Title
Neuraxial anesthesia for external cephalic versions: A review

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Publication Date
2017

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Abstract

Background: Anesthesia and analgesia in external cephalic versions (ECVs) may improve success rates without significant increases in adverse effects. In light of the potential to decrease cesarean sections using ECVs, there is significant initiative to increase success rates for ECVs. Prior studies have demonstrated that neuraxial blockade may improve success rates of ECVs, and that this may be dependent on anesthetic or analgesic drug choice and dosing. Neuraxial blockade has included epidural, spinal, and combined spinal epidural (CSE) methods. Thus, this review intends to determine if the use of neuraxial anesthesia improves ECV success outcomes and decreases cesarean deliveries.

Methods: PubMed and Cochrane database searches were performed using search terms "external cephalic version," "anesthesia," and "analgesia." Studies were screened based on title and abstract, and deemed eligible based on study design, English text availability, and published status. Of the 179 initially identified studies, 19 studies published between 1994-2016 were selected for examination. These studies consisted of 10 randomized controlled trials, 5 prospective and 3 retrospective studies, and 1 survey.

Results: Of the 10 randomized clinical trials, 6 studies found significant improvement in ECV success rates and 2 studies found decreased cesarean delivery rates in neuraxial blockade intervention groups. Of the 5 prospective studies, 1 study found significant improvement in ECV success rates and increased vaginal delivery rate in the neuraxial blockade intervention group. Of the 3 retrospective studies, 2 studies demonstrated significant improvement in ECV success rates with neuraxial blockade. The same 2 studies showed increased cesarean delivery rates in groups that did not receive neuraxial

blockade. The survey examined demonstrated that ECVs are variably used and executed across institutions.

Conclusions: Neuraxial blockade has been found to significantly increase ECV success rates in about half of studies examined. Success rates may be associated with using drugs at anesthetic dosing that promote anesthetic rather than solely analgesic effects. The role of neuraxial blockade for ECVs in decreasing cesarean deliveries is still unclear.

Introduction

Neuraxial techniques may improve outcomes in external cephalic versions (ECV) for singleton breech presentations, thereby decreasing the need for cesarean deliveries and their subsequent complications. Singleton breech presentation occurs in 3-4% of term pregnancies[2]. An external cephalic version is a procedure in which the practitioner applies pressure on the abdominal wall in order to rotate a singleton breech-presenting fetus into cephalic position optimal for vaginal birth, with the goal of avoiding a cesarean delivery[3]. Repeated cesarean deliveries can increase maternal risks for uterine rupture, abnormal placentation, and other adverse ramifications, thus implicating the positive role for ECVs in the attempt to reduce cesarean rates.

The indication for an ECV is singleton non-cephalic fetal presentation in a mother who has achieved at least a 36 0/7 week-gestation, however 37 0/7 is preferred due to decreased risk of spontaneous reversion after performing the ECV[2-3]. The American College of Obstetricians and Gynecologists recommends attempting versions in women between 36 0/7 and 37 0/7 week gestations who have fetal breech presentations. The ECV success rate overall ranges from 16% to 100%, (pooled success rate 58%), but this may differ based on gestation age[2]. An example of this ambiguity between gestation age

groups is a 2003 randomized controlled trial that demonstrated early ECV at 34-36 week gestations may be more successful at preventing noncephalic presentation at delivery, compared to later ECV at 37-38 week gestations[4]. However, the reductions in the early ECV group were non-significant likely secondary to inadequate sample size, despite the similar rates of spontaneous reversion in both early and delayed ECV groups. A 2008 meta-analysis demonstrated that predictors for successful ECV include multi-parity, non-engaged fetus, palpable fetal head, relaxed uterus, and maternal non-obesity. Other factors that increase likelihood of ECV success include reassuring amniotic fluid index, posterior placenta, and complete breech lie[5].

The absolute contraindication for ECV is if vaginal delivery is impossible, i.e. placenta previa, whereas relative contraindications for ECV include any condition that causes danger to the mother or fetus with vaginal delivery, i.e. history of cesarean sections, rupture of membranes, and multi-fetal gestation[2]. Predictors for failed ECV include engaged fetus, non-palpable fetal head, tense uterus, maternal obesity, and anterior placenta. Pooled ECV complication rate is reported to be 6.1%, of which complications include preterm labor, placental abruption, uterine rupture, fetomaternal hemorrhage, isoimmunization, and amniotic fluid embolism[2]. A 2004 systematic review of ECV risks reported that the most common ECV complications were transient and persistent abnormal cardiotocography (CTG) patterns (0.37-5.7%), fetomaternal transfusion (3.7%), emergency cesareans (0.43%), and perinatal mortality (0.16%)[6].

