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Citation: Spillane, E., Walker, S. & McCourt, C. (2022). Optimal time intervals for vaginal breech births: a case-control study. *NIHR Open Research*, 2(45), doi: 10.3310/nihropenres.13297.1

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RESEARCH ARTICLE

Optimal time intervals for vaginal breech births: a case-control study [version 1; peer review: 1 approved with reservations, 1 not approved]

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<https://doi.org/10.3310/nihropenres.13297.1>Latest published: 04 Aug 2022, 2:45
<https://doi.org/10.3310/nihropenres.13297.1>

Abstract

Background: Breech births are associated with a high rate of hypoxic injury, in part due to cord occlusion during emergence. Maximum time intervals and guidelines oriented toward earlier intervention have been proposed in a Physiological Breech Birth Algorithm. We wished to further test and refine the Algorithm for use in a clinical trial.

Methods: We conducted a retrospective case-control study conducted in a London teaching hospital, including 15 cases and 30 controls, during the period of April 2012 to April 2020. Our sample size was powered to test the hypothesis that exceeding recommended time limits is associated with neonatal admission or death. Data collected from intrapartum care records was analysed using SPSS v26 statistical software. Variables were intervals between the stages of labour and various stages of emergence (presenting part, buttocks, pelvis, arms, head). The chi-square test and odds ratios were used to determine association between exposure to the variables of interest and composite outcome. Multiple logistic regression was used to test the predictive value of delays defined as non-adherence the Algorithm.

Results: Logistic regression modelling using the Algorithm time frames had an 86.8% accuracy, a sensitivity of 66.7% and a specificity of 92.3% for predicting the primary outcome. Delays between umbilicus and head >3 minutes (OR: 9.508 [95% CI: 1.390-65.046] $p=0.022$) and from buttocks on the perineum to head >7 minutes (OR: 6.682 [95% CI: 0.940-41.990] $p=0.058$) showed the most effect. Lengths of time until the first intervention were consistently longer among the cases. Delay in intervention was more common among cases than head or arm entrapment.

Conclusion: Emergence taking longer than the limits recommended in the Physiological Breech Birth algorithm is predictive of adverse

Open Peer Review

Approval Status

	1	2
version 1		
04 Aug 2022	view	view

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2. **Kirsten Small** , Griffith University, Meadowbrook, Australia

Any reports and responses or comments on the article can be found at the end of the article.

outcomes. Some of this delay is potentially avoidable. Improved recognition of the boundaries of normality in vaginal breech births may help improve outcomes.

Keywords

Breech Presentation, Midwifery, Obstetrics, Medical Education, Case-Control, Delivery: Breech, Training

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Author roles: **Spillane E:** Data Curation, Formal Analysis, Investigation, Methodology, Writing – Original Draft Preparation; **Walker S:** Conceptualization, Formal Analysis, Supervision, Validation, Writing – Original Draft Preparation; **McCourt C:** Methodology, Supervision, Writing – Review & Editing

Competing interests: ES and SW are Directors of Breech Birth Network, Community Interest Company. They receive speaking fees and expenses for training activities.

Grant information: SW is funded by a National Institute of Health Research (NIHR300582) Advanced Fellowship. *The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

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How to cite this article: Spillane E, Walker S and McCourt C. **Optimal time intervals for vaginal breech births: a case-control study [version 1; peer review: 1 approved with reservations, 1 not approved]** NIHR Open Research 2022, 2:45 <https://doi.org/10.3310/nihropenres.13297.1>

First published: 04 Aug 2022, 2:45 <https://doi.org/10.3310/nihropenres.13297.1>

Plain english summary

When babies are born bottom-first, there is a risk that the baby could be starved of oxygen during the birth. To help prevent this, researchers developed a flowchart to guide when to help a baby out, the Physiological Breech Birth Algorithm. The first version was based on a study of actual breech birth videos and recommends that the birth should be complete within 7-5-3 minutes from buttocks-pelvis-umbilicus visible. This is different from current national guidance not to intervene until 5 minutes after the baby's pelvis is born. We are using this new algorithm to guide midwives and doctors in the OptiBreech Care Trial, so we wanted to make sure it is safe and accurate.

Introduction

Whilst vaginal breech birth accounts for only 0.3% of all births in the UK¹, it is overrepresented in cerebral palsy litigation costs, accounting for 12% of all claims². Awareness of this increased risk has led to a reliance on caesarean section (CS). Although occurring in only 3–4% of pregnancies, breech presentation is one of the leading causes for a first-time planned CS and associated risks in subsequent pregnancies^{3,4}. However, a policy of universal 36-week ultrasound scans does not eliminate undiagnosed term breech presentation⁵. As a majority of compensation claims occur following diagnosis late in labour², improving outcomes in these rarely occurring births to reduce the litigation burden remains an important concern. Additionally, some women wish to plan a vaginal breech birth and encounter reluctance from health care professionals who fear they cannot keep the birth safe^{6,7}.

