

## Supplementary Online Content

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**eMethods.** Definitions of outcome measures

**eTable 1.** Indications for operative deliveries

**eTable 2.** Participants' satisfaction with birthing experience in second stage based on a modified Mackey Childbirth Satisfaction Rating Scale

**eTable 3.** Primary and secondary efficacy outcomes (per protocol)

**eTable 4.** Primary and secondary efficacy outcomes (as treated)

This supplementary material has been provided by the authors to give readers additional information about their work.

## eMethods. Definitions of outcome measures

Outcome Measure	Definition
1.Spontaneous vaginal delivery	Delivery that occurs without the use of forceps, vacuum, or cesarean
2.Operative vaginal delivery	Delivery that occurs with the use of forceps or vacuum
3.Duration of second stage	Time interval from complete cervical dilation to delivery
4.Duration of active pushing	Time interval from initiation of maternal pushing to delivery
5.Postpartum hemorrhage	Estimated blood loss>500ml after vaginal delivery of 1000ml after cesarean
6.Severe postpartum hemorrhage	Estimated blood loss >1000ml for vaginal delivery and >2000ml for cesarean
7.Chorioamnionitis in the second stage of labor	Chorioamnionitis diagnosed by the treating physician after complete dilation (after trial entry)
8.Endometritis	Endometritis clinically diagnosed by the treating obstetrics provider anytime from delivery until 6 weeks postpartum. Clinical diagnosis, guided by: i) maternal fever (temperature >38.0°C on two occasions, 4 hours apart or >39.0°C on one occasion) >12 hours after delivery, ii) uterine tenderness, and iii) no evidence of another infection
9.Second degree perineal laceration	Laceration of the vaginal mucosa and/or perineal skin and deeper subcutaneous tissue
10.Third degree perineal laceration	Laceration of the vaginal mucosa and/or perineal skin and deeper subcutaneous tissue, with partial or complete laceration of the anal sphincter muscle
11.Fourth degree perineal laceration	Laceration of the vaginal mucosa and/or perineal skin, deeper subcutaneous tissue, complete laceration of the anal sphincter muscle, with laceration of the rectal mucosa

12. Neonatal death	Neonatal death prior to discharge
13. Major birth injury	Serious neonatal injury including skull fracture, brachial plexus injury, cephalohematoma
14. Neonatal acidemia	Umbilical cord arterial pH <7.10
15. Respiratory distress	Nasal flaring, subcostal and intercostal retractions, and need for supplemental oxygen to maintain oxygen saturations > 95%
16. Transient tachypnea	Respiratory rate >60/min with or without supplementary oxygen to maintain oxygen saturation > 95%
17. Meconium aspiration with pulmonary hypertension	Respiratory distress and transthoracic echocardiographic findings of main pulmonary artery pressures (right-left shunting across the patent ductus arteriosus and atria, a flattened septum, and a tricuspid regurgitation jet)
18. Hypoxic-ischemic encephalopathy	One or more of: umbilical artery arterial pH < 7.0, base deficit > -16, need for respiratory support at 10 minutes of life, 5-minute Apgar score < 5 – <i>and</i> – Moderate-severe neonatal encephalopathy <i>or</i> seizure activity
19. Neonatal hypoglycemia	Neonatal venous blood glucose < 40mg/dL
20. Suspected neonatal sepsis	Symptomatic neonate, defined as one or more of: respiratory distress, temperature instability, apnea, lethargy – <i>with or without</i> – Abnormal complete blood count (6-12 hours after birth, with leukopenia or leukocytosis with an I:T ratio of >0.2) <i>and/or</i> positive blood culture
21. Neonatal intensive care unit admission	Admission to the neonatal intensive care unit >12 hours for any reason prior to hospital discharge
22. Maternal death	Any maternal death
23. Life-threatening maternal event	Life threatening events in the mother are defined as those that in the view of the investigators put the individual patient at imminent substantial risk of

	dying, or if continued participation in the study might have resulted in death
24. Maternal admission to the intensive care unit	Maternal admission to the intensive care unit for any indication
25. Unplanned hysterectomy	Unplanned hysterectomy performed during cesarean or following a vaginal delivery
26. Neonatal death	Neonatal death prior to discharge
27. Life-threatening neonatal event	Any life-threatening neonatal event, defined as those that in the view of the research staff and PI put the individual patient at imminent substantial risk of dying, within the first 24 hrs. of life