In light of the stark contrast between ECV pooled success versus complication rates, the American College of Obstetricians and Gynecologists recommends performing ECVs in candidates of appropriate gestational age with minimal maternal risk factors

when cesarean delivery services are available[2]. A 2015 systematic review concluded that attempting ECV at or near term significantly reduced the non-cephalic births and cesarean sections without significant differences in one- and five-minute Apgar scores, umbilical vein pH at birth, neonatal admissions, perinatal deaths, and time to delivery[7].

Neuraxial blockade may improve ECV success rates. A 2004 meta-analysis evaluated four randomized controlled clinical trials with women who received some form of central axial anesthesia found that women who received anesthesia were 1.5 times more likely to undergo a successful ECV compared to women who did not receive anesthesia[8]. A 2011 systematic review concluded that neuraxial techniques in ECVs improve ECV success rates with unclear superiority of spinal versus local techniques[9]. The same review concluded that ECV does not significantly increase fetomaternal morbidity, evidenced by a 0.22% incidence of placental abruption in patients undergoing ECVs under neuraxial block, compared to 0.48% in controls[9]. A 2011 meta-analysis demonstrated that spinal and epidural regional anesthesia is associated with a higher success rate of ECV (59.7%) compared to intravenous or no analgesia (37.6%), without a difference in risk of cesarean delivery between the neuraxial anesthesia group and intravenous/no analgesia group[10].

Thus, the objective of this review is to determine if ECV outcomes are improved with concurrent reduction in cesarean deliveries when using neuraxial anesthesia.

Methods

A total of 179 studies were identified through PubMed and Cochrane online databases using the search terms, “external cephalic version,” “anesthesia,” and “analgesia.” Screening was based on title and abstract content. Eligibility criteria for

report characteristics included availability of text in English and published status. Eligibility criteria for study design included randomized controlled trials, retrospective and prospective studies, and surveys that utilized neuraxial anesthesia or analgesia methods in patients eligible for ECV. Reader GL determined risk of bias within and across studies qualitatively. The Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) 2009 review protocol checklist was used to guide the format of this review[11]. The quality of randomized controlled trials was examined using the Jadad score[13-14].

Results

Of the 179 initially identified studies through the PubMed and Cochrane online database searches, 70 duplicate studies were removed. The remaining 109 studies were screened by title and abstract for relevance, and 75 studies were removed. The remaining 34 studies were assessed for eligibility as described in the "Methods" section above, and 15 studies were subsequently excluded. A total of 19 studies were thus included for qualitative synthesis. These studies were comprised of 1 survey, 10 randomized controlled trials, 5 prospective studies, and 3 retrospective studies.

Survey

Weiniger (2016) assessed ECV practice among obstetric anesthesiologist members of the Society for Obstetric Anesthesiology and Perinatology by a 15-item survey[12]. This survey demonstrated that the frequency of using neuraxial blockade varied widely, in addition to the technique, type, and dose of anesthetic used. 5.6% of respondents reported always utilizing neuraxial blockade in ECVs, whereas 38.5% rarely or never used neuraxial blockade, leaving 46.5% of respondents often or sometimes using

neuraxial blockade. Technique varied with spinal (18.9%) versus epidural (43.8%) versus combined spinal epidural (45.3%) blockade. Epidural and intrathecal drugs used included bupivacaine, lidocaine, ropivacaine, fentanyl, and sufentanil at varying doses and concentrations. Anesthetic (43.8%) versus analgesic (31.7%) sensory target varied as well. Although limitations of this study may have overestimated the reported ECV with anesthesia rate due to subpar response rate (30.5%) and selection bias for respondents being obstetric anesthesiologists who manage ECV cases in academic institutions or institutions that reported ECV rate <50% by itself, this survey demonstrated that the practice of administering neuraxial blockade in ECVs varies widely across institutions and practitioners.

Randomized Controlled Trials

Ten randomized trials from 1997-2016 were examined to determine technique, drugs/doses/concentrations utilized, and to compare success rates between neuraxial blockade groups versus control groups as demonstrated in Table 1. Two studies used an epidural technique to establish both anesthetic and analgesic sensory targets[15,17]. Four studies used a spinal technique, with one study using spinal with intravenous technique or substituting in a combined spinal-epidural technique with intravenous technique[16,18,19,22]. One study exclusively used a combined spinal-epidural technique[20], and three studies exclusively used an intravenous technique[21,23,24].

Neuraxial blockade success rate in ECV ranged from 44% to 84% across studies, of which 484 total participants received neuraxial blockade, 375 participants in the control group did not receive intervention, 47 participants in the control group received

50 μg fentanyl IV[20], and 60 participants in the control group received inhaled nitrous oxide 3 minutes prior to the ECV procedure[23].