Studies of vaginal breech birth outcomes frequently seek to identify risk factors associated with the mother or fetus that may increase the risk of a poor outcome, and guidelines often present a set of criteria which should be met before women are offered the option of a vaginal breech birth³. However, even in studies with very large samples, clear associations between commonly accepted risk factors and adverse outcomes are not reliably demonstrated, with the consistent exception of birthweight <10th centile^{8–10}.

Although some of the increased risk is explained by underlying conditions which can cause the foetus to present in the breech position, the skill of the practitioner facilitating the vaginal breech birth is understood to have a significant effect on its safety^{3,10,11}. The components of what constitutes skilled practice, how these are developed and whether they might be modifiable to improve outcomes are less well understood. One of these components is thought to be an understanding of the mechanisms and physiology of a normal breech birth¹². Familiarity with these mechanisms underpins an ability to anticipate and avert complications, a marker of breech experience¹². Careful, evidence-based descriptions of what is 'normal' in breech births may therefore help more novice clinicians to anticipate and avert difficulty despite their lack of clinical experience.

The available guidance on timings in late second stage (emergence) in vaginal breech births is inconsistent and largely based on professional opinion. The Royal College of Obstetricians

and Gynaecologists 2017 guideline on the *Management of Breech Presentation* suggests that "intervention to expedite breech birth is required ... if there is a delay of more than 5 minutes from delivery of the buttocks to the head, or of more than 3 minutes from the umbilicus to the head"^{3(p17)}. The K2MS Perinatal Training Programme states, "The expected time interval between the birth of the baby's bottom until the shoulders appear should be approximately 2 minutes."¹³ A 2009 textbook, *Training in Obstetrics and Gynaecology: the essential curriculum*, states: "The rule of '5' has traditionally been used – 5 min for each of the three delivery stages: to umbilicus, rest of the body and shoulders, head."^{14(p278)}

Recent ability to analyse videos has created an opportunity to base such guidelines on evidence rather than assumption or tradition. Reitter *et al.*'s recent analysis of a cohort of upright (kneeling) VBB videos with good outcomes identified that in over 75% of births, the time interval between birth of the pelvis and head was under 3 minutes¹⁵. However, it is not known whether intervals differ in cases of adverse outcomes, and if so, whether these delays are associated with unpreventable entrapment or avoidable delay in intervention. Further evidence is needed to develop robust guidance.

Based on Reitter *et al.*'s 2020 analysis, a Physiological Breech Birth Algorithm was developed by Dr Shawn Walker and refined with feedback from professionals attending vaginal breech birth training. The most recent version is presented in Figure 1. Our study aimed to test the ability of the Algorithm to predict neonatal death or intensive care unit (NICU) admission among a retrospective sample of births in a London teaching hospital, based on whether the birth conformed to the guideline time frames in the Algorithm or not. We hoped to further verify or refine the Algorithm for use in a clinical trial.

Methods

A single-centre retrospective case control study was conducted. The protocol defined cases as births where neonatal deaths or NICU admissions occurred (primary outcome). Controls were identified as the two vaginal breech births involving no neonatal death nor NICU admission, occurring directly prior to the identified case. Two previous births were used to prevent bias on the understanding that an adverse outcome can affect clinical decision-making for subsequent births¹⁶. Any NICU admission was included because this indicates a neonate which requires additional observation, tests and/or intervention. Neonates who are not admitted are deemed as generally well¹⁷. Neonatal admissions are very costly, and reducing avoidable admissions at term has been recognised as a priority¹⁸. Additionally, separation from the baby was considered an important outcome by our Patient and Public Involvement (PPI) Group¹⁹, who also requested more information on the timing of cord clamping.

To calculate our sample size, based on the work of Reitter *et al.*,¹⁵ we hypothesised that the rate of exposure to a pelvis-to-head interval >3 minutes would be 25% among controls and 75% among cases. Using a case:control ratio

Physiological Breech Birth Algorithm

by Shawn Walker RM PhD
Adapted June 2022 from original, published in
Reitter A, Halliday A, Walker S (2020, Birth)
with thanks to the OptiBreech Collective

