hours after placement. In women whose Bishop score was 5 or higher, induction of labour was resumed using artificial rupture of the membranes and/or administration of oxytocin. PGE2 vaginal tablets (3 mg) were inserted if contractions had not started 6 hours later, a second dose of 3 mg was administered in 22 women. The oxytocin group had an initial dose of 1.5 mIU/minute and a constant increase of 1.5 mIU per minute every 20 minutes until 3 contractions in 10 minutes were reached (as long as fetal monitoring was reassuring). Labour was managed according to obstetric criteria in all women.
Follow-up	**24–48 hours**
Conflict of interest/source of funding	One author had a patient licencing agreement with the manufacturer.

Analysis

Study design issues: Computer generated random assignment to 1 of the 3 arms of the study, allocation concealment unclear, and lack of blinding. Women with method failure (Bishop score of <4) were crossed over to other arms in the study.

Indications for labour induction were pregnancy-induced hypertension, post-date pregnancy, diabetes, elective induction, non-reassuring non-stress test, fetal growth restriction and fetal death.

Study population issues: There were no significant differences in baseline between groups.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **95**

Induction and intrapartum outcomes

	DBC (n=35)	PGE2 vaginal insert (n=30)	Oxytocin % (n=30)	p value
Bishop score (median, range)	5 (0–7)	5 (0–9)	2.5 (0–9)	<0.1
Cervical dilation >3 cm (assessed after 12 hours of induction) % (n)	85.7 (30)	50 (15)	23.3 (7)	<0.1
Method failure* % (n)	5.7 (2)	20 (6)	53.3 (16)	<0.001
Induction to delivery, hours (mean±SD)	21.3±7.0	23.2±12.5	28.2±14.7	
Success rate for vaginal delivery % (n)	77.1 (27)	70 (21)	26.7 (8)	<0.01
Caesarean delivery % (n)	20 (7/35)	13.3 (4/30)	46.6 (14/30)	<0.05

*Defined as a second Bishop score of no more than 4.

Neonatal outcomes

Neonatal outcomes were the same for all 3 methods with regard to mean weight Apgar scores at 1 and 5 minutes. Perinatal morbidity was not significantly different among the 3 groups.

Abbreviations used: DBC, double balloon catheter; PGE2, prostaglandin E2; SD, standard deviation

Efficacy

Ripening success (Bishop score increase by 2 or more points or cervical dilation of 3 cm or more)

A nested study (n=186) within a randomised controlled trial (RCT) of 188 pregnant women, comparing double balloon catheter (DBC) plus extra-amniotic saline infusion (EASI; n=60) against single balloon catheter (SBC) plus EASI (n=126) reported that 'ripening success' (defined as increase in Bishop score 2 or more points or cervical dilation of 3 cm or more) was comparable between the DBC and SBC groups (96.4% versus 92.7%; p=0.55)[3].

A secondary analysis (n=160) of the same RCT, comparing DBC plus EASI (n=60) against DBC without EASI (n=100) reported that ripening success rate was comparable between the groups (96.4% [54/60] versus 99% [99/100]; p=0.29)[4].

Time from catheter insertion to delivery

An RCT of 302 pregnant women (293 in the final analysis) comparing DBC (n=148) against SBC (n=145) for induction of labour (IOL) reported that length of time from catheter insertion to delivery was 19.4±6.0 and 19.1±6.8 hours in the 2 groups respectively (p=0.8)[2]. Length of time was not significantly different between the groups regardless of parity (primiparous or multiparous)[1].

A quasi-RCT of 188 women at term with singleton pregnancy comparing DBC (n=100) against SBC plus EASI (n=88) for IOL reported that time from insertion to delivery was significantly shorter in the SBC plus EASI group compared with the DBC group (20.5 hours versus 17.3 hours respectively; p=0.03)[2]. The nested study (n=186) in this RCT, comparing DBC plus EASI (n=60) against SBC plus EASI (n=126) reported balloon insertion to delivery interval was significantly shorter in the DBC plus EASI group compared with the SBC plus EASI group (14.2 hours versus 15.5 hours; p=0.04)[3].

The secondary analysis (n=160) of the RCT of 188 women, comparing DBC plus EASI (n=60) against DBC without EASI (n=100) reported that catheter insertion to delivery interval was significantly shorter in the DBC plus EASI group compared with the DBC without EASI group (14.19 hours versus 20.45 hours; p<0.001)[4].

An RCT of 330 nulliparous pregnant women with unfavourable cervices compared 3 methods (DBC [n=107] versus SBC [n=110] versus prostaglandin gel [dinoprostone, n=113]) for IOL at term. The induction to delivery interval was longer in the DBC group (median 24.5 hours, 95% confidence interval [CI] 23.7 to 30.6) than the SBC group (median 23.2 hours; 95% CI 20.8 to 25.8) or the prostaglandin gel group (23.8 hours; 95% CI 21.7 to 26.8; p=0.043)[5].

A multicentre RCT of 825 pregnant women with an unfavourable cervices comparing DBC (n=412) against vaginal prostaglandin E2 (PGE2; n=413) reported that median induction time (calculated as time of intervention or time of randomisation to time of birth) was 27.3 hours in the balloon group and 29.8 hours in the dinoprostone group (difference was not significant)[9].

A multicentre RCT of 326 pregnant women with unfavourable cervices at term comparing DBC plus oral misoprostol (OM; n=162) against OM alone (n=151) reported that median catheter insertion to delivery interval was 32.4 hours in the DBC plus OM group and 22.5 hours in the control group (OM alone; p=0.004). This difference was not seen when assessed according to parity (nulliparous p=0.19; multiparous p=0.06). The number of applications (2 versus 3; p<0.001) and dose of OM used was lower in the DBC plus OM group (100 mg versus 200 mg; p<0.001)[6].

An RCT of 122 pregnant women with unfavourable cervices at term comparing DBC plus OM (n=59) against OM alone (n=63) reported that median catheter insertion to delivery interval was 15.3 hours in the DBC plus OM group and 20.8 hours in the control group (p=0.15). Among women without premature rupture of membranes, the median times for induction were 15.8 hours versus 32.6 hours (p=0.02)[7].

Caesarean section rate

The RCT of 302 pregnant women (293 women in the final analysis) comparing DBC (n=148) against SBC (n=145) reported that caesarean delivery rate was 18% and 10% in the 2 groups respectively (p=0.9)[2]. The incidence of operative (vacuum or caesarean) deliveries was significantly higher in the DBC group compared with the SBC group (26% versus 14%; p=0.02; odds ratio 0.49, 95% CI 0.26 to 0.92)[1].