Of these 966 total participants, neuraxial blockade was found to significantly increase success rates in six studies[15,17,18,19,22,24]. Of these six studies, two studies used anesthetic dosing of epidural 2% lidocaine with 1:200,000 epinephrine at T6[15] and lumbar levels[17], respectively. Three studies used anesthetic dosing of spinal bupivacaine 7.5mg[18,19] and spinal hyperbaric bupivacaine 9 mg with fentanyl 15 μg or remifentanil 0.1 μg/kg/min infusion[22]. Three studies used intravenous remifentanil 0.1μg/kg/min infusion with 0.1 μg/kg demand boluses[24].

Neuraxial blockade was not found to significantly increase ECV success rates in four studies, all of which used drugs at analgesic dosing. Of these four studies, one study used intrathecal bupivacaine 2.5 mg with sufentanil 10 μg[16]. One study used intrathecal bupivacaine 2.5 mg with fentanyl 15 μg and epinephrine 15 μg[20]. The two remaining studies used intravenous remifentanil 0.1 μg/kg/min infusions with 0.1 μg/kg rescue boluses[21,23].

Of the randomized controlled trials, the overall ECV success rate across all neuraxial blockade group participants was 69.8% (338/484), and 42.3% (204/482) for all control group participants. Relative rate based on these rates is 1.65, thus women who received neuraxial blockade were overall 1.65 times more likely to have a successful ECV than women who did not (95% CI 1.46 to 1.85, $p < 0.0001$). The number needed to treat based on these rates is 3.63 (95% CI 2.98 to 4.65). Of note, these rates include the minority of control group women who received fentanyl[20] and nitrous oxide[23] interventions.

Study	Technique	Drug/dose/conc	Neuraxial blockade (NB) success rate	Control success rate	Jadad score[13-14]
Schorr[15]	Epidural	2% lidocaine + 1:200,000 epinephrine at T6	69% (24/35)*	31% (11/34)*	3
Dugoff[16]	Spinal (SA)	Sufentanil 10 µg + bupivicaine 2.5 mg	44% (22/50)	42% (22/52)	3
Mancuso[17]	Epidural	2% lidocaine 3 ml + 1:200,000 epinephrine, lumbar + 2% lidocaine 10 ml with fentanyl 100 µg infusion if no AE	54% (28/54)*	24% (13/54)*	3
Weiniger[18]	SA	Bupivacaine 7.5 mg	66.7% (24/36)*	32.4% (11/34)*	2
Weiniger[19]	SA	Bupivacaine 7.5 mg	87.1% (27/31)*	57.5% (19/33)*	2
Sullivan[20]	Combined spinal-epidural (CSE)	Bupivacaine 2.5 mg and fentanyl 15 µg + lidocaine 45mg and epinephrine 15 µg	47% (23/48)	31% (15/47)	3
Muñoz[21]	Intravenous analgesia (IVA)	Remifentanil 0.1 µg/kg/min infusion + 0.1 µg/kg rescue boluses	54.8% (17/31)	41.3% (12/29)	3
Khaw[22]	SA or CSE, and IVA	Hyperbaric bupivacaine 9 mg + fentanyl 15 µg, or remifentanil 0.1 µg/kg/min infusion	Phase I: 83% (52/63) SA and 64% (40/63) IVA* Phase II: 78% (7/9) SA and 0% (0/9) IVA*	64% (40/63)*	3
Burgos[23]	IVA	Remifentanil 0.1 µg/kg/min infusion + 0.1 µg/kg rescue boluses	51.7% (31/60)	51.7% (31/60)	3
Liu[24]	IVA	Remifentanil 0.1 µg/kg/min infusion + 0.1 µg/kg demand boluses	56.5% (43/76)*	39.5% (30/76)*	3

Table 1. Outcomes of randomized studies.
* indicates significant $p<.05$

Table 2 demonstrates vaginal versus cesarean delivery rates across studies. Only two studies found significant differences in delivery method between neuraxial blockade and control groups[15,17]. Schorr[15] found increased vaginal delivery rates in the neuraxial blockade group and increased cesarean delivery rates in the control group. Mancuso[17] only found increased vaginal delivery rates in the neuraxial blockade group, and did not report cesarean delivery rates. All other studies did not find statistically significant differences in method of delivery after successful ECV with or without neuraxial blockade.