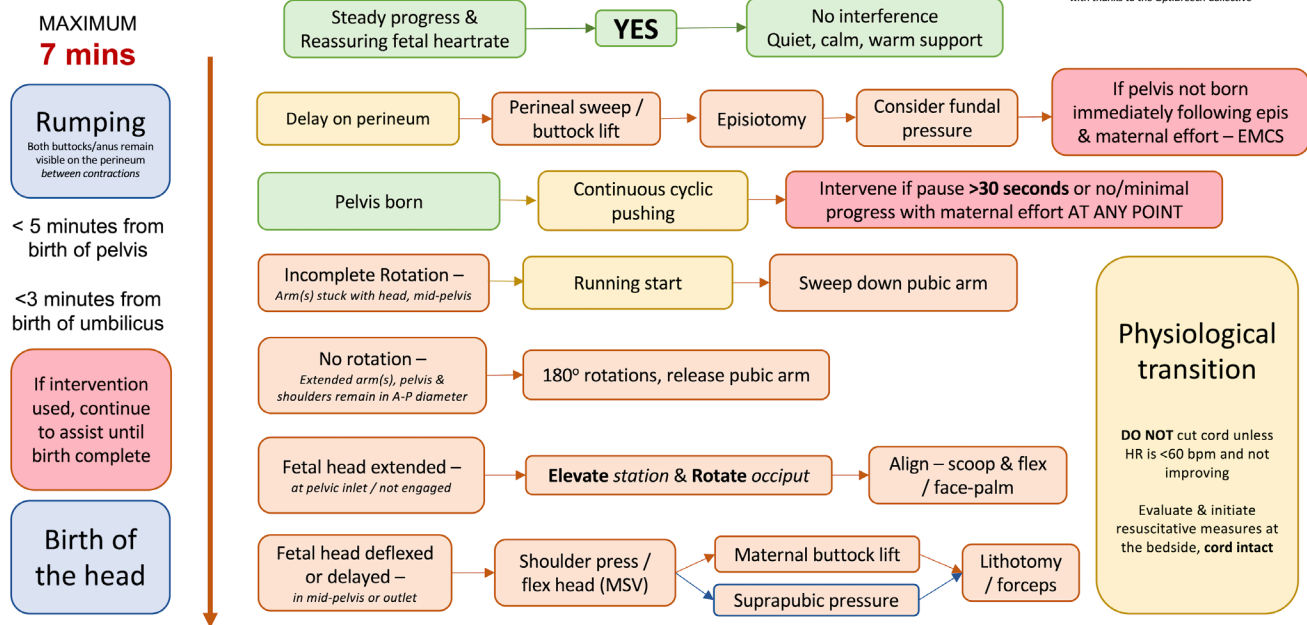


Figure 1. Physiological Breech Birth Algorithm. Designed by Shawn Walker RM PhD, June 2022 version. First published in Reitter A, Halliday A, Walker S, 2020, Practical insight into upright breech birth from birth videos: a structured analysis, Birth, 47(2):211–219.

of 1:2, we determined that 15 independent cases and 30 controls were required to infer an association between a pelvis-to-head interval >3 minutes and the composite neonatal outcome with a confidence interval of 95% and a power of 80%. We began seeking cases from the year 2020 and worked backward until the specified sample size was achieved.

The study was conducted within the maternity unit at a London District General Hospital which serves a large population of 176,313 people. Two thirds are of white British ethnicity and one third from Black, Asian and Minority Ethnic (BAME) backgrounds. The community the hospital serves is thought of as affluent, with good employment rates, particularly employment in high-end jobs. The hospital itself serves a wider community than the borough it is situated within and has 5000 births per year. It has a level two NICU situated within the maternity unit. The Algorithm was not in use at the site, and none of the authors were employed by the Trust, until 2020.

Our sample of 15 cases was achieved within the window of 2012 and 2020. These involved NICU admissions as no neonatal deaths occurred among the sample. A total of 71 term vaginal breech births were identified from routine electronic health records during this period. From this, we selected our 30 controls as the two vaginal breech births in the sample occurring immediately prior to each case. The Medical Record Numbers were sent to the Health Records Department for the complete files to be retrieved. Data were extracted by the lead

researcher from the intrapartum care records and recorded anonymously in a Microsoft Excel spreadsheet.

A structured data collection tool was developed based on Reitter *et al.*¹³ The data collection tool consisted of information usually recorded in the notes during a breech birth and included: lead professional, type of breech, position, epidural, fetal monitoring, meconium, what emerged first, time each part of the breech born, documented manoeuvres used, time performed and information related to the condition of the neonate at birth.

First, we calculated the time to event interval for variables of interest. We then reported descriptive statistics for all variables, including means, medians, absolute and interquartile ranges for continuous variables. Exposures and confounders were converted into binary variables, reflecting the guidance used in the Algorithm. These were then tested for association with the primary outcome using the non-parametric chi-square, or Fisher’s Exact tests where cell frequencies were too small for the chi-square test and odds ratios.

Logistic regression analysis was used to test the predictive values of meeting or exceeding the recommended time limits in the Physiological Breech Birth Algorithm. Logistic regression analyses were conducted with all variables that showed an association with the composite neonatal outcome to determine their predictive value, and additional variables to explore

their potential as confounding factors for investigation in future studies. Finally, a Receiver Operating Characteristics (ROC) curve analysis was conducted to compare the sensitivity and specificity of the 7-5-3 minute time limit guidance. All statistical analyses were performed using IBM SPSS version 26.

This research was unfunded and was conducted as part of Spillane's role as a Consultant Midwife with a remit for supporting vaginal breech births within the Trust. Spillane is also a Principal Investigator and Walker is the Chief Investigator for the OptiBreech Care Trial, an NIHR-funded feasibility study (NIHR300582, ISRCTN14521381) currently using the Physiological Breech Birth Algorithm. Two of the researchers have had a long-term involvement with the OptiBreech PPI group, who have experience of breech pregnancy and childbirth. Whilst the PPI group did not directly consider this study, their input into other aspects of the OptiBreech Project, including the prioritisation of outcomes, influenced our choices about variables of interest¹⁹.