The nested study (n=186) within the RCT of 188 women, comparing DBC plus EASI (n=60) against SBC plus EASI (n=126) reported the caesarean section delivery rate was significantly lower in the DBC group compared with the SBC group (8.3% versus 20.8%; p=0.05)[3].

The secondary analysis (n=160) of the RCT of 188 women, comparing DBC plus EASI (n=60) against DBC without EASI (n=100) reported that the caesarean section delivery rate was comparable between the groups (8.3% versus 20%; p=0.07)[4].

An RCT of 210 women reported no difference in caesarean delivery rates between the DBC and PGE2 groups (24% versus 26%; odds ratio 0.88, 95% CI, 0.47 to 1.65)[10]. An RCT of 126 women with oligohydramnios and a low Bishop score (less than 6) reported that there was no significant difference between the DBC group (n=67) and the dinoprostone vaginal insert group (n=59) in caesarean section rates (16% versus 22%; p=0.42)[11].

The RCT of 330 nulliparous pregnant women with unfavourable cervices comparing 3 methods (DBC [n=107] versus SBC [n=110] versus PGE2 gel [n=113]) reported no difference in caesarean delivery rates between the groups (DBC 43%, SBC 36%, PGE2 37%; p=0.567)[5].

The multicentre RCT of 825 pregnant women with an unfavourable cervices comparing DBC (n=412) against vaginal PGE2 (n=413) reported that caesarean section rates were similar between the groups (DBC 28% [114/412] versus 26% [107/413]; p=1.07)[9].

Vaginal delivery within 24 hours

The RCT of 210 women with unfavourable cervices comparing DBC (n=105) against prostaglandin gel (n=103) reported that more women in the DBC group had a vaginal delivery within 24 hours than in the prostaglandin gel group (69% versus 49% respectively; odds ratio 2.22; 95% CI 1.26 to 3.91)[10].

The multicentre RCT of 326 pregnant women with unfavourable cervices at term comparing DBC plus OM (n=162) against OM alone (n=151) reported that the rate of spontaneous vaginal delivery within 48 hours did not differ significantly between the groups (80% [101/162] versus 85% [90/106]; p=0.29)[7].

Rate of failure to induce labour (defined as no vaginal delivery within 48 hours)

The RCT of 122 pregnant women with an indication for IOL comparing DBC plus OM (n=59) against OM alone (n=63) reported that the rate of failure to induce labour was significantly lower in the DBC plus OM group in comparison with the control group (OM alone; 9.3% versus 21.2%; p=0.007). In women without rupture of membranes, the rates of failure for IOL were 10.8% versus 28.2% (p=0.002)[7].

The multicentre RCT of 825 pregnant women with an unfavourable cervices comparing DBC (n=412) against vaginal PGE2 (n=413) reported a significantly higher failure rate for labour induction (defined as women who went into labour spontaneously before the induction, had developed ripe cervix since randomisation, could not have the balloon catheter placed or regretted participation in the study and women in whom labour could not be induced) in the balloon group (relative risk: 1.25, 95% CI: 1.02 to1.49)[9].

Length of hospital stay

The secondary analysis (n=160) of the RCT of 188 women, comparing DBC with EASI (n=60) against DBC without EASI (n=100) reported that the length of hospital stay was significantly shorter in the DBC with EASI group compared against the DBC without EASI group (4.29±1.8 days versus 6.69±5.9 days; p<0.001)[4].

Maternal satisfaction

The nested study (n=186) within the RCT of 188 women, comparing DBC plus EASI (n=60) against SBC plus EASI (n=126) reported that there was no significant difference in maternal satisfaction (assessed on a scale of 1–10, with higher scores indicating greater satisfaction) in the DBC group compared against the SBC group (7.7±2.8 versus 7.0±2.8; p=0.42)[3]. The RCT of 122 women, comparing DBC plus OM (n=59) against OM alone (n=63) reported a significant positive birth experience (on the German language version of Salmon Item List score) in the DBC group (87.7 ±15.8 versus 79.3±17.3; p=0.030)[8].

Apgar score of less than 7 at 5 minutes

The multicentre RCT of 326 pregnant women reported more Apgar scores of less than 7 (at 5 minutes) in the DBC plus OM group than the OM alone group (8 versus 1; p=0.04)[6]. In the quasi-RCT of 188 patients and the nested study (n=186), the number of Apgar scores of less than 7 (at 5 minutes) was similar between the study groups[2, 3, 4].

Safety

Uterine hyperstimulation

Uterine hyperstimulation occurred in 14% (16/113) of women in the PGE2 group, with none occurring in the DBC and SBC groups in an RCT of 330 nulliparous pregnant women[5]. Five of these women had non-reassuring fetal heart rate patterns and tachysystole. Uterine tachysystole or hypertonus occurred more frequently in the PGE2 group compared against the DBC group (10% versus 0%; p=0.007) in an RCT of 210 women[10]. The incidence of tachysystole and non-reassuring fetal heart rate status was significantly lower in the DBC group than the PGE2 group (p<0.05) in an RCT of 126 women with oligohydramnios and unfavourable cervcies[11].

Cord pH

Cord pH was lower in the PGE2 group compared with the DBC and SBC groups (median arterial pH: DBC group 7.26, SBC 7.26, PGE2 7.25; p=0.05) in the RCT of 330 nulliparous pregnant women[5].

Newborn infants with an umbilical artery pH of less than 7.00 were more common in the PGE2 group than in the DBC group (6% versus 25%; p=0.03) in the RCT of 126 pregnant women with oligohydramnios and unfavourable cervices[11].

Pain

Pain (score of more than 4) was reported in 55% of women in the DBC group, 36% in the SBC group and 63% in the PGE2 group (p<0.001) in the RCT of 330 nulliparous pregnant women[5]. Pain perception during the insertion procedure was similar in both groups (on a visual analogue scale 1–10, higher scores representing worse pain; mean score 3.1 versus 3.7; p=0.19) in a nested study

(n=186) in an RCT of 188 patients comparing DBC plus extra-amniotic saline infusion (EASI; n=60) against SBC plus EASI (n=126)[3].

