Contents lists available at ScienceDirect

European Journal of Obstetrics & Gynecology and **Reproductive Biology**

journal homepage: www.journals.elsevier.com/european-journal-of-obstetrics-and-gynecology-andreproductive-biology

Techniques for managing an impacted fetal head at caesarean section: A systematic review

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ARTICLE INFO

Keywords:

Caesarean

Second stage

Complication

Push method

Impacted fetal head

Reverse breech extraction

Patwardhan's technique

ABSTRACT

A complication arising at caesarean birth when the baby's head is deeply engaged in the pelvis and may be difficult to deliver, is known as an 'impacted fetal head'. This obstetric emergency occurs in 16% of second stage caesarean sections. Multiple techniques are described in the literature to manage the complication but there is no consensus regarding which technique results in the best maternal and neonatal outcomes. The objective of this review is to determine which technique for managing impacted fetal head at caesarean section has the best maternal and neonatal outcomes.

A literature search of three electronic databases was conducted in November 2021. Studies directly comparing two methods for the management of impacted fetal head at caesarean section in the second stage were included. Systematic reviews, meta-analyses, case-control studies, and studies not fitting the search criteria were excluded. Data was extracted in Covidence and meta-analysis of the six most commonly reported outcomes was conducted using RevMan 5.4.

In total, 16 studies (3344women) were included. 13 studies (2506women) compared the push method with reverse breech extraction, meta-analysis showed that risk of extension of the uterine incision, blood transfusion, bladder injury, postpartum haemorrhage, NICU admission and Apgar score <7 at 5 min were significantly higher with the push method compared with reverse breech extraction. Three studies (838women) compared the push method with Patwardhan's technique. meta-analysis of studies comparing the push method with Patwardhan's technique found no significant differences between the two groups in any of the six maternal or neonatal outcomes

Evidence derived from small, inadequately powered studies suggests reverse breech extraction is associated with better outcomes than the push method. The method which produces the best outcomes is still unknown as not all methods have been tested. Further high quality, adequately powered RCTs are warranted for definitive conclusions to be drawn and to ameliorate the paucity of evidence on how best to manage this complication.

Introduction

Impacted fetal head is a complication occurring at caesarean section which is most commonly observed following a failed instrumental delivery. The fetal head becomes fixed or 'impacted' in the woman's pelvis causing a lack of space between the bony pelvis, pelvic muscles and the fetal head (1). This can happen at any stage of labour but is most common in the second stage (2,3). The complication occurs in up to 5 % of all caesareans (4-7) and 16 % of second stage caesareans (8). Impacted fetal head carries a high risk of maternal and neonatal complications.

Many different techniques have been advocated for managing an impacted fetal head. Using gravity by lowering the head end of the operating table and maintaining it in this position for ten minutes is called the head down tilt method. Devices such as fetal pillow and Tydeman Tube have also been developed. The Fetal Pillow is a silicone balloon cephalic elevation device which is inserted beneath the fetal head, with the woman in the lithotomy position. The pillow is then and inflated with saline (1,9), elevating the fetal head three to four centimetres from its original position (1). The Tydeman Tube is a semi-rigid silicone tube with a hollow section in the middle and a soft cup at one end. Because the tube is hollow, air can move into the space surrounding the fetal head which helps to break the partial vacuum between the woman's pelvis and the fetal head caused by Ferguson reflexes (10). Tocolytic medications such as terbutaline (11), ritodrine (12) and

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https://doi.org/10.1016/j.ejogrb.2022.12.017

Received 14 September 2022; Received in revised form 2 December 2022; Accepted 8 December 2022 Available online 12 December 2022 0301-2115/© 2022 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).







Table 1

Characteristics of included studies - continued.

Author, year	Type of study	Country	Study setting	Techniques compared	Number of women in study
Bastani, 2012	Randomised control trial	Iran	Taleghani Women's Hospital – a single centre in Tabriz (city in Iran)	Push Reverse breech	59
Bhoi, 2019	Observational study	India	VSS Medical college and hospital, Burla, Odisha, India	Push Patwardhan	420
Chopra, 2009	Observational study	India	Nehru Hospital, Postgraduate Institute of Medical Education and Research, Chandigarh	Push Reverse breech	182
Ezra, 2020	Observational study	Israel	Department of obstetrics and gynaecology, JN medical college, Aligarh	Push Reverse breech	969
Fasubaa, 2002	Randomised control study	Nigeria	Obafemi Awolowo University Teaching Hospitals Complex – 2 obstetric units in Ile- Ife and Ilesha which are both semi-urban towns	Push Reverse breech	108
Frass, 2011	Case control study	Yemen	Obstetrics and Gynaecology Department, Al-Thawra General Hospital, Sana'a, Yemen	Push Reverse breech	118
Gil, 2019	Observational study	Israel	2 campuses of public university tertiary referral centre	Push Reverse breech	321
Kadhum, 2009	Randomised control study	Iraq	l-Zahraa Maternity and Paediatric Teaching Hospital in Al- Najaf	Push Reverse breech	50
Keepanasseril, 2019	Cohort study	India	Tertiary teaching hospital in South India – Women and Children's hospital attached to the Jawaharlal Institute of Medical Education and Research, Puducherry	Push Patwardhan	298
Lal, 2018	Observational study	India	Himalayan Institute of Medical Sciences – a tertiary care centre at Dehradun, Uttarakhand, India	Push Patwardhan	120
Lenz, 2019	Case control study	Switzerland	Tertiary care hospital in Zurich	Push Reverse breech	137
Levy, 2005	Observational study	Israel	Kaplan medical centre, Rehevot, Israel	Push Reverse breech	48
Nooh, 2017	Randomised control trial	Egypt	Al-Ahrar District General Hospital (DGH); Zagazig	Push Reverse breech	192
Tahir, 2020	Randomised control trial	Pakistan	Department of Obstetrics and Gynaecology Military Hospital, Rawalpindi Majority of the women live rurally with limited health care and literacy; a large number of them arrive at hospital already in advanced labour or with obstruction as a result	Push Reverse breech	110
Veisi, 2012	Observational study	Iran	Imam Reza Hospital, Kermanshah, Iran	Push Reverse breech	72
Ziyauddin, 2013	Observational study	India	Department of obstetrics and gynaecology, JN medical college, Aligarh	Push Reverse breech	140

nitroglycerin (13) have been used in caesareans to relax the womb, allowing for more manoeuvre room. This can minimise some of the complications that arise from impacted fetal head due to a lack of space in the uterine cavity. With the push method, the head is flexed and pushed upwards through the vagina by an assistant (14). In a reverse breech extraction, the surgeon reaches through the uterine incision and delivers the baby feet-first with gentle traction (15–17). Patwardhan's technique is a modification of the reverse breech method (18) whereby the shoulders of the baby are delivered first (1,19) followed by rotation of the head and delivery of the posterior shoulder and arm. Once the body is delivered, the head is lifted out of the pelvis (20,21).