Approval was obtained through the Health Research Authority (IRAS 294936, 21/HRA/0562) and the Trust's Research and Development department. This was a retrospective study

using data that was anonymised by a member of the clinical care team; therefore, explicit consent was neither required nor sought.

Results

The Physiological Breech Birth Algorithm reported in Reitter *et al.*¹⁵ proposes three key interval limits: rumping(+3 station)-to-birth within 7 mins, pelvis-to-birth within 5 mins and umbilicus-to-birth within 3 mins. Our single-factor correlation tests showed that, in each of these categories, exceeding these limits was associated with NICU admission (Table 1). When tested together in a logistic regression, the percentage accuracy (PAC) was 86.8%. The combination had a positive predictive value of 80.0% and sensitivity of 66.7%, and a negative predictive value of 85.7% and specificity of 92.3%. The most contributory factors predicting the primary outcome were an umbilicus-to-birth interval >3 minutes (aOR:9.508 [95% CI:1.390-65.046], $p=0.022$) and, to a lesser extent, a rumping-to-birth interval >7 minutes (aOR:6.282 [95% CI: 0.940-41.990], $p=0.058$). The ROC curve is presented in Figure 2.

There was a statistically significant association between a pelvis-to-head interval of >3 minutes, the interval we used to

Table 1. Association of intrapartum risk factors with primary outcome (NICU admission or death). *P*-values calculated with chi-square or Fisher's exact test (2-sided).

Variable	Incidence of variable among controls vs cases	Odds Ratio	95% confidence interval	<i>p</i> -value
Length of second stage longer than 60 mins	6/30 vs 6/15	2.667	(.680 – 10.458)	.153
Length of second stage longer than 90 mins	3/30 vs 4/15	3.273	(.627 – 17.092)	.146
Rumping to birth exceeding 7 minutes	5/27 vs 10/14	11.000	(2.424 – 49.915)	.001
Pelvis born to birth exceeding 5 minutes	5/29 vs 8/13	7.680	(1.756 – 33.583)	.004
Pelvis born to birth exceeding 3 minutes	10/29 vs 13/13	*	*	<.0005
Umbilicus born to birth exceeding 3 minutes	8/29 vs 13/15	17.063	(3.127 – 93.106)	<.0005
Birth outside an obstetric unit	4/30 vs 2/15	1.00	(.161 – 6.192)	1.000
Birth facilitated by a midwife	18/30 vs 7/15	.583	(.167 – 2.036)	.396
Birth NOT facilitated by a senior registrar or consultant obstetrician	27/30 vs 7/15	.375	(.104 – 1.349)	.128
Non-extended breech presentation	6/30 vs 5/14	2.222	(.541 – 9.126)	.262
Intermittent monitoring	10/30 vs 1/14	.154	(.018 – 1.349)	.062
Meconium in labour	8/30 vs 6/15	1.833	(.494 – 6.810)	.362
Upright maternal birthing position	12/29 vs 7/15	1.240	(.353 – 4.348)	.737
Use of manual interventions	13/30 vs 15/15	*	*	<.0005
Use of epidural	6/30 vs 2/15	.615	(.108 – 3.495)	.581
Diagnosis after the start of labour	19/30 vs 12/15	2.316	(.534 – 10.041)	.255
Immediate cord clamping (<1 minute)	14/30 vs 14/14	*	*	.001