Cord prolapse

Cord prolapse was reported in 1 woman in the DBC group in an RCT of 302 pregnant women (293 women in the final analysis) comparing DBC (n=148) against SBC (n=145)[1]. An emergency caesarean delivery was performed.

Abnormal fetal presentation

Fetal malpresentation (1 persistent mento-posterior presentation and 1 transverse position) after catheter removal was reported in 2 women in the DBC group in the RCT of 302 pregnant women (293 women in the final analysis) comparing DBC (n=148) against SBC (n=145). One had a vaginal delivery after an external cephalic version was performed and 1 had a caesarean section[1].

Placental abruption

Placental abruption occurred in 1 woman in the PGE2 group with none occurring in the DBC and SBC groups in the RCT of 330 nulliparous pregnant women[5].

Intrapartum fever

Intrapartum fever was reported in 8 and 2 women respectively in the DBC and SBC groups (p=0.10) in the RCT of 302 pregnant women comparing DBC (n=148) against SBC (n=145)[1].

Postpartum endometritis

Postpartum endometritis after caesarean section occurred in 1 woman in the DBC plus OM group (n=59) with none in the OM alone group (n=63) in the RCT of 122 pregnant women with unfavourable cervix at term[7]. Postpartum endometritis occurred in 2 women in the OM alone group (n=151) with none occurring in the DBC group (n=162) in an RCT of 326 pregnant women with unfavourable cervices at term[6].

Postpartum haemorrhage

The incidence of postpartum haemorrhage (more than 1000 ml) was higher (but not significantly) in the PGE2 group compared to the DBC and SBC groups (PGE2 group=12, DBC=5, SBC=5; p=0.143) in the RCT of 330 nulliparous pregnant women[5].

Birth canal injury

Birth canal injury was reported in 1 and 5 women respectively in the DBC and PGE2 groups (p=0.10) in the RCT of 126 pregnant women with oligohydramnios and unfavourable cervices[11].

Maternal discomfort

Maternal discomfort due to the ripening device was reported in 5 women in the DBC group (n=107) in the RCT of 330 women. Two women were unable to void,

2 women had decreased balloon volume and in 1 woman the device was removed[5].

Newborn infection

Newborn infection occurred in the babies of 4 women in the DBC plus OM group (n=162) and 1 baby in the OM alone group (n=151) in the RCT of 326 pregnant women with unfavourable cervices at term[6].

Validity and generalisability of the studies

- Methods of mechanical induction were used alone or in combination with other interventions.
- Studies used different comparators, protocols, regimens and outcome measures of effectiveness and arrived at different conclusions.
- 2 RCTs compared the Atad DBC[5, 12]. All the other studies assessed the Cook's DBC.
- Comparison between DBC and SBC (Foley catheter) reported that both catheters are equally efficacious (mainly in primiparous women)[1, 3, 5, 10] and DBC offered no advantage over SBC or prostaglandins (in mixed parities)[5]. DBC is associated with more operative deliveries and adverse events[10].
- Studies also compared different combinations which include SBC and DBC with or without EASI: DBC compared against SBC with EASI reported significantly higher time to delivery interval[2]. DBC with EASI resulted in higher vaginal delivery rates and reduced time to delivery compared to SBC with EASI. Ripening success was comparable and caesarean section rates were significantly lower in the DBC group[3]. Comparison of DBC with EASI against DBC without EASI reported shorter time to delivery, and comparable caesarean section and ripening success rates[4]. Addition of EASI to DBC or SBC resulted in a shorter induction process.
- Comparison between DBC and prostaglandins alone did not show any significant difference in the duration of induction to delivery or in caesarean delivery rates. Sequential use of DBC and PGE2 did not improve the rate of delivery within 48 hours compared with OM alone but the time to delivery and rates of failure were significantly lower in the DBC and PGE2 group,

particularly in women without premature rupture of membranes[6, 7]. Women were also satisfied with induction of labour using DBC and it was found to have a positive impact on the birth experience[8].

Existing assessments of this procedure

In 2012, a Cochrane review on mechanical methods for induction of labour (which included 71 RCTs, 9722 women) compared against placebo or no treatment, prostaglandins or oxytocin. The mechanical methods studied were laminaria tents or synthetic equivalents, catheters (Foley catheter and Atad ripener) or extra-amniotic infusion by catheter. The review concluded no significant difference in caesarean section rates after the use of mechanical methods, prostaglandins or misoprostol in cervical ripening. However, mechanical methods reduced the risk of hyperstimulation with fetal heart rate changes when compared with vaginal prostaglandins (risk ratio 0.19, 95% CI 0.08 to 0.43, p=0.000063; 9 studies, n=1931). The study also reported that, compared with oxytocin alone, mechanical methods of cervical ripening reduced the risk of caesarean section (risk ratio 0.62, 95% CI 0.42 to 0.90, p=0.011; 5 studies, n=398). It also concluded that mechanical methods do not increase the overall number of women who had not delivered within 24 hours, however the proportion of multiparous women who did not achieve vaginal delivery within 24 hours was higher when compared with vaginal PGE2. Serious maternal and neonatal adverse events were not often reported and did not differ between the interventions. Infection reported in a few studies appeared not to be higher when using mechanical methods[13].

Related NICE guidance

Below is a list of NICE guidance related to this procedure. Appendix B gives details of the recommendations made in each piece of guidance listed.

NICE guidelines

- Intrapartum care: care of healthy women and their babies during childbirth. NICE clinical guideline 190 (2014). Available from www.nice.org.uk/CG190
- Caesarean section. NICE clinical guideline 132 (2011). Available from www.nice.org.uk/CG132
- Induction of labour. NICE clinical guideline 70 (2008). Available from http://www.nice.org.uk/guidance/CG70
- Diabetes in pregnancy: management of diabetes and its complications from pre-conception to the postnatal period. NICE clinical guideline 63 (2008). Available from http://www.nice.org.uk/guidance/CG63

Specialist advisers' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College. The advice received is their individual opinion and is not intended to represent the view of the society. The advice provided by Specialist Advisers, in the form of the completed questionnaires, is normally published in full on the NICE website during public consultation, except in circumstances but not limited to where comments are considered voluminous, or publication would be unlawful or inappropriate. Three Specialist Advisor Questionnaires for insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section were submitted and can be found on the NICE website; http://www.nice.org.uk/guidance/indevelopment/gid-ip1278/documents

Patient commentators' opinions

NICE's Public Involvement Programme was unable to gather patient commentary for this procedure.