Our aim was to conduct a systematic review of techniques for managing an impacted fetal head at caesarean section.

Material and methods

Data sources and study selection

A protocol was developed prior to data collection and was prospectively registered with PROSPERO (CRD42021284573). A literature search was carried out using Embase (1974 – November 2021), Ovid Medline (1946 – November 2021), and the Maternity and Infant Care Database (MIDIRS) (1971 – November 2021) for studies published up until November 1st 2021. A search strategy was developed as shown in Appendix C. Study selection was carried out using EndNote (22) for abstract screening and Covidence (23) for full-text screening. They were assessed individually by two authors (AP and EB). Data extraction

Using a bespoke data extraction form (Fig. A1 – appendices), data was extracted from included studies using Covidence systematic review software (24). Details of included studies such as lead author contact details, study setting, and any relevant notes on the study, were also extracted for points of reference; this information is shown in Table 1. The population, inclusion and exclusion criteria of included studies are shown in Table 2. Data was extracted independently by AP and EB to avoid error and then compared for consensus in Covidence, any disagreements were resolved by discussion with a third reviewer KFW.

To meet the inclusion criteria, each study had to compare the outcomes from two different techniques for managing an impacted fetal head at caesarean section. The studies had to provide primary data and hence systematic and literature reviews were excluded but randomised controlled trials, case control studies, and prospective and retrospective cohort studies were included. No language restrictions or study setting restrictions were made and all papers were available in English.

Statistical analysis

Statistical analysis was performed using Review Manager 5.4. Data sets with an I^2 below 50 % were analysed using the Mantel-Haenszel method and a fixed-effect model. Any outcomes that had an I^2 over 50 % were analysed using a random effects model. Summaries of the intervention effects for each study were provided using risk ratios (for dichotomous outcomes) or standardised mean differences (for continuous outcomes). Forest plots were generated for each analysis with a risk ratio at a 95 % confidence interval. Both models produced a Chi^2 figure with a corresponding p-value and the random effects model also

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uthor, year	Population	Inclusion Criteria	Exclusion Criteria	Author, year	Population Description	Inclusion Criteria	Exclusion Criteria
astani, 2012	Description Women with prolonged obstructed labour with fully dilated	 Very low station of fetal head in the second stage of delivery Dystocia 	 Multiple pregnancies Fetal anomalies Previous caesarean delivery 			 Cephalic presentation Obstructed labour Women requiring abdominal delivery 	
	cervix, arrest of descent for >1 h and obstructed labour at station +2	 Dystocia Vertex presentation 	- Premature delivery	Gil, 2019	Women undergoing caesareans with fully dilated cervix and fetal head at level of ischial spine of	 Singleton pregnancies Fully dilated cervix Fetal head at ischial spine or below 	 Multiple pregnancies Congenital fetal anomalies Preterm deliverie (<37 weeks) Cases in which as inverted T uterin
shoi, 2019	Women undergoing caesarean sections in advanced labour with deeply impacted head	 Singleton pregnancies Cephalic presentation 	 Major fetal anomaly Non-vertex presentation with labour Pre-existing maternal disease Pregnancy complications (eg. gestational diabetes or 		below		 incision was performed Cases with missin information Cases where both delivery methods were uss Fetal head above the ischial spines
			gestational hypertension)	Kadhum, 2009	Women submitted for emergency caesarean	 Singleton pregnancies 2nd stage At least 1 h fully 	NA
hopra, 2009	Women undergoing caesarean section in advanced labour with impacted fetal	 Singleton pregnancies Cephalic presentation Fetal head deeply engaged in the pelvis 	NA		section with deeply engaged fetal head	dilated cervix - Deeply engaged head - Transverse uterine incision	
	head	7 cm dilatation and vertex at or below zero station		Keepanasseril, 2019	Women who underwent caesarean at full dilation	 Fetal head station at ischial spine or below Push method Patwardhan's 	 Multiple pregnancies Non-vertex presentation Delivery by pull
zra,2020	Women undergoing caesarean	- Vertex presentation	 Gestational age <37+0 Multiple gestation 			- Tatwarunan 3	method
	section at the second stage of delivery		 Non-vertex presentation Missing data on mode of extraction and uterine rupture 	Lal, 2018	Women undergoing caesarean for impacted fetal head	NA	 Intrauterine feta death Congenital fetal abnormality Multiple pregnancy Preterm caesarea section
asubaa, 2002	Women with prolonged obstructed labour at term	NA	 Intrauterine fetal death Congenital fetal anomaly 				 Previous caesare section
	with live fetus undergoing caesarean section		 Multiple pregnancy Ruptured uterus Previous caesarean section Fetal head >2 fingerbreadths palpable per abdomen 	Lenz, 2019	Women at term required an intrapartum caesarean section	 At term Singleton pregnancies Cephalic presentation Cervical dilation >/= 7 cm 	 Multiple pregnancies Fetal anomalies Preterm delivery Fetal presentatio other than cepha
rass, 2011	Women with obstructed labour requiring abdominal delivery	 Singleton pregnancies Term pregnant women (depending on the last menstrual period or early first 	 Multiple pregnancy Non-cephalic presentation Previous scar Preterm labour 	Levy, 2005	Women undergoing non-elective caesarean deliveries	- Cases with documented difficult extraction of a singleton, term fetus in vertex presentation, during non-elective Caesarean deliveries	NA