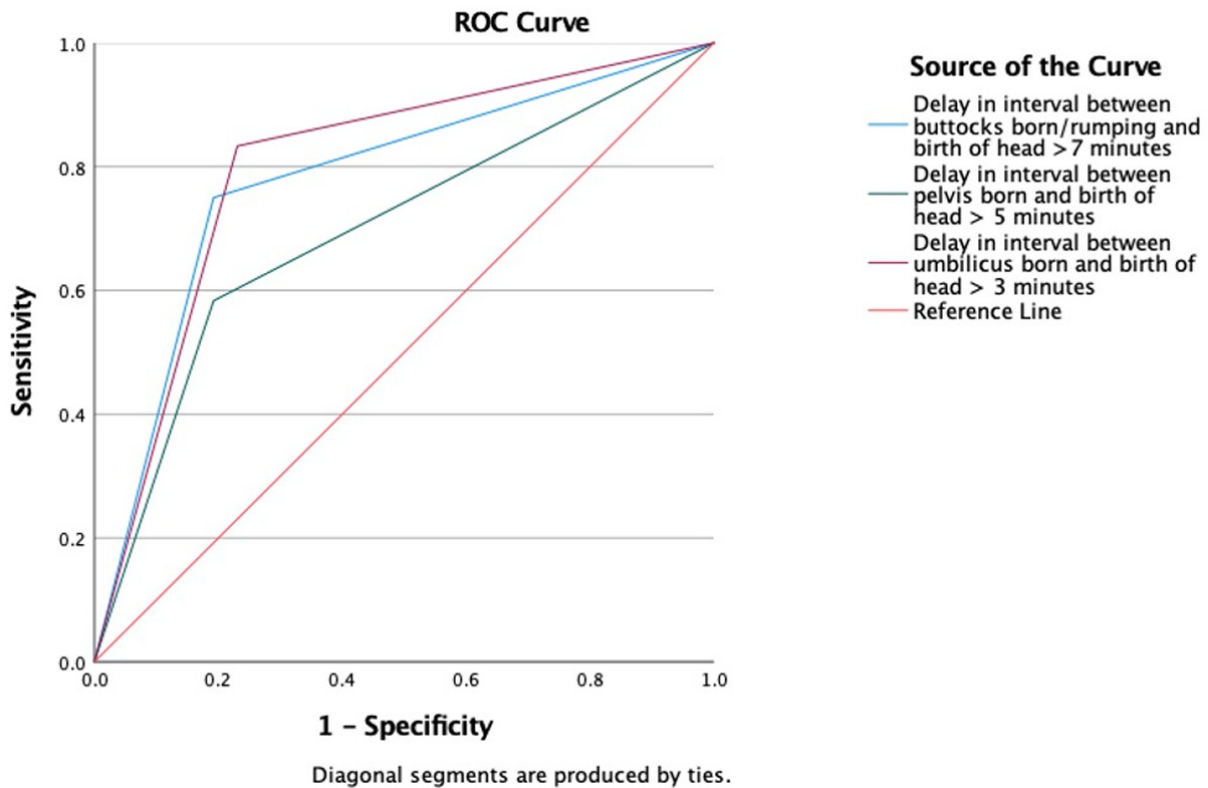


Figure 2. Predictive value of Physiological Breech Birth Algorithm's 7-5-3 time limits.

calculate our sample size, and NICU admission following the birth ($p < 0.005$). However, this result was highly confounded with an umbilicus-to-birth interval > 3 minutes.

As expected, there was an association between use of manual interventions to assist the birth and the composite outcome of interest ($p < .005$). Manoeuvres were used in 13/30 controls and 15/15 cases. The intervals between the birth of the pelvis and the first manoeuvre used to assist the arms or head were twice as long in cases (mean 5.83, median 4, range 1–19 minutes) compared to controls (mean 2.45, median 2, range 0–6 minutes) (Table 2). Where an episiotomy was performed, the interval between rumping and episiotomy was also longer in cases (mean 5.67, median 5, range 0–18 minutes) compared to controls (mean 1.75, median 1, range 0–5 minutes).

In both cases and controls, the mean and median reported times spent on manoeuvres to release the head were < 1 minute. In only one case did the reported time exceed 2 minutes. In this case, 7 minutes were spent trying to release the head. However, intervals between the birth of the arms and initiation of manoeuvres to release the head were longer in cases (mean 2.42, median 2, range 1–5 minutes) than in controls (mean 1.20, median 1, range 0–2 minutes). In the case where head manoeuvres required 7 minutes, interventions were not attempted until 2 minutes after the arms were born and 13 minutes after the pelvis was born.

Similarly, in both cases and controls, the mean and median reported times spent on manoeuvres to release the arms were < 1 minute. In one case, this took 3 minutes, and in one case it required 5 minutes. The intervals between the birth of the umbilicus and initiation of manoeuvres to release the arms were also longer in cases (mean 2.5, median 2, range 0–6 minutes) than in controls (mean .88, median 1, range 0–2 minutes).

In this sample, lengths of the first stage of labour were shorter for cases compared to controls. In contrast, the intervals between diagnosis of second stage of labour and birth were longer for cases compared to controls, as were the intervals between the onset of expulsive pushing and birth. Neither of these were significantly associated with NICU admission, either in single-factor analysis or logistic regression. Although 5-minute Apgar scores were lower for cases (mean 6.14, median 6) compared to controls (mean 9.76, median 10), arterial pH and base excess results did not differ.

An unexpected finding was that 28/44 (64%) of neonates experienced immediate umbilical cord clamping (UCC) following their breech births (Table 1). This included 100% of the babies admitted to the neonatal unit, although in general the arterial cord blood gas results were marginally better among cases than controls (Table 2). Mean arterial pH was 7.14 among controls vs 7.21 among cases, and mean base excess (BE) was -7.11 among controls compared to -6.65 among cases.

Table 2. Intervals of emergence and other variables.