**eTable 1.** Indications for operative deliveries

Indications	Immediate pushing	Delayed pushing	P
Operative vaginal delivery, n (%)	N=76	N=71	0.37
Non-reassuring fetal status	43 (56.6)	36 (50.7)	
Other/Unknown/Mixed	19 (25.0)	19 (26.8)	
Maternal exhaustion	8 (10.5)	10 (14.1)	
Inadequate expulsive efforts	3 (4.0)	6 (8.5)	
Arrest of Descent	3 (4.0)	0	
Elective	0	0	
Cesarean delivery, n (%)	N=93	N=91	0.71
Arrest of Descent	57 (61.3)	46 (50.6)	
Other/Unknown/Mixed	28 (30.1)	34 (37.4)	
Non-reassuring fetal status	6 (6.5)	7 (7.7)	
Inadequate expulsive efforts	1 (1.1)	2 (2.2)	
Failed VAVD/FAVD	1 (1.1)	1 (1.1)	
Maternal exhaustion	0	1 (1.1)	

The denominator of % is sum of deliveries

**eTable 2.** Participants' satisfaction with birthing experience in second stage based on a modified Mackey Childbirth Satisfaction Rating Scale

	Immediate pushing (n=1200 )	Delayed pushing (n=1204)	Mean Difference/ Relative Risk (95% CI)	P
Overall satisfaction with experience in second stage, median (IQR)	5(4, 5)	5(4, 5)	0.01 (-0.04, 0.06)	0.67
Comfort in second stage (1- 5 scale), median (IQR)	4(4, 5)	4(4, 5)	0.03 (-0.02, 0.09)	0.22
Control in second stage (1- 5 scale), median (IQR)	5(4, 5)	5(4, 5)	0.01 (-0.03, 0.05)	0.63
Satisfaction with baby's physical condition at birth(1- 5 scale), median (IQR)	5(5, 5)	5(5, 5)	0.03 (0.004, 0.06)	0.03
Satisfaction with physical care in second, median (IQR)	5(5, 5)	5(5, 5)	0.003 (-0.02, 0.02)	0.82
Birth experience meeting expectation(1- 4 scale), median (IQR)	3(2, 3)	3(2, 4)	-0.01 (-0.12, 0.10)	0.87
Total second stage satisfaction score, median (IQR)	26(24, 28)	26(23, 28)	0.09 (-0.19, 0.37)	0.52
Preference for the same second stage management plan in subsequent delivery, n (%)	1055 (91.3)	1066 (91.0)	1.00 (0.99, 1.02)	0.62

Mean difference (95% CI) for binary outcomes and relative risk (95% CI) for continuous outcomes is obtained from generalized estimating equations models which were used to account for study site.