Table 2 (continued)

Author, year	Population Description	Inclusion Criteria	Exclusion Criteria
Nooh, 2017	Women with obstructed labour, and requiring abdominal delivery	 Singleton pregnancies At term (37–42 weeks) Cephalic presentation Second stage of labour for 2 h (multipara) or 3 h (primipara) obstructed labour 	 Multiple pregnancy Preterm labour (<37 weeks gestation) Non-cephalic presentation Previous uterine scar
Tahir, 2020	Women undergoing caesarean due to obstructed labour, requiring abdominal delivery	 Singleton pregnancy Cephalic presentation >37 weeks of gestation 	 Multiple pregnancies Non-cephalic presentation Previous caesarear section scar Preterm labour
Veisi, 2012	Pregnant women with obstructed dystocia with impacted fetal head at full dilation leading to caesarean delivery via push or pull methods following a failed attempt at operative vaginal delivery by forceps application or vacuum extraction.	 Singleton pregnancy at 37 to 42 weeks Cephalic presentation Reactive fetal heart rate pattern 	 Estimated fetal weight >4000 g Intrauterine fetal death Multiple pregnancy Previous caesarear or myomectomy Chorioamnionitis Third-trimester haemorrhage
Ziyauddin, 2013	Women needing a caesarean section with an impacted fetal head	 Singleton pregnancy Cephalic presentation Term-pregnancy Late stage of labour with >/= 7 cm Vertex at or below 0 station 	NA

calculated Tau². The significance of each result was determined by an overall p-value < 0.05.

All studies were assessed for bias. The ROBINS-I (25) tool was used for cohort studies and the Cochrane risk of bias tool (26) was used to assess randomised controlled trials. Descriptive statistics that were commonly reported such as operative time, duration of hospital stay, maternal blood loss and fetal birth weight were analysed graphically using mean values and compared across the various methods.

Results

The PRISMA flow diagram for this study is shown in Fig. 1. We identified 155 studies in our search. 100 remained after removal of duplicates. All 100 studies were English language. Following screening of titles and abstracts, 18 studies were excluded. For the remaining 82 studies, full texts were examined against the inclusion criteria, leaving

16 studies to be analysed. Papers were excluded for reasons such as lack of data. Table 1 gives the study characteristics for the 16 included studies.

Thirteen studies compared the push method and reverse breech extraction, and three studies compared the push method with Patwardhan's technique. The majority (11) of the included studies were observational. All three studies comparing the push method with Patwardhan's technique were observational and all randomised studies compared the push method with reverse breech extraction.

Clinical heterogeneity was examined in Tables 1 and 2 using outcomes, study characteristics, inclusion and exclusion criteria, and study setting. Risk of bias is presented in Figs. 2 and 3.

Primary outcome measure - Extension of the uterine incision

The push method showed a significantly higher risk of uterine incision extension, compared with reverse breech extraction [RR 3.0, 95 % CI 2.1–4.2, P < 0.00001; 12 studies; 2366 women; Fig. 4]. The push method showed no significant difference in risk of extension of the uterine incision compared with Patwardhan's technique [RR 4.5, 95 % CI 0.46–45, P = 0.20; 3 studies; 838 women; Fig. 4].

Secondary outcome measures - Maternal

Blood transfusions

For studies where intra and post-operative blood transfusions were reported separately, the data was combined to produce a total number of blood transfusion events. The push method showed a significantly higher risk of blood transfusion, compared with reverse breech extraction [RR 1.9, 95 % CI 1.4–2.5, P < 0.00001; 9 studies; 2079 women; Fig. 5]. The push method showed no significant difference in the risk of blood transfusions compared with Patwardhan's technique [RR 1.7, 95 % CI 0.7–4.0, P = 0.26; 3 studies; 838 women; Fig. 5].

Postpartum haemorrhage

For studies where atonic and traumatic PPH were reported separately, the data was combined to produce a number for the total events of PPH. Ezra 2020 (12) specified that the medical team set their own definition. Gill 2019 (28) defined PPH as >1000 ml blood loss. Keepanasseril 2019 (29) defined PPH as >1500 ml blood loss. The push method showed a significantly higher risk of PPH, compared with reverse breech extraction [RR 2.2, 95 % CI 1.7–3.0, P < 0.00001; 6 studies; 1790 women; Fig. 6]. The push method showed no significant difference in risk of PPH compared with Patwardhan's technique [RR 2.1, 95 % CI 0.6–7.3, P = 0.25; 2 studies; 418 women; Fig. 6].

Bladder injury

The push method showed a significantly higher risk of bladder injury, compared with reverse breech extraction [RR 1.9, 95 % CI 1.1–3.3, P = 0.02; 5 studies; 1672 women; Fig. 7]. The push method showed no significant difference in risk of bladder injury compared with Patwardhan's technique [RR 4.4, 95 % CI 0.57–34, P = 0.15; 2 studies; 418 women; Fig. 7].

Secondary outcome measures - Neonatal

NICU admission

The push method showed a significantly higher risk of NICU admission, compared with reverse breech extraction [RR 1.8, 95 % CI 1.4–2.5, P < 0.0001; 8 studies; 1967 babies; Fig. 8]. The push method showed no significant difference in risk of NICU admission compared with Patwardhan's technique [RR 0.92, 95 % CI 0.5–1.6, P = 0.78; 3 studies; 838 babies; Fig. 8].

Apgar score

The push method showed a significantly higher risk of Apgar score

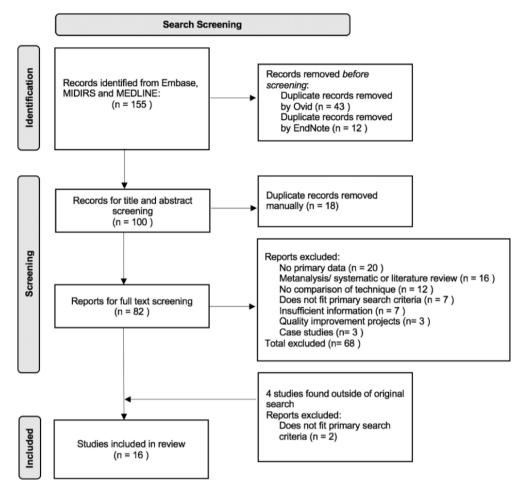


Fig. 1. PRIMSA flow diagram.