Variable	Cases/Controls	Mean mins	Median mins	Minimum mins	Maximum mins	Inter-Quartile Range
Start of labour to diagnosis of second stage	Controls without interventions (17)	323	268	65	807	150 – 466
	Controls with interventions (13)	232	180	5	755	68 – 326
	Cases (14)	180	170	23	472	69 – 256
Diagnosis of second stage to birth	Controls without interventions (17)	46	27	6	163	15 – 64
	Controls with interventions (13)	42	28	9	137	18 – 52
	Cases (15)	74	49	7	294	18 – 97
Diagnosis of second stage to onset of active expulsive effort	Controls without interventions (17)	16	4	<1	91	<1 – 17
	Controls with interventions (13)	19	16	<1	78	<1 – 28
	Cases (15)	12	<1	<1	68	<1 – 25
Onset of active expulsive effort to birth	Controls without interventions (17)	31	22	6	77	11 – 53
	Controls with interventions (13)	23	13	4	117	9 – 22
	Cases (15)	61	31	7	294	13 – 91
Presenting part first visible to birth	Controls without interventions (17)	22	11	1	77	7 – 39
	Controls with interventions (13)	17	10	2	92	7 – 13
	Cases (14)	34	19	7	112	10 – 59
Rumping (buttocks born to +3 station) to birth	Controls without interventions (15)	4.5	3	1	13	1 – 7
	Controls with interventions (12)	7.5	6	2	32	3.3 – 7
	Cases (14)	15.5	10.5	5	55	7 – 19
Pelvis born to birth	Controls without interventions (16)	2.9	1.5	<1	10	1 – 5
	Controls with interventions (13)	3.6	3	1	7	2.5 – 5
	Cases (13)	8.8	7	4	22	5 – 9.5
Umbilicus born to birth	Controls without interventions (16)	2.2	1	<1	5	1 – 4
	Controls with interventions (13)	2.6	2	1	6	2 – 3.5
	Cases (15)	6.3	6	3	15	4 – 8
Arms born to birth	Controls without interventions (16)	1.3	1	<1	5	1 – 1
	Controls with interventions (11)	1.5	1	1	2	1 – 2
	Cases (14)	3.3	2.5	1	9	2 – 4
Rumping and episiotomy	Controls (4)	1.8	1	<1	5	<1 – 4.25
	Cases (9)	5.7	5	<1	18	<1 – 9
Birth of the pelvis to first manoeuvre to assist arms or head	Controls (11)	2.5	2	<1	6	1 – 4
	Cases (12)	5.8	4	1	19	2.25 – 7
Birth of the umbilicus to first manoeuvre to release the arms	Controls (8)	.9	1	<1	2	<1 – 1.75
	Cases (12)	2.5	2	<1	6	1 – 4.75
Birth of the arms to first manoeuvre to release the head	Controls (5)	1.2	1	<1	2	.5 – 2
	Cases (12)	2.4	2	1	5	2 – 3

Variable	Cases/Controls	Mean mins	Median mins	Minimum mins	Maximum mins	Inter-Quartile Range
Total time spent on manoeuvres to release the arms	Controls with interventions (8)	.38	<1	<1	2	<1 – 0.75
	Cases (12)	.83	<1	<1	5	0 – 1
Total time spent on manoeuvres to release the head	Controls with interventions (7)	.14	<1	<1	1	<1 – <1
	Cases (13)	.85	<1	<1	7	0 – 1
Arterial pH	Controls without interventions (2)	*	*	7.11	7.13	*
	Controls with interventions (8)	7.14	7.14	7.04	7.26	7.05 – 7.21
	Cases (6)	7.21	7.17	7.11	7.38	7.14 – 7.30
Arterial BE	Controls without interventions (2)	*	*	-9.3	-6.9	*
	Controls with interventions (8)	-7.11	-7.35	-10.9	-1.1	-10.38 – -4.53
	Cases (6)	-6.65	-7.40	-1.7	-11.6	-9.20 – -2.96
5-minute APGAR	Controls without interventions (16)	9.75	10	9	10	9 – 10
	Controls with interventions (13)	9.77	10	8	10	10 – 10
	Cases (14)	6.14	6	0	10	4.5 – 9
Timing of cord clamping	Controls without interventions (17)	9.29	1	<1	52	<1 – 12.5
	Controls with interventions (13)	2.46	<1	<1	28	<1 – 1
	Cases (14)	<1	<1	<1	<1	*

The data that support the findings of this study are openly available on Figshare, reference number 15134427.

Discussion

Main findings

Our findings demonstrate a relationship between NICU admission and longer time intervals around the time of emergence in vaginal breech births, including comparative delay in providing assistance. We found that the time limits described in the Physiological Breech Birth Algorithm, together, have a predictive accuracy (PAC) of 86.8%, with a sensitivity of 66.7% and specificity of 92.3%. Our findings therefore support the Algorithm's guidance that it is 'normal' for vaginal breech births to be complete in under 7 minutes from rumping, under 5 minutes from the birth of the pelvis, and/or under 3 minutes from the birth of the umbilicus, including time for manual assistance.

Our findings support a more active approach to intervention in births that are not progressing swiftly once the breech begins to emerge. Delay in assisting appears likely to be a more significant contributing factor to neonatal compromise than head or arm entrapment. Regarding ability to predict no NICU admission, the true negative rate (92.3%) was higher than the ability to predict NICU admission, the true positive rate (66.7%). This suggests that adherence to Algorithm time frames is reassuring and safe but may result in unnecessary intervention in some births. Delay in response may be a modifiable

contributing factor to poor outcomes in vaginal breech births, but it is not the only determinant.