Study	NB vaginal delivery	Control vaginal	NB cesarean delivery	Control cesarean
Schorr[15]	65.7%* (23/35)	20.5%* (7/34)	34.2%* (12/35)	79.4%* (27/34)
Dugoff[16]	32% (16/50)	48% (25/52)	68% (34/50)	52% (27/52)
Mancuso[17]	54%* (29/54)	30%* (16/54)	Not reported (NR)	NR
Weiniger[18]	NR	NR	NR	NR
Weiniger[19]	87.1% (27/31)	90.9% (30/33)	NR	NR
Sullivan[20]	36% (17/48)	25% (12/48)	NR	NR
Muñoz[21]	82.4% (14/17)	91.7% (11/12)	17.6% (3/17)	8.3% (1/12)
Khaw[22]	77% (40/52)	80% (32/40)	0.1% (5/63)	0.05% (3/63)
Burgos[23]	NR	NR	36.7% (22/60)	40.0% (24/60)
Liu[24]	84.2% (64/76)	92.1% (70/76)	15.8% (12/76)	0.07% (6/76)

Table 2. Vaginal versus cesarean delivery rates in randomized studies.
* indicates significant $p<.05$

Table 3 demonstrates the unique inclusion and exclusion criteria between randomized studies. Inclusion criteria for all randomized studies included singleton breech presentation in participants and viably candidacy for ECV, as determined by each study's practitioners. Reactive non-stress test (NST) was an inclusion factor in one study[16]. Transverse in addition to breech lie, maternal age minimum of 18 years, and reassuring fetal heart rate (FHR) were inclusion factors in one study[17]. Willingness to receive CSE or systemic analgesia was listed as an inclusion factor in one study[20].

Exclusion criteria for all randomized studies included uterine or fetal abnormalities and allergies to study interventions. Placenta previa, abruption, or third trimester bleeding was a listed exclusion factor in seven studies[15,16,17,21,22,23,24]. Rupture of membranes (ROM), premature rupture of membranes (PROM), and active labor were exclusion criteria in six studies[15,16,17,21,22,24]. Transverse or oblique lie was an exclusion factor in one study[16], whereas transverse lie was an indication in another study[17]. Maternal factors such as hypertension, cardiovascular disease, coagulopathies, neuropathy, back pain, poor communication, and body mass index (BMI)>40 were exclusion criteria in five studies[17,18,19,21,24]. Rhesus incompatibility was excluded in two studies[21,23].

Other factors were listed as both inclusion and exclusion criteria between studies. American Society of Anesthesiologists (ASA) status dictated inclusion or exclusion in five studies[18,19,22,21,24]. Amniotic fluid index (AFI) or amniotic fluid pockets dictated inclusion and exclusion in four studies[16,17,19,21]. Estimated fetal weight (EFW) dictated inclusion and exclusion in three studies[16,17,24].

Study	Inclusion factors	Exclusion factors
Schorr[15]	-	Placenta previa, ROM
Dugoff[16]	Reactive NST, 2x2cm amniotic fluid pocket, EFW>4000 g,	Placenta previa, transverse or oblique lie, third-trimester bleeding, active labor
Mancuso[17]	≥18 years maternal age, breech or transverse lie, 5cm<AFI<25cm, 2000g<EFW<4000g, reassuring FHR	Placenta previa, third-trimester bleeding, uncontrolled maternal hypertension, active labor
Weiniger[18]	ASA I-II	Contraindications or refusal for vaginal delivery or regional analgesia, neuropathy or severe back pain, poor communication, and BMI>40
Weiniger[19]	ASA I-II	Contraindications or refusal for vaginal delivery or regional analgesia, AFI<7cm, neuropathy or severe back pain, poor communication, and BMI>40
Sullivan[20]	Willing to receive CSE or systemic analgesia	Contraindications to neuraxial anesthesia or allergies to study medications
Muñoz[21]	-	ASA>2, EFW>3800g, IUFD, maternal coagulation or CV disease or HTN, AFI<4cm, Rh incompatibility CP ratio>5th percentile, abnormal CTG, ROM, placental abruption
Khaw[22]	ASA I-II	Third-trimester bleeding, nuchal cord, PROM, labor
Burgos[23]	-	Placenta previa, abruption, AFI<5cm, Rh incompatibility, coagulopathies, indications for CS
Liu[24]	-	ASA>2, contraindications to vaginal delivery, maternal CV disease, HTN, PROM, abruption, IUFD, EFW>3800g

Table 3. Inclusion and exclusion criteria of randomized studies.
- indicates inclusion criteria universal to all studies as described previously.

Table 4 demonstrates demographic and procedural characteristics across studies. The characteristics of gestational age at time of intervention, gestational age at time of delivery, placentation, amniotic fluid index, Newman score, maternal race, maternal height, maternal weight gain, gravity, prior preterm status, maternal weight, fetal spine position, digital cervical examination, birth weight, and use of tocolysis were not statistically significantly different between intervention and control groups across studies.