**eTable 3.** Primary and secondary efficacy outcomes (per protocol)

Outcome	Immediate pushing (N=1111) <sup>[1]</sup>	Delayed pushing (N=970) <sup>[1]</sup>	Absolute Difference (95% CI)	Relative Risk (95% CI)	P
<b>PRIMARY OUTCOME</b>					
Spontaneous Vaginal Delivery, n (%)	961 (86.5)	843 (86.9)	-0.4 (-3.3, 2.5)	1.00 (0.97, 1.03)	0.78
<b>PRESPECIFIED SECONDARY OUTCOMES</b>					
<b>MATERNAL</b>					
Total Duration of Second Stage (min), median (IQR) mean (SD)	73 (43, 126) 97.3(75.3)	122 (93, 178) 144.8(74.1)	-46.9 (-52.6, -41.3)		<0.001
Duration of Active Pushing (min) median (IQR) mean (SD), n	57 (29, 111) 81.5(74.4), 1109	52 (27, 104) 77.0(71.4), 969	4.9 (0.4, 9.4)		0.03
From Complete Dilation to Push (min), median (IQR) mean (SD), n	15 (11, 20) 16.0(8.2), 1109	67 (62, 74) 67.7(13.7), 969	-51.7 (-53.2, -50.2)		<0.001
Operative Vaginal Delivery, n (%)	68 (6.1)	55 (5.7)	0.5 (-1.6, 2.5)	1.1 (0.7, 1.7)	0.76
Vacuum Assisted Vaginal, n (%)	50 (4.5)	42 (4.3)	0.2 (-1.6, 1.9)	1.0 (0.7, 1.5)	0.89
Forceps Assisted Vaginal, n (%)	18 (1.6)	13 (1.3)	0.3 (-0.8, 1.3)	1.2 (0.6, 2.4)	0.59
Cesarean Delivery, n (%)	82 (7.4)	72 (7.4)	-0.0 (-2.3, 2.2)	1.0 (0.9, 1.1)	0.93
Postpartum Hemorrhage, n (%)	24 (2.2)	38 (3.9)	-1.8 (-3.3, -0.3)	0.6 (0.3, 1.0)	0.05
Endometritis, n (%)	6 (0.5)	3 (0.3)	0.2 (-0.3, 0.8)	1.8 (0.4, 7.4)	0.43
Chorioamnionitis, n (%)	73 (6.6)	86 (8.9)	-2.3 (-4.6, 0.0)	0.7 (0.6, 1.0)	0.03
Overt Levator Ani Muscle injury (perineal laceration ≥2 <sup>nd</sup> degree), n (%)	509 (45.8)	459 (47.3)	-1.51 (-5.8, 2.8)	0.97 (0.93, 1.02)	0.21
2 <sup>nd</sup> , n (%)	445 (40.1)	419 (43.2)	-3.14 (-7.4, 1.1)	0.93 (0.90, 0.98)	0.002
3 <sup>rd</sup> , n (%)	59 (5.3)	38 (3.9)	1.39 (-0.4, 3.2)	1.4 (1.1, 1.7)	0.01
4 <sup>th</sup> , n (%)	5 (0.5)	2 (0.2)	0.24 (-0.2, 0.7)	2.2 (0.6, 7.6)	0.23

Outcome	Immediate pushing (N=1111) <sup>[1]</sup>	Delayed pushing (N=970) <sup>[1]</sup>	Absolute Difference (95% CI)	Relative Risk (95% CI)	P
<b>NEONATAL</b>					
Composite Neonatal Morbidity, (%)	78 (7.0)	76 (7.8)	-0.8 (-3.1, 1.5)	0.9 (0.7, 1.2)	0.52
Neonatal death	0	0	-	-	-
Major birth injury	6 (0.5)	1 (0.1)	0.4 (-0.0, 0.9)	5.1 (1.6, 16.1)	0.01
Acidemia (pH<7.1)	7 (0.6)	12 (1.2)	-0.6 (-1.4, 0.2)	0.6 (0.3, 0.9)	0.02
Respiratory distress	27 (2.4)	18 (1.9)	0.6 (-0.7, 1.8)	1.3 (0.9, 1.9)	0.18
Transient tachypnea	6 (0.5)	5 (0.5)	0.0 (-0.6, 0.7)	1.1 (0.3, 3.8)	0.93
Meconium aspiration with pulmonary hypertension	0	2 (0.2)	-0.2 (-0.5, 0.1)	-	-
Hypoxic-ischemic encephalopathy	3 (0.3)	2 (0.2)	0.1 (-0.4, 0.5)	1.3 (0.3, 5.7)	0.73
Hypoglycemia	24 (2.2)	22 (2.3)	-0.1 (-1.4, 1.2)	1.0 (0.5, 1.9)	0.96
Hypothermic treatment (cooling)	1 (0.1)	0	-0.2 (-0.6, 0.2)	0.3 (0.0, 1.9)	0.20
Suspected sepsis	34 (3.1)	31 (3.2)	-0.14 (-1.6, 1.4)	1.0 (0.7, 1.3)	0.78
<b>OTHER EXPLORATORY SECONDARY OUTCOMES</b>					
Estimated blood loss (ml), median (IQR) mean (SD), n	350 (300, 450) 414.8(246.1), 1077	350 (300, 450) 426.1(312.2), 944	-11.3 (-26.8, 4.2)		0.15
Blood transfusion, n (%)	14 (1.3)	13 (1.3)	-0.1 (-1.1, 0.9)	1.0 (0.6, 1.6)	0.86
Shoulder dystocia, n (%)	36 (3.2)	22 (2.3)	1.0 (-0.4, 2.4)	1.4 (1.0, 2.1)	0.05
3 <sup>rd</sup> or 4 <sup>th</sup> degree laceration, n (%)	64 (5.8)	40 (4.1)	1.6 (-0.2, 3.5)	1.4 (1.1, 1.8)	0.01
NICU admission, n (%)	57 (5.1)	54 (5.6)	-0.4 (-2.4, 1.5)	1.0 (0.7, 1.3)	0.74