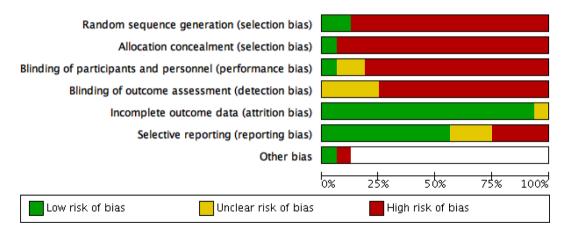


Fig. 2. Risk of bias graph generated from Review Manager 5.4 (27) - judgements about each risk of bias item presented as percentages across all included studies.

 $<\!\!7$ at 5 min, compared with reverse breech extraction minutes [RR 1.5, 95 % CI 1.0–2.3, P = 0.04; 6 studies; 1648 babies; Fig. 9].

Discussion

No studies which compared the push method with Patwardhan's technique reported Apgar score <7 at 5 min however, Apgar score <3 at 5 min was reported in one study and the push method showed no significant difference in risk of Apgar score <3 at 5 min compared with Patwardhan's technique [RR 1.7, 95 % CI 0.87–3.3, P = 0.12; 1 study; 420 babies; Fig. 10].

Main findings

Reverse breech extraction was associated with significantly lower risk of extension of the uterine incision, need for blood transfusion, bladder injury, postpartum haemorrhage, NICU admission and Apgar score <7 at 5 min, when compared with the push method. On the other hand, there was no significant difference in risk of extension of the uterine incision, blood transfusions, bladder injury, postpartum

Ziyauddin 2013	Veisi 2012	Tahir 2020	Nooh 2017	Levy 2005	Lenz 2019	Lal 2018	eepanasseril 2019	Kadhum 2009	Gill 2019	Frass 2011	Fasubaa 2002	Ezra 2020	Chopra 2009	Bhoi 2019	Bastani 2012	_
			•		•	•				•	•	•				Random sequence generation (selection bias)
			•							•		•				Allocation concealment (selection bias)
			•		•		•			•	~	•			~	Blinding of participants and personnel (performance bias)
•			~		•	•	•			~	~	•			~	Blinding of outcome assessment (detection bias)
•	Ŧ	Ŧ	•	•	•	•	•	~	Ŧ	•	•	•	•	•	•	Incomplete outcome data (attrition bias)
•	•		•	•	•	•	•	~	Ŧ	~	•		~			Selective reporting (reporting bias)
												•				Other bias

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Fig. 3. Risk of bias summary generated from Review Manager 5.4 (27) - review authors' judgements about each risk of bias item for each included study.