The only statistically significant difference in demographic variables was in Weiniger[18], in which maternal age was 24.6±3.8 years in the intervention group compared to 28.1±4.1 years in the control group ($p < 0.001$). Univariate and multivariate analyses of factors for successful ECV across studies demonstrated statistically significant differences between intervention and control groups in four studies[16,18,20,23]. Multiparity (63% successful ECVs, 37% unsuccessful ECVs, $p = 0.001$) and multiparity without a history of cesarean (68% successful ECVs, 32% unsuccessful ECVs, $p = 0.001$) were found to be statistically significant[16]. Odds for success were 2.6 times higher if the mother was multiparous (95% CI 1.1-6.2, $p = 0.03$)[23]. Fetal presentation was found to be statistically significant, as odds for success were 8.2 times higher if the fetus presented in a complete breech presentation prior to the ECV in contrast to a frank breech presentation (95% CI for OR 2.2-30.3, $p = 0.001$)[18]. Increasing ECV duration, increasing obstetrician-perceived version difficulty, and decreasing obstetrician-perceived abdominal relaxation were found to be associated more with unsuccessful ECVs ($p < 0.01$)[20].

Study	Gestation age	Control group intervention	Maximum ECV attempts	Tocolysis	Intravenous fluids	Operator skill level
Schorr[15]	38, 37	None	3	250 µg terbutaline, x1-3	2000 ml lactated Ringer's (LR)	Resident
Dugoff[16]	38, 38	None	4	250 µg terbutaline x1	500 ml LR	Physician
Mancuso[17]	38, 38	None	2	250 µg terbutaline x1	1500 ml LR	Resident
Weiniger[18]	38, 38	None	NR	50 mg ritodrine or 20mg nifedipine	1000 ml LR	Physician
Weiniger[19]	38, 38	None	NR			Physician
Sullivan[20]	38, 38	50 µg fentanyl	NR	250 µg terbutaline	500 ml LR	Physician
Muñoz[21]	NR	100 ml saline	NR	200 µg/min ritodrine	None	Physician
Khaw[22]	36, 37	500 ml Hartmann's solution	5	10 µg hexoprenaline	None	NR
Burgos[23]	37, 37	Nitrous oxide	4	200 µg/min ritodrine or 6.75 mg atosiban	NR	Physician

Liu[24]	37, 37	None	NR	NR	Paracetamol 1g, 100ml NS	NR

Table 4. Demographic and procedural characteristics of randomized studies.
Number (intervention group mean, control group mean), * indicates $p<.05$

Common sources of bias across randomized studies included operator bias and single-center selection bias. Common risks of bias within randomized studies included low overall ECV success rates in study populations[15,17] and inadequate blinding, sample size, power, and randomization resulting in treatment bias and Hawthorne effect in obstetricians proceeding further with ECV based on perception of the participant's pain[17,18,19,20,21,22]. Other sources of bias included excluding participants based on parity and AFI which could have been confounders[18,19], crossover methods to encourage enrollment such as for control group participants to receive neuraxial blockade due to pain[18], and premature ECV termination[15,16,18,23].

Common reasons for ECV termination included patient discomfort (Schorr[15] 1/35 epidural group versus 4/34 control group, Dugoff[16] 4/50 control group, Weiniger[18] 15/34 control group), inability to disengage fetus from maternal pelvis (Burgos[23] 14/29 intravenous remifentanil group versus 17/29 control nitrous oxide group), and uterine abnormality discovered at time of cesarean delivery (Schorr[15] 1/35 epidural group). Of note, the Burgos[23] study was terminated early due to a second interim analysis that demonstrated statistically insignificant measures of efficacy ($p = 1.00$) of using intravenous remifentanil versus nitrous oxide in ECVs.

Prospective Studies

Five prospective studies from 1998-2013 were examined to determine technique, drugs/doses/concentrations utilized, and to compare neuraxial blockade-assisted ECV success rates between studies as demonstrated in Table 5. Two studies[25,26] used an

epidural technique, of which one study recorded using 2% lidocaine 2 ml with 3 ml every 10 minutes to achieve a sensory target of a symmetric block with subsequent motor blockade[26]. Two studies used a spinal technique using sufentanil 10 μg and 0.5% Bupivicaine 1.8 ml with fentanyl 15 μg, respectively[27,28]. One study used inhaled nitrous oxide (50:50 nitrous oxide and oxygen mixture)[29].

ECV success rates with neuraxial blockade ranged from 39.7% to 100% across studies. 278 total participants received neuraxial blockade, and 177 participants did not receive neuraxial blockade across studies. Of these 455 total participants, neuraxial blockade was found to significantly increase success rates in one study[27].