Issues for consideration by IPAC

- Ongoing studies:
  - NCT01091285: Induction of labor with single and double balloon catheters, a randomized controlled trial, phase 4; n=180; location: Norway; status: completed (not yet published).
  - NCT01720394: Efficacy of induction of labor on term using a double balloon catheter compared to dinoprostone vaginal-insert; multicenter randomised controlled trial, phase 4; n=253; primary outcome: time interval from primary treatment to delivery; location: Austria; estimated completion date: April 2015.
  - NCT02223949: Labor induction and maternal BMI, comparison of different pre-induction cervical ripening methods, randomised controlled trial, phase 3; Cook double balloon catheter versus PGE 1 tablet in lean, overweight and obese women; n=624; primary outcome: caesarean section rate; Location: Israel; completion date: November 2016.
  - ACTRN12614000039684: Prostaglandin inpatient induction of labour compared with balloon outpatient induction of labour: a randomised

controlled trial; primary outcome: composite measure of improved perinatal outcomes; n=2500; location: Australia; completion date: 2016.

References

1. Salim R, Zafran N.et al (2011). Single-balloon compared with double-balloon catheters for induction of labor: a randomized controlled trial Obstetrics & Gynecology 118: 79-86
2. Mei-Dan E, Walfisch A et al (2012). Comparison of two mechanical devices for cervical ripening: a prospective quasi-randomized trial Journal of Maternal-Fetal & Neonatal Medicine 25: 723-727
3. Mei-Dan E, Walfisch A et al (2014). Making cervical ripening EASI: a prospective controlled comparison of single versus double balloon catheters Journal of Maternal-Fetal & Neonatal Medicine 27: 1765-1770
4. Walfisch A, Mei-Dan E et al (2014).Trans-cervical double balloon catheter with and without extra-amniotic saline infusion for cervical ripening: a prospective quasi-randomized trial. J Matern.Fetal Neonatal Med. 1-6
5. Pennell CE, Henderson JJ et al (2009). Induction of labour in nulliparous women with an unfavourable cervix: a randomised controlled trial comparing double and single balloon catheters and PGE2 gel.[Erratum appears in BJOG. 2011 Mar;118(4):521 Note: McCleery, S [corrected to McChlery, S]] BJOG: An International Journal of Obstetrics & Gynaecology 116: 1443-1452
6. Kehl S, Ziegler J et al (2014). Sequential use of double-balloon catheter and oral misoprostol versus oral misoprostol alone for induction of labour at term (CRBplus trial): a multicentre, open-label randomised controlled trial. BJOG. 20-10-2014
7. Kehl S, Ehard A et al (2011). Combination of misoprostol and mechanical dilation for induction of labour: a randomized controlled trial. European Journal of Obstetrics, Gynecology, & Reproductive Biology. 159: 315-319
8. Kehl S, Welzel G et al (2013). Women's acceptance of a double-balloon device as an additional method for inducing labour. European Journal of Obstetrics, Gynecology, & Reproductive Biology. 168: 30-35
9. Lokkegaard E, Lundstrom M et al (2015). Prospective multi-centre randomised trial comparing induction of labour with a double-balloon catheter versus dinoprostone. J Obstet Gynaecol 1-6.
10. Cromi A, Ghezzi F et al (2012). A randomized trial of preinduction cervical ripening: dinoprostone vaginal insert versus double-balloon catheter American Journal of Obstetrics & Gynecology. 207: 125-127
11. Wang W, Zheng J et al (2014). Which is the safer method of labor induction for oligohydramnios women? Transcervical double balloon catheter or dinoprostone vaginal insert Journal of Maternal-Fetal & Neonatal Medicine 27:1805-1808

12. Atad J, Hallak M et al (1996). A randomized comparison of prostaglandin E2, oxytocin, and the double-balloon device in inducing labor. Obstetrics & Gynecology. 87: 223-227.

13. Jozwiak M, Bloemenkamp KWM, Kelly AJ, Mol BWJ, Irion O, Boulvain M (2012). Mechanical methods for induction of labour. Cochrane Database of Systematic Reviews, Issue 3. Art. No.: CD001233. DOI: 10.1002/14651858.CD001233.pub2.

Appendix A: Additional papers on insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section

The following table outlines the studies that are considered potentially relevant to the IP overview but were not included in the main data extraction table (table 2). It is by no means an exhaustive list of potentially relevant studies.

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Atad J, Hallak M et al (1997). Ripening and dilatation of the unfavourable cervix for induction of labour by a double balloon device: experience with 250 cases. British Journal of Obstetrics & Gynaecology. 104: 9-32	USA case series n=250 Women with unfavourable cervix (Bishop score <4) Double Balloon Catheter for Induction of Labour	Increase in Bishop score-mean change 4.6 (from 2.0 to 6.6, p<0.05) Mean time interval from insertion to delivery was 18.9hrs. From removal to delivery was 6.9 hrs. Caesarean section performed in 16% (39/250), others normal delivery.	Similar studies included in table 2.
Atad J, Bornstein J et al (1991). Nonpharmaceutical ripening of the unfavorable cervix and induction of labor by a novel double balloon device. Obstetrics & Gynecology. 77: 146-152.	USA Women with unfavourable cervix (Bishop score <4) 3 phases Phase 1 n=48 PGE2 gel via cannula phase 2 (double blind RCT) n=10 PGE2gel via DBC versus 10 placebo gel via DBC Phase 3 n=50 DBC only.	In phase 1, a mean increase in 3 points in Bishop's score and mean installation to delivery time was 34.2 hours. phase 2- no sign diff in the increase of bishop score between the groups (5.8 versus 6.0) 90% women in both groups delivered vaginally with a mean of 20.8 hours after device insertion. Phase 3-a mean increase in 4.4 points in the bishop score noted.	Similar studies included in table 2.
Du C, Liu Yet al (2014). Double-balloon catheter vs. dinoprostone vaginal insert for induction of labor with an unfavorable cervix. Arch.Gynecol.Obstet. 19-11-2014	China RCT n=155 Women with an unfavourable cervix (DBC 76 versus dinoprostone vaginal insert 79) for IOL	Vaginal delivery rate within 24 hrs (50 versus 536%, p=0.69) Caesarean section rate (39.5 versus 31.6%, p=0.18) Oxytocin administration (75 versus 31.65%, p<0.001) Uterine hyper-stimulation (0 versus 10.1%, p=0.007) Neonatal outcomes similar between groups.	Similar studies included in table 2.
Gadel Rab MT, Mohammed AB et al (2014). Transcervical Foley's catheter versus Cook balloon for cervical ripening in stillbirth with	RCT n=200 100 transcervical Foley's catheter versus 100 Cook cervical ripening	Time from balloon insertion to expulsion and from balloon insertion to delivery was significantly shorter in Foley's catheter group. However, the difference between the 2 groups regarding time from balloon insertion	Women with previous lower segment c-scar were included in