Push Patwardhan Risk Ratio Risk Ratio Study or Subgroup Events Total Weight M-H, Random, 95% CI M-H, Random, 95% CI Bhoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] Keepanasseril 2019 55 221 20 77 39.8% 0.96 [0.62, 1.49]		Risk Ratio		Risk Ratio		reech	Reverse B	n I	Pusi	
Veisi 2012 24 35 3 37 5.8% 8.46 [2.79, 25.60] Frass 2011 24 59 3 59 5.6% 8.00 [2.55, 25.13] Tahir 2020 25 55 5 55 7.6% 5.00 [2.06, 12.11] Lenz 2019 29 82 5 55 7.6% 3.89 [1.60, 9.43] Lenz 2019 29 82 5 55 7.6% 3.89 [1.60, 9.43] Lewy 2005 14 28 3 20 5.9% 3.33 [1.10, 10.08] Bastani 2012 15 30 5 29 7.7% 2.30 [1.60, 4.07] Kadhum 2009 14 25 6 25 8.7% 2.33 [1.07, 5.09] Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Heterogeneity: Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% M-H, Random, 95% CI M-H, Random, 95% CI Bhoi 2019 34 291 0 129 25.3% 30.72 [1.90,	CI	M-H, Random, 95% CI		I-H, Random, 95% CI	Weight	Total	Events	Total	Events	Study or Subgroup
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Tahir 2020 25 55 5 55 7.6% 5.00 [2.06, 12.11] Lenz 2019 29 82 5 55 7.6% 3.89 [1.60, 9.43] Levy 2005 14 28 3 20 5.9% 3.33 [1.10, 10.08] Bastani 2012 15 30 5 29 7.7% 2.90 [1.21, 6.95] Fasubaa 2002 16 54 6 54 7.9% 2.33 [1.07, 5.09] Kadhum 2009 14 25 6 25 8.7% 2.33 [1.07, 5.09] Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% CI) 1415 951 100.0% 2.98 [2.14, 4.15] 10 Test for overall effect: Z = 6.43 (P < 0.00001)		│ — • —		8.46 [2.79, 25.60]	5.8%	37	3	35	24	Veisi 2012
Lenz 2019 29 82 5 55 7.6% 3.89 [1.60, 9.43] Lewy 2005 14 28 3 20 5.9% 3.33 [1.10, 10.08] Bastani 2012 15 30 5 29 7.7% 2.90 [1.21, 6.95] Fasubaa 2002 16 54 6 54 7.9% 2.67 [1.13, 6.30] Nooh 2017 46 96 18 96 12.5% 2.56 [1.60, 4.07] Kadhum 2009 14 25 6 25 8.7% 2.33 [1.07, 5.09] Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% CI) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity: Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.11 10 Favours Push Favours Revent 0.129 25.3% 30.72 [1.90, 497.23] Keepanasseril 2019 34 291 0 129 25.3%				8.00 [2.55, 25.13]	5.6%	59	3	59	24	Frass 2011
Levy 2005 14 28 3 20 5.9% $3.33[1.10, 10.08]$ Bastani 2012 15 30 5 29 7.7% $2.90[1.21, 6.95]$ Fasubaa 2002 16 54 6 54 7.9% $2.67[1.13, 6.30]$ Nooh 2017 46 96 18 96 12.5% $2.56[1.60, 4.07]$ Kadhum 2009 14 25 6 25 8.7% $2.33[1.07, 5.09]$ Ezra 2020 158 615 42 354 14.5% $2.17[1.58, 2.96]$ Gill 2019 61 200 29 121 13.7% $1.27[0.87, 1.86]$ Total (95% CI) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity: Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.11 10 Favours Push Favours Rever Favours Rever 0.002 0.11 10 Study or Subgroup Events Total Events Total Meight M-H, Random, 95% CI Bhoi 2019 34	-			5.00 [2.06, 12.11]	7.6%	55	5	55	25	Tahir 2020
Bastani 2012 15 30 5 29 7.7% 2.30 [1.21, 6.95] Fasubaa 2002 16 54 6 54 7.9% 2.67 [1.13, 6.30] Nooh 2017 46 96 18 96 12.5% 2.56 [1.60, 4.07] Kadhum 2009 14 25 6 25 8.7% 2.33 [1.07, 5.09] Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% CI) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity: Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.1 10 Favours Push Patwardhan Risk Ratio Risk Ratio M-H, Random, 95% CI Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Bhoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] Keepanasseril 2019 55 221		—•—		3.89 [1.60, 9.43]	7.6%	55	5	82	29	Lenz 2019
Fasubaa 2002 16 54 6 54 7.9% 2.67 1.13 6.30 Nooh 2017 46 96 18 96 12.5% 2.56 [1.60, 4.07] Kadhum 2009 14 25 6 25 8.7% 2.33 [1.07, 5.09] Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% CI) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity. Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); I ² = 60% 0.002 0.1 10 Favours Push Patwardhan Risk Ratio Risk Ratio M-H, Random, 95% CI Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Bhoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] 4.51 [0.46, 44.56] Lal 2018 15 64 2 56		- _		3.33 [1.10, 10.08]	5.9%	20	3	28	14	Levy 2005
Nooh 2017 46 96 18 96 12.5% 2.56 [1.60, 4.07] Kadhum 2009 14 25 6 25 8.7% 2.33 [1.07, 5.09] Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% Cl) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 126 100.0% 2.98 [2.14, 4.15] Total events 457 126 100.0% 2.98 [2.14, 4.15] 10 Test for overall effect: Z = 6.43 (P < 0.00001) Patwardhan Risk Ratio Risk Ratio M-H, Random, 95% Cl Study or Subgroup 24 Patwardhan Risk Ratio M-H, Random, 95% Cl M-H, Random, 95% Cl Shoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] 46.56 [1.57, 27.45] Study or Subgroup 55 221 20 77 39.8% 0.96 [0.62, 1.49]		_ 		2.90 [1.21, 6.95]	7.7%	29	5	30	15	Bastani 2012
Kadhum 2009 14 25 6 25 8.7% 2.33 [1.07, 5.09] Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% Cl) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity. Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.1 1 10 Test for overall effect: Z = 6.43 (P < 0.00001) Patwardhan Risk Ratio Risk Ratio M-H, Random, 95% Cl Study or Subgroup 24 291 0 129 25.3% 30.72 [1.90, 497.23] M-H, Random, 95% Cl Study or Subgroup 34 291 0 129 25.3% 30.72 [1.90, 497.23] M-H, Random, 95% Cl Store parasseril 2019 55 221 20 77 39.8% 0.96 [0.62, 1.49] 4.51 [0.46, 44.56] Ical (95% Cl) 576 262 100.0% 4.51 [0.46, 44.56] 4.51 [0.46, 44.56]		_ -		2.67 [1.13, 6.30]	7.9%	54	6	54	16	Fasubaa 2002
Ezra 2020 158 615 42 354 14.5% 2.17 [1.58, 2.96] Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% Cl) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity: Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.1 1 10 Test for overall effect: Z = 6.43 (P < 0.00001) Patwardhan Risk Ratio Risk Ratio Risk Ratio Study or Subgroup $Events$ Total Events Total Weight M-H, Random, 95% Cl M-H, Random, 95% Cl Shoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] 4.51 [0.46, 44.56] Cal (95% Cl) 576 262 100.0% 4.51 [0.46, 44.56] 4.51 [0.46, 44.56]				2.56 [1.60, 4.07]	12.5%	96	18	96	46	Nooh 2017
Gill 2019 61 200 29 121 13.7% 1.27 [0.87, 1.86] Total (95% Cl) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity. Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.1 1 Test for overall effect: Z = 6.43 (P < 0.00001) Patwardhan Risk Ratio Risk Ratio Risk Ratio Study or Subgroup Push Patwardhan Risk 0 M-H, Random, 95% Cl M-H, Random, 95% Cl Bhoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] Keepanasseril 2019 55 221 20 77 39.8% 0.96 [0.62, 1.49] 4.51 [0.46, 44.56] Total (95% Cl) 576 262 100.0% 4.51 [0.46, 44.56] 4.51 [0.46, 44.56]				2.33 [1.07, 5.09]	8.7%	25	6	25	14	Kadhum 2009
Total (95% CI) 1415 951 100.0% 2.98 [2.14, 4.15] Total events 457 126 Heterogeneity: Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.1 1 Test for overall effect: Z = 6.43 (P < 0.00001)		-		2.17 [1.58, 2.96]	14.5%	354	42	615	158	Ezra 2020
Total events 457 126 Heterogeneity. Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.1 10 Test for overall effect: Z = 6.43 (P < 0.00001) Patwardhan Risk Ratio Risk Ratio Risk Ratio Study or Subgroup Push Patwardhan Risk Ratio M-H, Random, 95% CI M-H, Random, 95% CI Study or Subgroup 34 291 0 129 25.3% 30.72 [1.90, 497.23] Steppanasseril 2019 55 221 20 77 39.8% 0.96 [0.62, 1.49]				1.27 [0.87, 1.86]	13.7%	121	29	200	61	Gill 2019
Heterogeneity: Tau ² = 0.17; Chi ² = 27.85, df = 11 (P = 0.003); l ² = 60% 0.002 0.1 10 Test for overall effect: Z = 6.43 (P < 0.00001)		•		2.98 [2.14, 4.15]	100.0%	951		1415		Fotal (95% CI)
OUR CONSTRUCTION OF CONSTRUCTURE OF CONSTRUCTION OF CONSTRUCTION OF CONSTRUCTURE OF							126		457	Total events
Test for overall effect: Z = 6.43 (P < 0.00001)	0 50		1	60%	0.003); I ²	L1 (P = 0	85, df = 3	$i^2 = 27.$	0.17; Ch	Heterogeneity: Tau ² =
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI M-H, Random, 95% CI Shoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] Image: Comparison of the		Favours Push Favours Reverse					00001)	(P < 0.)	Z = 6.43	Test for overall effect:
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI M-H, Random, 95% CI Shoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] Image: Comparison of the									-	
Shoi 2019 34 291 0 129 25.3% 30.72 [1.90, 497.23] Keepanasseril 2019 55 221 20 77 39.8% 0.96 [0.62, 1.49] Lal 2018 15 64 2 56 34.9% 6.56 [1.57, 27.45] Fotal (95% Cl) 576 262 100.0% 4.51 [0.46, 44.56] Total events 104 22	-									
Seepanasseril 2019 55 221 20 77 39.8% 0.96 [0.62, 1.49] Lal 2018 15 64 2 56 34.9% 6.56 [1.57, 27.45] Fotal (95% Cl) 576 262 100.0% 4.51 [0.46, 44.56] Image: Comparison of the second	CI	M–H, Random, 95% CI		M-H, Random, 95% Cl	Weight		Events			, ,
Lal 2018 15 64 2 56 34.9% 6.56 [1.57, 27.45] Fotal (95% CI) 576 262 100.0% 4.51 [0.46, 44.56] Total events 104 22				30.72 [1.90, 497.23]	25.3%	129	0	291	34	3hoi 2019
Fotal (95% CI) 576 262 100.0% 4.51 [0.46, 44.56] Fotal events 104 22				0.96 [0.62, 1.49]	39.8%	77	20	221	55	Keepanasseril 2019
otal events 104 22				6.56 [1.57, 27.45]	34.9%	56	2	64	15	al 2018.
				4.51 [0.46, 44.56]	100.0%	262		576		Total (95% CI)
							27		104	Total events
Heterogeneity. Tau ² = 3.38; Chi ² = 16.60, df = 2 (P = 0.0002); I ² = 88%	10 10									
Test for overall effect: $Z = 1.29$ (P = 0.20) (P = 0.20) (P = 0.0002), T = 88% (P = 0.001 0.1 1 1) (P = 0.001 0.1 1)				² = 88%	0.00021	2(P = 1)	560 df =	hi ² = 16	33810	-leterogeneity Taur =