Study	Technique	Drug/dose/conc	NB success rate	No NB success rate
Neiger[25]	Epidural	NR	72% (18/25)	60% (50/83)
Rozenberg[26]	Epidural	2% lidocaine 2 ml with 3 ml q10min to achieve sensory target	39.7% (27/68)	N/A
Birnbach[27]	SA	Sufentanil 10 μg	80%* (16/20)	33%* (5/15)
Suen[28]	SA	0.5% Bupivicaine 1.8 ml with fentanyl 15 μg	100% (8/8)	N/A
Burgos[29]	Inhaled	50:50 N_2O and O_2	52.3% (82/157)	52.7% (41/79)

Table 5. Outcomes of prospective studies.
* indicates significant $p<.05$

Table 6 demonstrates vaginal versus cesarean delivery rates across prospective studies. Only one study found significant differences in vaginal delivery rates between neuraxial blockade and non-neuraxial blockade groups[27]. Birnbach[27] found increased vaginal deliveries in the neuraxial blockade group and did not report cesarean delivery rates. One study did not find statistically significant differences in method of delivery after successful ECV in neuraxial blockade and non-neuraxial blockade groups, and one study did not find differences in method of delivery solely in the neuraxial blockade group[26,29]. Two studies did not report vaginal and cesarean delivery rates[25,28].

Study	NB vaginal delivery	No NB vaginal	NB cesarean delivery	No NB cesarean
Neiger[25]	NR	NR	NR	NR
Rozenberg[26]	32% (16/50)	48% (25/52)	68% (34/50)	52% (27/52)
Birnbach[27]	54%* (29/54)	30%* (16/54)	NR	NR

Suen[28]	NR	NR	NR	NR
Burgos[29]	87.1% (27/31)	90.9% (30/33)	NR	NR

Table 6. Vaginal versus cesarean delivery rates in prospective studies.
* indicates significant $p<.05$

Table 7 demonstrates demographic and procedural characteristics across studies. The characteristics of gestational age at time of intervention, gravidity, maternal age, birth weight, AFI, and obstetrician performing the ECV when reported were not statistically significantly different between intervention and control groups across studies. The only statistically significant differences in demographic variables between groups were maternal weight[27] and ultrasound-estimated fetal weight[29].

Analysis for factors associated with successful ECV across studies demonstrated statistically significant differences between intervention and control groups in one study. Maternal overweight status ($p = 0.004$), incomplete breech presentation (versus complete, $p = 0.07$) and nulliparity ($p = 0.002$) were found to be negatively associated with ECV success rates in this study[26].

Study	Gestation age	Maximum ECV attempts	Tocolysis used	Intravenous fluids	Operator
Neiger[25]	37.5, 38.0	NR	250 µg terbutaline, x1	NR	NR
Rozenberg[26]	37.7	NR	N/A	1500 ml LR	NR
Birnbach[27]	37.0, 36.9	5	250 µg terbutaline x1	500 ml LR	NR
Suen[28]	36.0	3	10 µg hexaprenaline	NR	Experienced operator
Burgos[29]	37	NR	200 µg/min ritodrine or 6.75 mg atosiban	NR	Obstetrician trained in ECV

Table 7. Demographic and procedural characteristics of randomized studies.
Number (intervention group mean or range, non-intervention group mean or range), * indicates $p<.05$

Common risks of bias within and across prospective studies included limited sample size that may have reduced the ability to find significant differences between intervention and control groups[25] and limited blinding[27]. Burgos[29] found that their consecutive cohort methodology and limited sample size was underpowered in addition

to not knowing if nitrous oxide had a synergistic effect with the physiologic changes of ECV procedure that could cause more adverse effects.

Retrospective Studies

Three retrospective studies from 1994-2010 were examined to determine technique, drugs/doses/concentrations utilized, and to compare neuraxial blockade-assisted ECV success rates between studies as demonstrated in Table 8. Two studies[30,31] used an epidural technique, of which one study recorded using 2% lidocaine with epinephrine 1:200,000 15-20 ml[31]. Two studies used a spinal technique using 1.5% lidocaine 45-60 mg with fentanyl 10 μg and 0.25% Bupivicaine 3 ml, respectively[31,32]. Of note, the Cherayil study used either spinal or epidural techniques[31].

Neuraxial blockade success rate in ECV ranged from 59% to 89% across studies. 99 total participants received neuraxial blockade, and 93 participants were reported in the non-neuraxial blockade groups across studies. Of these 192 total participants, neuraxial blockade was found to significantly increase success rates in two studies[30,32].

Study	Technique	Drug/dose/conc	NB success rate	No NB success rate
Carlan[30]	Epidural	NR	59%* (19/32)	24%* (9/37)
Cherayil[31]	SA	1.5% lidocaine 45-60 mg with fentanyl 10 μg	83% (5/6)	0% (0/22)
	Epidural	2% lidocaine with epinephrine 1:200,000 15-20 ml	89% (8/9)	
Yoshida[32]	SA	0.25% Bupivicaine 3 ml	78.8%* (41/52)	55.9%* (19/34)

Table 8. Outcomes of retrospective studies.
* indicates significant $p<.05$

Table 9 demonstrates vaginal versus cesarean delivery rates across retrospective studies. Two studies found significant differences in cesarean delivery rates between neuraxial blockade and non-neuraxial blockade groups[30,32]. Carlan[30] and Yoshida[32] both found increased cesarean deliveries in the non-neuraxial blockade group, and did not report vaginal delivery rates. One study did not find statistically significant differences in

method of delivery after successful ECV in neuraxial blockade and non-neuraxial blockade groups[31].