SD denotes standard deviation and IQR denotes interquartile range.

[1] N unless otherwise stated. Absolute difference (95% CI) for binary outcomes is calculated from binomial distribution. Relative risk (95% CI) for binary outcomes and absolute difference (95% CI) for continuous outcomes is obtained from generalized estimating equations models which were used to account for study site.



**eTable 4.** Primary and secondary efficacy outcomes (as treated)

Outcome	Immediate pushing (N=1345) <sup>[1]</sup>	Delayed pushing (N=1059) <sup>[1]</sup>	Absolute Difference (95% CI)	Relative Risk (95% CI)	P
<b>PRIMARY OUTCOME</b>					
Spontaneous Vaginal Delivery, n (%)	1159 (86.2), 1344	913 (86.2)	0.0 (-2.8, 2.8)	1.00 (0.98, 1.03)	0.98
<b>PRESPECIFIED SECONDARY OUTCOMES</b>					
<b>MATERNAL</b>					
Total Duration of Second Stage (min), median (IQR) mean (SD), n	71.5 (43, 125) 96.1(74.3), 1344	123 (92, 181) 146.5(77.1)	-49.5 (-55.4, -43.6)		<0.001
Duration of Active Pushing (min) median (IQR) mean (SD), n	52 (26, 106.5) 78.4(73.4), 1340	55 (27, 111) 79.9(74.7), 1058	-0.5 (-5.4, 4.3)		0.83
From Complete Dilation to Push (min), median (IQR) mean (SD), n	16 (11, 22) 17.9(11.3), 1340	67 (61, 74) 66.6(16.1), 1058	-48.7 (-50.2, -47.3)		<0.001
Operative Vaginal Delivery, n (%)	84 (6.3), 1344	63 (6.0)	0.3 (-1.6, 2.2)	1.0 (0.7, 1.5)	0.81
Vacuum Assisted Vaginal, n (%)	64 (4.8), 1344	47 (4.4)	0.3 (-1.4, 2.0)	1.1 (0.8, 1.5)	0.73
Forceps Assisted Vaginal, n (%)	20 (1.5), 1344	16 (1.5)	-0.0 (-1.0, 1.0)	1.0 (0.6, 1.5)	0.93
Cesarean Delivery, n (%)	101 (7.5), 1344	83 (7.8)	-0.3 (-2.5, 1.8)	1.0 (0.8, 1.1)	0.67
Postpartum Hemorrhage, n (%)	34 (2.5)	41 (3.9)	-1.3 (-2.8, 0.1)	0.7 (0.4, 1.1)	0.11
Endometritis, n (%)	7 (0.5)	4 (0.4)	0.1 (-0.4, 0.7)	1.4 (0.5, 4.0)	0.52
Chorioamnionitis, n (%)	97 (7.2)	93 (8.8)	-1.6 (-3.8, 0.6)	0.8 (0.6, 1.1)	0.19
Overt Levator Ani Muscle injury (perineal laceration ≥2 <sup>nd</sup> degree), n (%)	608 (45.2)	501 (47.3)	-2.1 (-6.1, 1.9)	0.97 (0.93, 1.00)	0.05
2 <sup>nd</sup> , n (%)	529 (39.3)	457 (43.2)	-3.8 (-7.8, 0.1)	0.92 (0.88, 0.96)	<0.001
3 <sup>rd</sup> , n (%)	73 (5.4)	42 (4.0)	1.5 (-0.2, 3.2)	1.4 (1.1, 1.8)	0.02
4 <sup>th</sup> , n (%)	6 (0.5)	2 (0.2)	0.3 (-0.2, 0.7)	2.4 (0.6, 9.5)	0.22