Fig. 4. Extension of the uterine incision.

haemorrhage and NICU admission, when the push method was compared with Patwardhan's technique.

Strengths and limitations

Impacted fetal head is difficult to define and so participant selection is at the discretion of the authors of each study. Clinical heterogeneity of the included studies was however, assessed thoroughly. This provided assurance that the included studies were of similar setting, and were defined by very similar populations, inclusion and exclusion criteria, making them suitable for *meta*-analysis.

Most of the studies included in this systematic review are observational and so at high risk of bias; caution must therefore be applied when interpreting the results. There were only five RCTs in this review (including a total of 519 women), all of which compared the push method to reverse breech extraction. No RCTs for other methods to manage an impacted fetal head fitted the search criteria for this review, highlighting the paucity of randomised trial data for other, lesscommonly used techniques. The observational studies in this review certainly suggest that reverse breech extraction is safer than the push method, but this must be tested in randomised trials.

The studies in this review included a mean population of 213 women however, the smallest studies included only 50 (Kadhum 2009 (30)) and 48 (and Levy 2005 (31)) women. When data from these studies was removed from the *meta*-analysis, the results for all three outcomes remained significant. The included studies in this review were from a diverse number of geographical locations with potential variation in healthcare services and availability. Other limitations for consideration include how the need for blood transfusion as an outcome measure could be influenced by the availability and local policy on giving blood products and is likely to vary in different settings, therefore differences observed between the different studies could be impacted by resource availability rather than a true difference in PPH.

Another limitation of the included studies in this study is the

	Pus	h	Reverse Breech Extr	action		Risk Ratio	Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI	M-H, Fixed, 95% CI
Bastani 2012	3	30	1	29	1.5%	2.90 [0.32, 26.30]	
Chopra 2009	5	136	4	46	8.6%	0.42 [0.12, 1.51]	
Ezra 2020	59	615	22	354	40.2%	1.54 [0.96, 2.47]	⊢ ∎−
rass 2011	6	59	4	59	5.8%	1.50 [0.45, 5.04]	-
Gill 2019	17	200	8	121	14.3%	1.29 [0.57, 2.89]	
Kadhum 2009	17	25	5	25	7.2%	3.40 [1.48, 7.79]	— • —
_evy 2005	3	28	0	20	0.8%	5.07 [0.28, 93.00]	
Nooh 2017	14	96	3	96	4.3%	4.67 [1.39, 15.72]	— • — –
Ziyauddin 2013	28	70	12	70	17.3%	2.33 [1.29, 4.21]	
Fotal (95% CI)		1259		820	100.0%	1.86 [1.41, 2.45]	•
Total events	152		59				
Heterogeneity: Chi ² =	12.15. d	lf = 8 (F	$P = 0.14$); $ ^2 = 34\%$				h
est for overall effect							0.01 0.1 1 10 100 Favours Push Favours Reverse Breech