Study	NB vaginal delivery	No NB vaginal	NB cesarean delivery	No NB cesarean
Carlan[30]	NR	NR	46%* (15/32)	89%* (26/37)
Cherayil[31]	66.6% (4/6) spinal, 66.6% (6/9) epidural	0% (0/22)	33.3% (1/6) spinal, 33.3% (3/9) epidural	100% (22/22)
Yoshida[32]	NR	NR	32.7%* (17/52)	50.0%* (17/34)

Table 9. Vaginal versus cesarean delivery rates in randomized studies.
* indicates significant $p<.05$

Table 10 demonstrates demographic and procedural characteristics across retrospective studies. The characteristics of placentation, maternal age, height, weight, gestational age at ECV and delivery, maternal BMI, fetal weight at ECV and delivery, gravidity, AFI, glucose tolerance testing, previous breech delivery, tocolysis, nuchal cord, uterine myoma status, and Apgar score were not statistically significantly different between intervention and control groups across studies[30-32].

The only statistically significant differences in demographic variables were in Carlan[30] in which labor or cervical dilation greater than 3 cm at time of ECV and the number of house-staff attempts at ECV were increased in the epidural group compared to the non-epidural group ($p < 0.05$). Cherayil[31] also found that there were more nulliparous women in the epidural group versus the spinal group in their study population of women who had an initial ECV failure ($p = 0.025$).

Yoshida[32] examined factors for successful ECV in a univariate analysis, which demonstrated that nulliparity, maternal BMI at or above 25, maternal age at or above 35 years, and anterior placentation were significantly higher in the epidural group. However, the multivariate analysis of factors demonstrated that maternal age, nulliparity, BMI, placentation, uterine myoma, nuchal cord, and previous cesarean were not significantly associated with success of ECV[32].

Study	Gestation age	Maximum ECV attempts	Tocolysis used	Intravenous fluids	Operator
Carlan[30]	38.0, 38.0	2	Magnesium 6g with 250 µg terbutaline, x1	1500-2000 ml LR	NR
Cherayil[31]	>36 weeks	3	250 µg terbutaline x1	1000 ml LR	Physician
Yoshida[32]	36.2, 35.8	1	67 µg/min ritodrine infusion	500 ml hydroxyethylated starch	Resident

Table 10. Demographic and procedural characteristics of randomized studies.
Number (intervention group mean or range, control group mean or range), * indicates $p<0.05$

Common risks of bias within and across retrospective studies included limited sample size (*n* ranging from 69-86 across studies)[30-32]. Lack of randomization and blinding were also global sources of potential bias. Operator bias may have affected the study by Carlan[30], as information about skill level of operators appeared limited based on the study's reporting. Carlan[30] and Cherayil[31] studies did not perform multivariate analyses that may have voided the statistically significant differences between groups regarding cervical dilation/labor[30], house-staff attempts at ECV[30], and nulliparity[31].

Discussion

Across the 19 randomized, prospective, and retrospective studies examined in this review, neuraxial blockade was found to significantly increase ECV success in 9 studies. Of the 10 randomized controlled trials examined, women who received neuraxial blockade were 1.65 times more likely to experience ECV success, with a number-needed-to-treat of about 4 women who would require neuraxial blockade for 1 baby to be converted to cephalic presentation. This has been substantiated in prior literature reviews and meta-analyses, thus indicating that our findings may have been validated over time.

Examples of these findings include a 2004 review[8] of 4 randomized controlled trials (RCTs) that demonstrated that neuraxial blockade increased the likelihood of ECV success by 1.5 times with a NNT of 7. A 2009 review[33] of 7 RCTs found that neuraxial blockade increased the likelihood of ECV success by 1.5 times with a NNT of 6. A 2010

review[34] of 7 RCTs demonstrated increased the likelihood of ECV success by 1.44 times with a NNT of 4, and a 2011 review[10] of 6 RCTs demonstrated increased the likelihood of ECV success by 1.58 times with a NNT of 5. Finally, a 2016 review of 9 RCTs demonstrated that neuraxial blockade increased the likelihood of ECV success, decreased risk of cesarean delivery, and decreased maternal discomfort[35].