a scarred uterus: a randomized controlled trial. J Matern.Fetal Neonatal Med. 14: 1-5	balloon Pregnant women with stillbirth, unfavourable cervix and scarred uterus.	to active labour, time from balloon expulsion to delivery, cervical ripening, caesarean section, instrumental delivery, pain score, need for analgesia, hospital stay and maternal satisfaction was not statistically significant. Foley's catheter and Cook cervical ripening balloon are comparable regarding efficacy and safety profile.	the study.
Hallak M (1997). Mechanical ripening of the unfavorable cervix for induction of labor. Contemporary Reviews in Obstetrics and Gynaecology.9 (2) (pp 99-105), 1997.Date of Publication: 1997. 1997 99-105	USA prospective randomised study n=95 women with unfavourable cervix (Bishop score <4) (35 DBC vs 30 PGE2 vs 30 oxytocin) for IOL	The change in bishop score (median 5 versus 5 versus 2.5, p<0.01) Cervical dilation of >3cm was more frequent and success rate was higher in DBC compared with PGE2 and oxytocin groups. Method failure (5.7% vs 20% versus 53.3%), induction delivery interval (mean 21.3 hrs versus 23.2 versus 28.2hrs), success rate for vaginal delivery (77.1% versus 70% versus 26.7%, p<.01).	Similar studies included in table 2.

He Y, Hu J et al (2014). [Clinical analysis of double-balloon catheter for cervical ripening in 66 cases]. [Chinese]. Chung-Hua Fu Chan Ko Tsa Chih [Chinese Journal of Obstetrics & Gynecology] 49: 741-745.	Prospective comparative case series n=128 full term pregnant women who had induction of labour with either a double-balloon catheter (n=66) or prostaglandin vaginal insert (n=62).	The efficacy for cervical ripening (Bishop scores improved by >2) had no significant differences between study and control groups [82% (54/66) versus 81% (50/62), P > 0.05]. The time interval between intervention and parturiency was significantly higher in the double balloon catheter group than in the prostaglandin vaginal insert group [(24.2 +/- 8.5) versus (14.5 +/- 8.0) hours, P < 0.05]. The proportion of women who achieved parturiency within 12 hours was significantly lower in the double-balloon catheter group than that in the control group [9% (6/66) versus 21% (13/62), P < 0.05]. The caesarean section rate showed no significant differences [41% (27/66) versus 43% (27/62), P > 0.05]. Intrauterine infection was significantly higher in the double-balloon catheter group [11% (7/66) versus 6% (4/62), P < 0.05]. The double-balloon catheter group had significantly lower rates of contraction over frequency [0(0/66) versus 42% (26/62), P < 0.05], hyperthermia [3% (2/66) versus 19% (12/62), P < 0.05], fetal heart rate abnormalities before removing the device or drug [5% (3/66) versus 19% (12/62), P < 0.05], as well as precipitate labour [2% (1/66) versus16% (10/62), P < 0.05].	Article in non-English language (Chinese).
Mattingly P, Temming L, and Bliss S (2015). Cervical ripening with a double-lumen balloon catheter for six versus twelve hours: A randomized controlled trial. American Journal of Obstetrics and Gynecology. Conference: 35th Annual Meeting of the Society for Maternal-Fetal Medicine: The Pregnancy Meeting San Diego, CA United States.Conference Start: 20150202 Conference End: 20150207.Conference Publication: (var (var.pagings) S264-2015.	Randomised controlled trial n=108 women with double balloon catheter randomised to either 6 or 12 hours (55 in 6 hour arm and 53 in 12 hour arm).	RESULTS: The mean time to delivery was 22.89 hours (+/- 9.63) in the 12 hour arm, and 20.19 hours (+/- 9.85) in the 6 hour arm with a trend towards significance in the groups (p=0.0742). There was a trend towards faster delivery time in those with balloon catheter in place for 6 hours. Our study was underpowered to detect the 3 hour difference that was noted. Given the cost and maternal discomfort associated with each additional hour of labour induction, providers can consider shorter time for cervical balloon catheter placement. This may shorten time to delivery and improve patient comfort and satisfaction.	Conference abstract only.

Sciscione AC. and Rushstaller K (2013). Double-balloon catheter results in higher rate of vaginal delivery within 24 h when compared with dinoprostone vaginal insert. Evidence Based Medicine 18: 140-141	RCT 105 DBC intracervical versus 105 PGE2 vaginal insert.	The results of the trial demonstrated no difference between the 2 methods from time of induction to delivery, but a higher rate of vaginal delivery within a 24hr period for women receiving the intracervical catheter.	Commentary
Shechter-Maor G, Haran G et al (2014). Intra-vaginal prostaglandin E2 versus double-balloon catheter for labor induction in term oligohydramnios. J Perinatol 1-4	Israel RCT n=52 In term oligohydramnios <5cm, bishop score<6 (DBC 26 vs vaginal insert 10mg timed release PGE2 [dinoprostone] 26) for IOL	Time from induction to active labour (13 with PGE2 vs19.5h DBC, p=0.243) No difference in caesarean rate (15.4 vs 7.7%, p=0.668). Early device removal (76.9 vs 26.9%, p=0.0001) mostly because of active labour or non-reassuring foetal heart rate. Oxytocin augmentation for IOL (53.8 VS 84.6%, P=0.034) Time to delivery (16 vs 20.5h, p=0.045).	Similar studies included in table 2.
Suffecool K, Rosenn BM et al (2014). Labor induction in nulliparous women with an unfavorable cervix: double balloon catheter versus dinoprostone. Journal of Perinatal Medicine. 42: 213-218	USA RCT n=62 Nulliparous women with an unfavourable cervix (bishop score<6) (DBC 31 vs CRA- 10mg Dinoprostone 31) for IOL	The mean induction to delivery time was shorter in the DBC group as compared to the dinoprostone group (17.9 versus 26.3 h) as time from induction to vaginal delivery (19.1 versus 24.4 h). More women in DBC group were delivered in 24 hrs compared to dinoprostone (87.1 % versus 47.4%). 50% of the women in both groups delivered by caesarean section.	Similar studies included in table 2.
Yuen PM, Pang HY et al (1996). Cervical ripening before induction of labour in patients with an unfavourable cervix: a comparative randomized study of the Atad Ripener Device, prostaglandin E2 vaginal pessary, and prostaglandin E2 intracervical gel. Australian & New Zealand Journal of Obstetrics & Gynaecology. 36: 291-295	Hong Kong Comparative randomised study n=119 women with unfavourable cervix (Bishop score <4) (36 DBC vs 39 PGE2 gel vs 39 PGE vaginal pessary) for IOL	No statistical significant difference between the 3 methods. PGE2 pessary seems to be more effective- 68% going to labour compared to 50% in the other 2 groups. Vaginal delivery rate - 87.2% pessary, 72% in DBC, 84.6% in gel. Duration of labour shorter in pessary 73.5% delivered in 24 hrs versus 57% DBC vs 57 % in gel. 5 developed complications during ripening period- 3 needed emergency C section, 2 had vaginal delivery.	Similar studies included in table 2.