The findings do not in any way suggest that manual interventions or episiotomy should be routine or immediate. Among controls, 17/30 births required no interventions. Application of manoeuvres prior to indication by delay or compromise could cause unintentional harm, just as much as hesitating to apply them. But the practice of instructing women to 'breathe and wait for the next contraction' should be abandoned²⁰. In the OptiBreech Trial, the guideline developed in consultation with our principal investigators indicates that, following any pause of 30 seconds or more, active maternal effort and movement ('wiggle and push') should be encouraged. This hands-off intervention can be used to confirm physical obstruction prior to use of manual interventions, to avoid iatrogenic harm.

Strengths

This study uses rigorous scientific methods to demonstrate an association between delay in providing needed intervention and NICU admission following vaginal breech births. Reducing early separation from baby is an important outcome to service users and has significant economic implications. Building on video research used to develop the recommended (7-5-3) time limits¹⁵, we formulated a plausible hypothesis that neonatal compromise would occur more often if the birth did not adhere to these. We then tested this hypothesis using a pre-specified sample size and found it was supported.

Limitations

Our study's sample size was determined to test a specific hypothesis, based on the pelvis-to-head interval identified in previous research¹⁵; it was sufficient for this purpose but was insufficient to evaluate the influence of other intervals, such as the lengths of first and second stages of labour. For example, exploratory modelling indicated that first diagnosis during labour may have predictive value. This accords with case analysis of cerebral palsy litigation claims, in which breech presentation diagnosed late in labour was over-represented², but this factor was not associated with NICU admission in our single-factor analysis. Additionally, though we included neonatal death as part of a composite outcome, no neonatal deaths occurred during this sample period in this setting. Further research should use larger sample sizes to confirm or refute our results with smaller confidence intervals and test the influence of further variables.

While we collected very detailed information about factors not included in most studies, we did not collect information on other factors that are often noted to influence neonatal outcomes, for example, parity or fetal weight. Though neither the Term Breech Trial nor PREMODA studies indicated that parity or high fetal weight increased adverse outcomes^{9,10}, these are often considered risk factors. They may be risk indicators instead, as both are more likely to increase exposure to delay in second stage, which if unaddressed may lead to harm. Prospective clinical studies are required to determine whether such delay is modifiable through changes in guidelines and training, and whether such changes improve outcomes or lead to other harms that delayed intervention helps to avoid.

This study used intrapartum care records, which are not always accurate. Reitter *et al.*'s study¹⁵ analysed the timings around emergence in breech births using videos and could use data that were confirmed accurate to the second by two independent assessors. This study relied on documentation rounded to the nearest minute, which may have been recorded in retrospect if a scribe were not available at the time of birth. Systematic errors in the sample are likely to have been applicable to both cases and controls, and these results may change if data are collected prospectively.

Interpretation

This research challenges some classical guidelines and beliefs concerning the intrapartum management of vaginal breech births. The RCOG guideline currently recommends that intervention is indicated at the point of a 5-minute delay following the birth of the pelvis. However, along with Reitter *et al.*¹⁵, we have presented evidence that in most births with good outcomes, the head is born *within* 3 minutes of the birth of the pelvis; therefore intervention is indicated sooner. Our logistic regression analysis also indicated that the within 7-minutes-from-rumping interval may be a better overarching guideline interval.

It is also physiologically plausible that delays in the early stages of emergence contribute to the complication of head entrapment.

Cord compression is likely once the breech reaches +3 station, when both buttocks and anus are visible on the perineum between contractions without recession. We refer to this as 'rumping,' the breech equivalent of crowning, after Evans²¹. Delay at this point is likely to cause hypoxia and hypercapnia, leading to a loss of fetal tone and deflexion of the head and torso/arms, all of which ultimately make manual assistance more difficult. While 'head entrapment' is the complication so many clinicians dread, where it occurs 13 minutes after the birth of the pelvis, as in this study, head deflection due to hypoxia and poor tone is a more likely cause than cephalopelvic disproportion.

Many training programmes promote the maxim, "Hands off the Breech,"^{22,23} and suggest that touching of the baby could stimulate a startle response leading to arm or head entrapment^{3,21}. While we agree that unskilled manipulation can cause harm, our findings suggest that delaying use of effective manoeuvres when indicated to assist the birth is also causing significant harm. Classical management strategies instruct trainees to 'let the baby hang' after the birth of the arms to assist head flexion and 'wait until you see the nape of the baby's neck.' Our findings suggest that these instructions should be reconsidered or very carefully qualified. Clinicians need to understand how long they should wait before assisting the head into the pelvis if required, to avoid loss of situational awareness at this crucial point. Similarly, women should not be instructed to resist an urge to push and 'wait for the next contraction' without evidence that this improves outcomes.