Chalifoux[36] and Cluver[37] argued that neuraxial blockade in ECVs may improve success rates by increasing maternal abdominal relaxation and to expedite epidural anesthesia in the case of a cesarean, which has been contrasted to undergoing general anesthesia methods[34]. The impact of abdominal relaxation was examined in Suen[28], in which the pressure-time integral (PTI) to measure the amount of force applied in an ECV was significantly lower in patients who underwent repeat ECV under spinal analgesia compared to patients who underwent repeat ECV without spinal analgesia (SA). Median PTI was 127 386 mmHg sec in the SA group compared to the median PTI of 298 424 mmHg sec in the group without SA ($p = 0.017$). Likewise, pain scores were significantly lower in the SA group compared to the group without SA (Pain score 0 in SA group, median pain score 7.5 in group without SA, $p = 0.016$). Suen et al. thus concluded that increased maternal abdominal tone was an indicator of pain, and increased abdominal tone increased the quantitative need for force applied during ECV[28].

Consequently, neuraxial blockade may play a role in ECV success, specifically epidural versus spinal techniques with anesthetic versus analgesic dosing of medications used. Sultan & Carvalho[9] concluded in their 2011 systematic review that the Dugoff[16] and Sullivan[20] randomized trials did not find significant differences in ECV outcomes between groups potentially due to the studies' use of analgesic rather than anesthetic

dosing. The two remaining studies[21,23] that were published after the Sultan & Carvalho review demonstrated no significant differences in ECV outcomes between groups when using intravenous analgesic dosing of remifentanil 0.1 μg/kg/min infusion with 0.1 μg/kg rescue boluses, further suggesting that analgesic dosing may be a consistent factor in failure to demonstrate differences in ECV outcomes between groups. The type of neuraxial blockade thus may implicate ECV success rates.

The role of neuraxial blockade in reducing cesarean deliveries is still unclear. Only 5 out of the total 19 studies examined in this review found significant differences in delivery method between neuraxial blockade and control groups. Interestingly, the only two randomized controlled trials found increased vaginal deliveries in the neuraxial blockade group[15,17] and increased cesarean deliveries in the control group[15] were the only two trials that used epidural anesthetic dosing. All other trials used analgesic dosing or spinal/intravenous methods, which may substantiate the claim made in a prior meta-analysis that anesthetic dosing of local anesthetic improves ECV success compared to analgesic dosing (RR = 1.95 with $p < 0.001$ for anesthetic dosing, RR = 1.18, $p = 0.15$ for analgesic dosing)[34].

Of the five prospective studies examined, the only study that found significant differences in vaginal delivery rates between neuraxial blockade and non-neuraxial blockade groups was the only study that found statistically significant increases in ECV success rates with neuraxial blockade[27]. However, this study did not report cesarean delivery rates. Among the three retrospective studies examined, two studies found statistically significant increases in cesarean delivery rates between neuraxial blockade and non-neuraxial blockade groups[30,32]. However, these studies did not report vaginal

delivery rates. Therefore, incomplete reporting of vaginal versus cesarean delivery methods in all prospective and retrospective studies limits our ability to generate conclusions on the effect of neuraxial blockade on cesarean delivery rates from this cohort of study designs at this time.

Limitations of the randomized trials examined in this review included operator bias, single-center selection bias, inadequate blinding, limited sample sizes, and inappropriate exclusion factors that could have been confounders. Prospective studies were largely limited in their inability to blind both participants and operators due to the nature of the intervention being repeated ECVs in many of the studies. Retrospective studies were globally limited by lack of complete reporting, as evidenced by questionable operator level and data omission regarding delivery methods.

There have been many reviews and meta-analyses that have examined the differences in reported pain levels, analyzed cost differences, and reported adverse events accrued throughout studies involving neuraxial blockade in ECVs. While the patient quality of life, cost-benefit, and safety of using neuraxial blockade in ECVs have been important areas of study to promote this practice, this review sought to determine the current status of ECV success rates with neuraxial blockade and its concurrent effect on cesarean delivery rates. In light of our objectives for this review, future directions of study may include examining the rates of cesarean delivery for ECVs under neuraxial blockade. Future studies should also directly compare epidural anesthetic versus spinal or intravenous analgesic dosing methods of delivering neuraxial blockade. Thus, differentiating between neuraxial blockade methods and dosing may help develop a standard of care for using neuraxial blockade in ECVs in the future.

Conclusion

Of the 19 randomized, prospective, and retrospective studies examined in this review, neuraxial blockade was found to significantly increase ECV success in 9 studies with unclear ramifications on reducing cesarean delivery rates. The method and dosing of neuraxial blockade may play a role in the ECV success rates, as epidural methods with anesthetic dosing have been implicated as preferable means. The effect of neuraxial blockade on reducing cesarean deliveries is still unclear due to incomplete data reporting, and it should be studied further in the future.

Funding

The University of California, San Diego Online Library was utilized to access the PubMed and Cochrane databases for this review.

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