Appendix B: Related NICE guidance for insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section

Guidance	Recommendations
Clinical guidelines	**Induction of labour: 2008 update. NICE clinical guideline 70 (2008). Available from http://www.nice.org.uk/guidance/CG70** This guidance updates and replaces NICE inherited clinical guideline D (published in 2001). **1.1 Information and decision-making** This section should be read in conjunction with Antenatal care: routine care for the healthy pregnant woman (NICE clinical guideline 62) and 'Intrapartum care: care of healthy women and their babies during childbirth' (NICE clinical guideline 55). 1.1.1.1 Women should be informed that most women will go into labour spontaneously by 42 weeks. At the 38 week antenatal visit, all women should be offered information about the risks associated with pregnancies that last longer than 42 weeks, and their options. The information should cover: • membrane sweeping: • that membrane sweeping makes spontaneous labour more likely, and so reduces the need for formal induction of labour to prevent prolonged pregnancy • what a membrane sweep is • that discomfort and vaginal bleeding are possible from the procedure • induction of labour between 41^{+0} and 42^{+0} weeks • expectant management. 1.1.1.2 Healthcare professionals should explain the following points to women being offered induction of labour: • the reasons for induction being offered • when, where and how induction could be carried out • the arrangements for support and pain relief (recognising that women are likely to find induced labour more painful than spontaneous labour; see also 1.6.2.1 and 1.6.2.2) • the alternative options if the woman chooses not to have induction of labour • the risks and benefits of induction of labour in specific circumstances and the proposed induction methods • that induction may not be successful and what the woman's options would be. 1.1.1.3 Healthcare professionals offering induction of labour should:

- allow the woman time to discuss the information with her partner before coming to a decision
- encourage the woman to look at a variety of sources of information
- invite the woman to ask questions, and encourage her to think about her options
- support the woman in whatever decision she makes.

1.2 Induction of labour in specific circumstances

1.2.1 Prevention of prolonged pregnancy

1.2.1.1 Women with uncomplicated pregnancies should be given every opportunity to go into spontaneous labour.

1.2.1.2 Women with uncomplicated pregnancies should usually be offered induction of labour between 41^{+0} and 42^{+0} weeks to avoid the risks of prolonged pregnancy. The exact timing should take into account the woman's preferences and local circumstances.

1.2.1.3 If a woman chooses not to have induction of labour, her decision should be respected. Healthcare professionals should discuss the woman's care with her from then on.

1.2.1.4 From 42 weeks, women who decline induction of labour should be offered increased antenatal monitoring consisting of at least twice weekly cardiotocography and ultrasound estimation of maximum amniotic pool depth[2].

1.2.2 Preterm prelabour rupture of membranes

1.2.2.1 If a woman has preterm prelabour rupture of membranes, induction of labour should not be carried out before 34 weeks unless there are additional obstetric indications (for example, infection or fetal compromise).

1.2.2.2 If a woman has preterm prelabour rupture of membranes after 34 weeks, the maternity team should discuss the following factors with her before a decision is made about whether to induce labour, using vaginal PGE_2[3]:

- risks to the woman (for example, sepsis, possible need for caesarean section)
- risks to the baby (for example, sepsis, problems relating to preterm birth)
- local availability of neonatal intensive care facilities.

1.2.3 Prelabour rupture of membranes at term

1.2.3.1 Women with prelabour rupture of membranes at term (at or over 37 weeks) should be offered a choice of induction of labour with vaginal PGE_2[3] or expectant management.

1.2.3.2 Induction of labour is appropriate approximately 24 hours after prelabour rupture of the membranes at term.[4]

1.2.4 Previous caesarean section

1.2.4.1 If delivery is indicated, women who have had a previous caesarean section may be offered induction of labour with vaginal PGE_2[3], caesarean section or expectant management on an individual basis, taking into account the woman's circumstances and wishes. Women

should be informed of the following risks with induction of labour:

- increased risk of need for emergency caesarean section during induced labour
- increased risk of uterine rupture.

1.2.5 Maternal request

1.2.5.1 Induction of labour should not routinely be offered on maternal request alone. However, under exceptional circumstances (for example, if the woman's partner is soon to be posted abroad with the armed forces), induction may be considered at or after 40 weeks.

1.2.6 Breech presentation

1.2.6.1 Induction of labour is not generally recommended if a woman's baby is in the breech presentation. If external cephalic version is unsuccessful, declined or contraindicated, and the woman chooses not to have an elective caesarean section, induction of labour should be offered, if delivery is indicated, after discussing the associated risks with the woman.

1.2.7 Fetal growth restriction

1.2.7.1 If there is severe fetal growth restriction with confirmed fetal compromise, induction of labour is not recommended.

1.2.8 History of precipitate labour

1.2.8.1 Induction of labour to avoid a birth unattended by healthcare professionals should not be routinely offered to women with a history of precipitate labour.

1.2.9 Intrauterine fetal death

1.2.9.1 In the event of an intrauterine fetal death, healthcare professionals should offer support to help women and their partners and/or family cope with the emotional and physical consequences of the death. This should include offering information about specialist support.

1.2.9.2 In the event of an intrauterine fetal death, if the woman appears to be physically well, her membranes are intact and there is no evidence of infection or bleeding, she should be offered a choice of immediate induction of labour or expectant management.