	Pus	h	Patware	dhan		Risk Ratio		Risk	Ratio		
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI		M-H, Rand	om, 95% CI		
Bhoi 2019	39	291	6	129	32.9%	2.88 [1.25, 6.64]					_
Keepanasseril 2019	13	221	7	77	31.8%	0.65 [0.27, 1.56]					
Lal 2018	21	64	8	56	35.4%	2.30 [1.11, 4.77]					
Total (95% CI)		576		262	100.0%	1.65 [0.69, 3.95]		-			
Total events	73		21								
Heterogeneity: Tau ² =	= 0.42; Cł	$ni^2 = 6.$	87, df =	2 (P = 0	0.03); I ² =	= 71%	0.01	01	1	0 10	7
Test for overall effect:	Z = 1.13	8 (P = C	0.26)				0.01	Favours Push	Favours Pat		U



	Pusi		Reverse B			Risk Ratio	Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI	M–H, Fixed, 95% CI
Ezra 2020	48	615	17	354	37.2%	1.63 [0.95, 2.78]	
Frass 2011	10	59	5	59	8.6%	2.00 [0.73, 5.50]	-
Gill 2019	12	200	б	121	12.9%	1.21 [0.47, 3.14]	
Kadhum 2009	7	25	3	25	5.2%	2.33 [0.68, 8.01]	
Nooh 2017	5	96	2	96	3.4%	2.50 [0.50, 12.57]	
Ziyauddin 2013	64	70	19	70	32.7%	3.37 [2.28, 4.98]	
Total (95% CI)		1065		725	100.0%	2.24 [1.70, 2.95]	•
Total events	146		52				
Heterogeneity: $Chi^2 =$	7.23, df	= 5 (P	$= 0.20); 1^2$	= 31%			
Test for overall effect							0.01 0.1 1 10 100 Favours Push Favours Reverse Breech
	Pus	h	Patward	han		Risk Ratio	Risk Ratio

	Pus	h	Patware	dhan		Risk Ratio		Risk	Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI		M-H, Rand	dom, 95% CI	
Keepanasseril 2019	26	221	8	77	52.0%	1.13 [0.54, 2.39]			-	
Lal 2018	23	64	5	56	48.0%	4.03 [1.64, 9.88]				
Total (95% CI)		285		133	100.0%	2.08 [0.60, 7.26]		-		
Total events	49		13							
Heterogeneity: Tau ² =	· ·		· ·	1 (P = 0	0.03); I ² =	= 78%	0.01	0.1	1 10	100
Test for overall effect:	Z = 1.15	(P = 0)	.251					Favours Push	Favours Paty	wardhan

Fig. 6. Postpartum haemorrhage.

discrepancy in defining PPH. The lack of detail on the length of, and indication for NICU admissions is a further limitation.

Our study drew similar conclusions to a 2016 systematic review (32) and a 2020 literature review (33).

Meaning of the study

It has been postulated that reverse breech extraction produces better neonatal outcomes than the push method because there is less risk of injury to the fetus during delivery (34). Reverse breech extraction was also associated with reduced rates of uterine incision extension and postpartum haemorrhage. A similar association may exist between larger babies and increased incidence of extension of the uterine incision. However, there was little difference between the average birth weights of babies in the push group and reverse breech extraction, but extension of the uterine incision occurred significantly less with reverse breech extraction, so this possible explanation is not corroborated by our

Unanswered questions for future research

Only three techniques were included in this systematic review which highlights the paucity of RCTs and observational studies for other methods used to manage an impacted fetal head. The question of which method produces the best maternal and neonatal outcomes still remains.

results. This review does not provide explanations as to why one tech-

nique may produce better outcomes than another. Evidence that one

method produces better outcomes without explanation is nonetheless useful with regards to designing randomised trials in this area.

For additional meaningful conclusions to be drawn and for these to be implemented in clinical practice, further RCTs will need to be conducted comparing other techniques not included in this review, with reverse breech extraction, the push method and Patwardhan's technique. Moreover, if these techniques are to be safely implemented in practice, clinicians will require further training in the management of

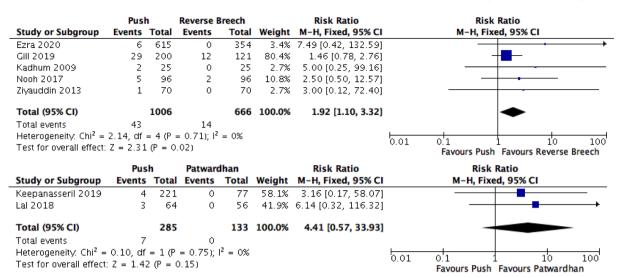
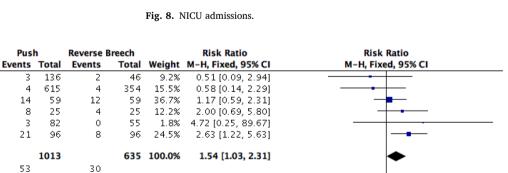


Fig. 7. Bladder injury.

	Pus	h	Reverse Bre	ech Extra	action		Risk Ratio	Risk Ratio
Study or Subgroup	Events	Total	Event	s	Total	Weight	M-H, Fixed, 95% CI	M-H, Fixed, 95% CI
Ezra 2020	17	615	1:	1	354	26.5%	0.89 [0.42, 1.88]	-
Fasubaa 2002	39	54	14	4	54	26.6%	2.79 [1.72, 4.50]	
Frass 2011	13	59	1:	1	59	20.9%	1.18 [0.58, 2.42]	_
Gill 2019	9	200		2	121	4.7%	2.72 [0.60, 12.39]	
Kadhum 2009	8	25	3	3	25	5.7%	2.67 [0.80, 8.90]	
Lenz 2019	2	82	:	1	55	2.3%	1.34 [0.12, 14.44]	·
Nooh 2017	15	96	-	7	96	13.3%	2.14 [0.91, 5.02]	
Veisi 2012	0	35	(C	37		Not estimable	
Total (95% CI)		1166			801	100.0%	1.82 [1.35, 2.46]	•
Total events	103		49	9				
Heterogeneity. $Chi^2 =$	8.80, df	= 6 (P	$= 0.19$; $ ^2 =$	32%				
Test for overall effect:	Z = 3.90	D (P < C	0.0001)					0.01 0.1 1 10 100 Favours Push Favours Reverse Breech
	F	Push	Patware	dhan			Risk Ratio	Risk Ratio
Study or Subgroup	Ever	nts To	tal Events	Total	Weight	: М-Н,	Random, 95% CI	M-H, Random, 95% CI
Bhoi 2019		84 2	91 30	129	36.3%	6	1.24 [0.86, 1.78]	
Keenonosseril 2010		20 7	21 45	77	20.29	,	0 67 10 48 0 801	-