Outcome	Immediate pushing (N=1345) <sup>[1]</sup>	Delayed pushing (N=1059) <sup>[1]</sup>	Absolute Difference (95% CI)	Relative Risk (95% CI)	P
<b>NEONATAL</b>					
Composite Neonatal Morbidity, (%)	109 (8.1), 1345	85 (8.0)	0.1 (-2.1, 2.3)	1.0 (0.8, 1.3)	0.80
Neonatal death	0, 1345	0	-	-	-
Major birth injury	8 (0.6), 1345	1 (0.1)	0.5 (0.1, 1.0)	6.1 (1.6, 22.9)	0.01
Acidemia (pH<7.1)	9 (0.7), 1345	14 (1.3)	-0.7 (-1.5, 0.2)	0.6 (0.3, 1.0)	0.06
Respiratory distress	34 (2.5), 1345	21 (2.0)	0.5 (-0.6, 1.7)	1.3 (0.9, 1.8)	0.20
Transient tachypnea	10 (0.7), 1345	7 (0.7)	0.1 (-0.6, 0.8)	1.1 (0.4, 3.5)	0.83
Meconium aspiration with pulmonary hypertension	0, 1345	2 (0.2)	-0.2 (-0.5, 0.1)	-	-
Hypoxic-ischemic encephalopathy	3 (0.2), 1345	2 (0.2)	0.0 (-0.3, 0.4)	1.2 (0.3, 5.2)	0.85
Hypoglycemia	28 (2.1)	26 (2.5)	-0.4 (-1.6, 0.8)	0.9 (0.5, 1.6)	0.70
Hypothermic treatment (cooling)	1 (0.1)	3 (0.3)	-0.2 (-0.6, 0.1)	0.3 (0.0, 1.8)	0.17
Suspected sepsis	56 (4.2)	35 (3.3)	0.9 (-0.7, 2.4)	1.3 (0.9, 1.8)	0.18
<b>OTHER EXPLORATORY SECONDARY OUTCOMES</b>					
Estimated blood loss (ml), median (IQR) mean (SD), n	350 (300, 450) 415.2(243.7), 1307	350 (300, 450) 429.9(313.1), 1030	-14.8 (-26.2, -3.3)		0.01
Blood transfusion, n (%)	16 (1.2)	13 (1.2)	-0.0 (-0.9, 0.8)	1.0 (0.6, 1.5)	0.99
Shoulder dystocia, n (%)	41 (3.1)	26 (2.5)	0.6 (-0.7, 1.9)	1.3 (1.0, 1.6)	0.06
3 <sup>rd</sup> or 4 <sup>th</sup> degree laceration, n (%)	79 (5.9)	44 (4.2)	1.7 (-0.0, 3.5)	1.4 (1.1, 1.9)	0.01
NICU admission, n (%)	81 (6.0)	60 (5.7)	0.4 (-1.5, 2.3)	1.1 (0.9, 1.3)	0.39

SD denotes standard deviation and IQR denotes interquartile range

[1] N unless otherwise stated. Absolute difference (95% CI) for binary outcomes is calculated from binomial distribution. Relative risk (95% CI) for binary outcome and absolute difference (95% CI) for continuous outcomes is obtained from generalized estimating equations models which were used to account for study site.