1.2.9.3 In the event of an intrauterine fetal death, if there is evidence of ruptured membranes, infection or bleeding, immediate induction of labour is the preferred management option.

1.2.9.4 If a woman who has had an intrauterine fetal death chooses to proceed with induction of labour, oral mifepristone, followed by vaginal PGE_2 or vaginal misoprostol[5], should be offered. The choice and dose of vaginal prostaglandin should take into account the clinical circumstances, availability of preparations and local protocol.

1.2.9.5 For women who have intrauterine fetal death and who have had a previous caesarean section, the risk of uterine rupture is increased. The dose of vaginal prostaglandin[3] should be reduced accordingly, particularly in the third trimester.

1.2.10 Suspected fetal macrosomia

1.2.10.1 In the absence of any other indications, induction of labour should

not be carried out simply because a healthcare professional suspects a baby is large for gestational age (macrosomic).

1.3 Recommended methods for induction of labour

Membrane sweeping involves the examining finger passing through the cervix to rotate against the wall of the uterus, to separate the chorionic membrane from the decidua. If the cervix will not admit a finger, massaging around the cervix in the vaginal fornices may achieve a similar effect. For the purpose of this guideline, membrane sweeping is regarded as an adjunct to induction of labour rather than an actual method of induction.

The Bishop score is a group of measurements made by doing a vaginal examination, and is based on the station, dilation, effacement (or length), position and consistency of the cervix. A score of eight or more generally indicates that the cervix is ripe, or 'favourable' – when there is a high chance of spontaneous labour, or response to interventions made to induce labour.

1.3.1 Membrane sweeping

1.3.1.1 Prior to formal induction of labour, women should be offered a vaginal examination for membrane sweeping[6].

1.3.1.2 At the 40 and 41 week antenatal visits, nulliparous women should be offered a vaginal examination for membrane sweeping.

1.3.1.3 At the 41 week antenatal visit, parous women should be offered a vaginal examination for membrane sweeping.

1.3.1.4 When a vaginal examination is carried out to assess the cervix, the opportunity should be taken to offer the woman a membrane sweep.

1.3.1.5 Additional membrane sweeping may be offered if labour does not start spontaneously.

1.3.2 Pharmacological methods

1.3.2.1 Vaginal PGE2 is the preferred method of induction of labour, unless there are specific clinical reasons for not using it (in particular the risk of uterine hyperstimulation). It should be administered as a gel, tablet or controlled-release pessary. Costs may vary over time, and trusts/units should take this into consideration when prescribing PGE2. For doses, refer to the SPCs. The recommended regimens are:

- one cycle of vaginal PGE2 tablets or gel: one dose, followed by a second dose after 6 hours if labour is not established (up to a maximum of two doses)
- one cycle of vaginal PGE2 controlled-release pessary: one dose over 24 hours.

1.3.2.2 When offering PGE2 for induction of labour, healthcare professionals should inform women about the associated risks of uterine hyperstimulation.

1.3.2.3 Misoprostol[5] should only be offered as a method of induction of labour to women who have intrauterine fetal death (see section 1.2.9) or in the context of a clinical trial.

1.3.2.4 Mifepristone should only be offered as a method of induction of

labour to women who have intrauterine fetal death (see section 1.2.9).

1.4 Methods that are not recommended for induction of labour

1.4.1 Pharmacological methods

1.4.1.1 The following should not be used for induction of labour:

- oral PGE_2
- intravenous PGE_2
- extra-amniotic PGE_2
- intracervical PGE_2
- intravenous oxytocin alone
- hyaluronidase
- corticosteroids
- oestrogen
- vaginal nitric oxide donors.

1.4.2 Non-pharmacological methods

1.4.2.1 Healthcare professionals should inform women that the available evidence does not support the following methods for induction of labour:

- herbal supplements
- acupuncture
- homeopathy
- castor oil
- hot baths
- enemas
- sexual intercourse.

1.4.3 Surgical methods

1.4.3.1 Amniotomy, alone or with oxytocin, should not be used as a primary method of induction of labour unless there are specific clinical reasons for not using vaginal PGE_2, in particular the risk of uterine hyperstimulation.

1.4.4 Mechanical methods

1.4.4.1 Mechanical procedures (balloon catheters and laminaria tents) should not be used routinely for induction of labour.

1.5 Setting and timing

1.5.1.1 In the outpatient setting, induction of labour should only be carried out if safety and support procedures are in place.

1.5.1.2 The practice of induction of labour in an outpatient setting should be audited continuously.

1.5.1.3 In the inpatient setting, induction of labour using vaginal PGE2 should be carried out in the morning because of higher maternal satisfaction.

1.6 Monitoring and pain relief

1.6.1 Monitoring

1.6.1.1 Wherever induction of labour is carried out, facilities should be available for continuous electronic fetal heart rate and uterine contraction monitoring.

1.6.1.2 Before induction of labour is carried out, Bishop score should be assessed and recorded, and a normal fetal heart rate pattern should be confirmed using electronic fetal monitoring.

1.6.1.3 After administration of vaginal PGE_2, when contractions begin, fetal wellbeing should be assessed with continuous electronic fetal monitoring. Once the cardiotocogram is confirmed as normal, intermittent auscultation should be used unless there are clear indications for continuous electronic fetal monitoring as described in 'Intrapartum care' (NICE clinical guideline 55).

1.6.1.4 If the fetal heart rate is abnormal after administration of vaginal PGE_2, recommendations on management of fetal compromise in 'Intrapartum care' (NICE clinical guideline 55) should be followed.

1.6.1.5 Bishop score should be reassessed 6 hours after vaginal PGE_2 tablet or gel insertion, or 24 hours after vaginal PGE_2 controlled-release pessary insertion, to monitor progress (see 1.3.2.1).

1.6.1.6 If a woman returns home after insertion of vaginal PGE_2 or tablet or gel, she should be asked to contact her obstetrician/midwife:

- when contractions begin, or
- if she has had no contractions after 6 hours.

1.6.1.7 Once active labour is established, maternal and fetal monitoring should be carried out as described in 'Intrapartum care' (NICE clinical guideline 55).

1.6.2 Pain relief

1.6.2.1 Women being offered induction of labour should be informed that induced labour is likely to be more painful than spontaneous labour.

1.6.2.2 Women should be informed of the availability of pain relief options in different settings (see 1.1.1.2 and 1.5.1.1).