restror overall effect. 2	. = 0.20 (r = 0.7	0)					Favours Push	Favour	rs Patward	han
Test for overall effect: Z			·	20 -	0.004), 1 -	- 02%	0.01	0.1	1	10	100
Heterogeneity, Tau ² = 0	n 19⊂chi ²	- 11 1	6 df –	2 (P =	0.0041.12	- 87%	L				
Total events	177		85								
Total (95% CI)		576		262	100.0%	0.92 [0.53, 1.61]		•			
Lal 2018	13	64	10	56	24.3%	1.14 [0.54, 2.39]			 		
Keepanasseril 2019	80	221	45	77	39.3%	0.62 [0.48, 0.80]					



0.01

Fig. 9. Apgar score <7 at 5 min.

impacted fetal heads. Education on other methods and on selecting an appropriate technique for individual cases is required if the results of our study are to be implemented in clinical practice.

3

4

14

8

3

53

Heterogeneity. $Chi^2 = 6.79$, df = 5 (P = 0.24); $I^2 = 26\%$

Test for overall effect: Z = 2.09 (P = 0.04)

Study or Subgroup

Chopra 2009

Kadhum 2009

Total (95% CI)

Total events

Ezra 2020

Frass 2011

Lenz 2019

Nooh 2017

None of the included studies examined longer term neonatal complications following a caesarean complicated by an impacted fetal head. The wider literature on long-term complications is scarce.

0.1

Conclusions

This systematic review suggests reverse breech extraction is

100

10

Favours Push Favours Reverse Breech

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study or Subgroup	Push Events Total	Patwardhan Events Total	Weight	Risk Ratio M-H, Fixed, 95% CI	м	Risk Ratio M-H, Fixed, 95% CI					
hoi 2019	38 291	10 129		1.68 [0.87, 3.28]		Ŧ	-				
Total (95% CI)	291	129	100.0%	1.68 [0.87, 3.28]							
otal events	38	10	100.070	1.00 [0.07, 5.20]							
leterogeneity: Not appl					0.01 0.1		10	100			
est for overall effect: Z	= 1.54 (P = 0)	.12)				rs Push Fa	vours Patwa				
		Fig	10 Ang	ar score <3 at 5 min.							
		Fig	. 10. Apg								
General information		Study fundi	ng sources		Table preview	1					
Study ID							Group 1 (N)	Group 2 (N)			
		Dessible es		reat far aturbu authora	Mean materr	al age (years)					
		Possible co	Intlicts of Inte	rest for study authors	Mean materr	al weight (kg)					
Title					Smokers						
Title of paper / abstract / report tł from	hat data are extracted	Participan	te		Pre-existing	condition					
					Maternal Eth	nicity					
		Population	description		Mean gestat	onal age					
Lead author contact details					(weeks)						
					Fetal birthwe	ight (kg)					
		Inclusion cr	iteria		Outcomes						
Country in which the study condu	icted										
 United States 											
⊖ UK		Exclusion c	riteria		Method and C	utcomes					
Canada						Method 1	Method 2	P-Value			
O Australia					Outcome 1						
Other		Total numb	er of participa	nts	Outcome 2						
					Outcome 3						
Study Setting					Outcome 4						
		Method 1			Outcome 5						
		O Push n			Outcome 6						
Notes			e breech/ pu	111	Outcome 7						
		 Fetal P Patwar 			Outcome 8						
		O Tydem			Outcome 9						
Characteristics of inclu	ded studies		tic medicatio	on	Outcome 10						
Study design					Outcome 11						
 Randomised controlled tria 	al	Number of	participants f	or method 1	Outcome 12						
O Non-randomised experime	ental study				Outcome 13						
 Cohort study 					Outcome 14						
 Cross sectional study 		Method 2	nothod		Outcome 15						
Case control study		O Push n	netnoa :e breech/ pu	ul.	Outcome 16						
Systematic review		 Revers Fetal P 			Outcome 17						
 Qualitative research Prevalence study 					Outcome 18						
Case series		 Tydem 			Outcome 19						
 Case report 		-	tic medicatio	on	Outcome 20						
 Diagnostic test accuracy s 	study										
 Clinical prediction rule 		Number of	participants for	or method 2	Conclusion						
 Economic evaluation 											
 Text and opinion 				o not have a clinical outcome							
Other		Number of				nclusion					

Fig. A1. Data extraction form - designed in Covidence (24).

associated with fewer adverse maternal and neonatal outcomes than the push method. The question of which method is the best still remains as not all techniques for impacted fetal heads were included in the studies analysed in this review; it also remains unclear whether the sequential use of techniques would produce fewer complications. The exponential increase in the number of studies investigating this since the 2016 Cochrane Review (19) highlights the importance of continued research on this topic. Further high quality, adequately powered RCTs and systematic reviews are warranted in order for definitive conclusions to be drawn.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. KFW has received a personal fellowship from the University of Nottingham which funds her time for this review.

Appendix A

Fig. A1.

B. PROSPERO registration form.

https://www.crd.york.ac.uk/prospero/display_record.php?ID = CRD42021284573 C. Ovid search strategy.

Term number	Search term	Number of results
1	caesarean OR caesarian OR Caesarean OR cesarian	229,991
2	section	539,271
3	1 AND 2	204,245
4	impacted f**tal head or deeply engaged head	145
5	deeply engaged f**tal head or impacted head	83
6	4 OR 5	192
7	3 AND 6	155
8	remove duplicates from 7	112

Funding

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European Journal of Obstetrics & Gynecology and Reproductive Biology 281 (2023) 12-22



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