1.6.2.3 During induction of labour, healthcare professionals should provide women with the pain relief appropriate for them and their pain (as described in 'Intrapartum care' [NICE clinical guideline 55]). This can range from simple analgesics to epidural analgesia.

1.6.2.4 Birth attendants (carers and healthcare professionals) should offer women support and analgesia as required, and should encourage women to use their own coping strategies for pain relief.

1.6.2.5 The opportunity to labour in water is recommended for pain relief[7].

1.7 Prevention and management of complications

1.7.1 Uterine hyperstimulation

1.7.1.1 Tocolysis should be considered if uterine hyperstimulation occurs during induction of labour.

1.7.2 Failed induction

Failed induction is defined as labour not starting after one cycle of

	treatment as described in 1.3.2.1. 1.7.2.1 If induction fails, healthcare professionals should discuss this with the woman and provide support. The woman's condition and the pregnancy in general should be fully reassessed, and fetal wellbeing should be assessed using electronic fetal monitoring. 1.7.2.2 If induction fails, decisions about further management should be made in accordance with the woman's wishes, and should take into account the clinical circumstances. 1.7.2.3 If induction fails, the subsequent management options include: • a further attempt to induce labour (the timing should depend on the clinical situation and the woman's wishes) • caesarean section (refer to Caesarean section [NICE clinical guideline 13]). 1.7.2.4 For women who choose caesarean section after a failed induction, recommendations in Caesarean section (NICE clinical guideline 13) should be followed. **1.7.3 Cord prolapse** 1.7.3.1 To reduce the likelihood of cord prolapse, which may occur at the time of amniotomy, the following precautions should be taken: • Before induction, engagement of the presenting part should be assessed. • Obstetricians and midwives should palpate for umbilical cord presentation during the preliminary vaginal examination and avoid dislodging the baby's head. • Amniotomy should be avoided if the baby's head is high. 1.7.3.2 Healthcare professionals should always check that there are no signs of a low-lying placental site before membrane sweeping and before induction of labour. **1.7.4 Uterine rupture** 1.7.4.1 If uterine rupture is suspected during induced labour, the baby should be delivered by emergency caesarean section (refer to Caesarean section [NICE clinical guideline 13]). **Induction of labour: Evidence Update 44 (July 2013) A summary of selected new evidence relevant to NICE clinical guideline 70 'Induction of labour' (2008)** (Evidence Updates do not replace current accredited guidance and do not provide formal practice recommendations) **Methods that are not recommended for induction of labour** • Nitric oxide donors do not seem to be effective for induction of labour. • Evidence for benefits of mechanical methods of induction of labour over prostaglandins seems to be inconclusive.

	• Compared with prostaglandin E2, Foley (balloon) catheters do not seem to lower rates of caesarean section, and are associated with longer time to delivery and higher likelihood of needing to administer oxytocin. **Diabetes in pregnancy: management of diabetes and its complications from pre-conception to the postnatal period. NICE clinical guideline 63 ([2008). Available from http://www.nice.org.uk/guidance/CG63** **This guidance is currently being updated.** [There is no information relevant to mechanical induction of labour] **Intrapartum care: care of healthy women and their babies during childbirth. NICE clinical guideline 190 (2014). Available from www.nice.org.uk/CG0190** This clinical guideline updates and replaces NICE clinical guideline 55 (published in 2007). [There is no information relevant to mechanical induction of labour] **Caesarean section. NICE clinical guideline 132 (2011). Available from www.nice.org.uk/CG0132** This clinical guideline updates and replaces NICE clinical guideline 13 (published in 2004). [There is no information relevant to mechanical induction of labour]

Appendix C: Literature search for insertion of a double balloon catheter for induction of labour in pregnant women without previous caesarean section

Databases	Date searched	Version/files
Cochrane Database of Systematic Reviews – CDSR (Cochrane Library)	25/03/2015	Issue 3 of 12, March 2015
HTA database (Cochrane Library)	25/03/2015	Issue 1 of 4, January 2015
Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library)	25/03/2015	Issue 2 of 12, February 2015
MEDLINE (Ovid)	25/03/2015	1946 to March Week 3 2015
MEDLINE In-Process (Ovid)	25/03/2015	March 24, 2015
EMBASE (Ovid)	25/03/2015	1974 to 2015 Week 12
PubMed	25/03/2015	n/a
CINAHL (NLH Search 2.0)	25/03/2015	n/a
JournalTOCS	25/03/2015	n/a

Trial sources searched on 22/10/2014

- National Institute for Health Research Clinical Research Network Coordinating Centre (NIHR CRN CC) Portfolio Database
- Current Controlled Trials *meta*Register of Controlled Trials – *m*RCT
- Clinicaltrials.gov

Websites searched on 22/10/2014

- National Institute for Health and Care Excellence (NICE)
- NHS England
- Food and Drug Administration (FDA) - MAUDE database
- French Health Authority (FHA)
- Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP – S)
- Australia and New Zealand Horizon Scanning Network (ANZHSN)
- Conference websites <<add details>>
- General internet search

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

1	Pregnant Women/
2	Pregnancy/
3	(Pregnan* adj4 (woman* or women* or lady* or female*)).tw.
4	Labor, Induced/
5	(Induc* adj4 labo?r).tw.
6	Parturition/
7	Delivery, Obstetric/
8	(Parturi* or childbirth* or accouchement* or childbear* or natalit* or deliver*).tw.
9	(unfavo?r* adj4 cervi*).tw.
10	or/1-9
11	Cervical Ripening/
12	Catheterization/
13	Catheter/
14	11 and (12 or 13)
15	((Cervix* or cervic*) adj4 (ripe* or soft* or dilat* or widen* or expan*) adj4 (balloon* or catheter*)).tw.
16	((((Double or two or duo or dual) adj4 (Inflat* or balloon* or transcervical* or trans-cervical*)) or double-balloon) adj4 (catheter* or tube* or device*)).tw.
17	((Extra-amniotic or extraamniotic or "extra amniotic") adj4 saline adj4 infusion*).tw.
18	EASI.tw.
19	or/14-18
20	10 and 19
21	(Cook adj4 Cervical adj4 Ripening adj4 Balloon*).tw.
22	(Atad adj4 device*).tw.
23	20 or 21 or 22
24	animals/ not humans/
25	23 not 24
26	limit 25 to ed=20141101-20150331