A recently published evaluation gathered prospective outcome data following training based on the Algorithm²⁴. The evaluation included 90 vaginal breech births occurring in 6 NHS hospitals, with 21/90 births attended by someone who had completed the training. Among these, there were no severe adverse outcomes, compared to a rate of 7% among women (PPH >1500mL and OASIS) and 7% among neonates (5-minute Apgar <4 and NICU admission >4 days), where no one who had completed the training was present. The results of the evaluation can only be considered pilot data, but it remains the only evidence available of a training package that has demonstrated potentially improved outcomes for vaginal breech births using methods other than caesarean delivery.

The finding that cord blood gases were marginally worse among controls compared to cases may reflect the higher incidence of optimal cord clamping among this population. Although previous studies have reported changes (lower pH, higher BE) following delayed cord clamping, the differences we observed were larger than previously reported^{25,26}, especially as nearly half of our controls also experienced immediate cord clamping. It seems likely that, in vaginal breech births, the high incidence of acute cord occlusion around the time of emergence (buttocks visible to birth) disrupts fetal gas exchange via the placenta. The blood captured within an immediately clamped umbilical cord may therefore reflect the fetal metabolic condition prior to the start of cord occlusion, rather than at birth. Cord blood taken from breech neonates at least 1 minute

after birth may more accurately reflect the fetal metabolic condition at birth, as the fetal blood recirculates. Once the occlusion is relieved, the bradycardia caused by cessation of blood flow from the placenta to the heart recovers audibly in most neonates, with or without obvious respiratory effort.

For this reason, the finding that 64% of neonates in this sample experienced immediate UCC is also of concern. Current NICE²⁷ and Resuscitation Council²⁸ guidelines recommend clamping after at least 60 seconds wherever possible, and this should be standard management for all neonates where the fetal heart is >60bpm and rising with initial stimulation. At least 75% of these neonates had an Apgar score of 10 at 5 minutes and would likely have met this criterion at birth, if properly assessed. UCC is considered an important outcome by birthing women¹⁹, who in general wish to prevent immediate UCC, and this priority is backed up by physiological evidence. UCC prior to the establishment of respiration in mildly hypoxic infants may initiate a reflex bradycardia and reduction in cardiac output, due to sudden cessation of blood flow returning to the heart. Such an ischemic insult may exacerbate any asphyxial insult^{29,30}. For some time, due to service user input and a consensus of professionals experienced in physiological breech birth³¹, our Algorithm has recommended initiation of resuscitation with the umbilical cord intact. We will continue to advocate for this approach, and have incorporated into the OptiBreech Care Trial guideline, as we continue to collect data on timing of UCC as both an outcome and an explanatory variable in outcomes for vaginal breech births.

Our case-control study suggests that skilled management around the time of emergence is a crucial factor in the safety of vaginal breech births. Differences in outcomes are apparent in a much smaller data set than those that have been used to define selection criteria, which appear to have a more negligible impact on outcomes. Despite the application of stricter selection criteria and consequent increase in the number of caesarean births for breech-presenting babies, rates of adverse outcomes for vaginal breech births themselves have not declined⁸. Stricter selection criteria are unlikely to improve

outcomes in the absence of critical changes to intrapartum guidelines, dissemination in training programmes and development of expertise within services³². While some factors may be predictive of delay and/or need for intervention in late second stage, outcomes for births where delay occurs unpredictably will not improve without changes to the way professionals respond around the time of emergence.

Conclusion

The Physiological Breech Birth Algorithm was originally designed to summarise and support training in the facilitation of breech births where the birthing person is in an upright position. However, the principles are applicable across all breech births, such as the sample in this study, which includes a mix of supine and upright birthing positions. The Algorithm's principles include clear boundaries for 'normality' in vaginal breech births and indications for interventions based on variations of the mechanisms of breech birth. The manoeuvres required to resolve obstruction are also based on the same physiological principles, performed in slightly different ways depending on the birth position. We suggest that it could be more widely used as a framework for training and for evaluating adverse outcomes when they occur. Clinical outcomes associated with its use can be expected with reports of the OptiBreech Care Trial.

Data availability

Underlying data

Figshare: Optimal Time Intervals of Breech Births Dataset, <https://doi.org/10.6084/m9.figshare.15134427.v1>.

Data are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver](#) (CC0 1.0 Public domain dedication).

Acknowledgements

SW is funded by a National Institute of Health Research (NIHR300582) Advanced Fellowship. The team would like to express their gratitude to Professor Stuart Hooper for explaining the physiological mechanisms underlying cardiovascular transition at birth and helping us to interpret our results.

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Open Peer Review

Current Peer Review Status:  

Version 1

Reviewer Report 16 August 2022

<https://doi.org/10.3310/nihropenres.14421.r28736>

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 **Kirsten Small** 

Transforming Maternity Care Collaborative, School of Nursing and Midwifery, Logan Campus, Griffith University, Meadowbrook, QLD, Australia

Congratulations on adding new and useful information to our understanding of how best to care for women during their vaginal breech birth. The writing is clear, logical, and free from errors. The abstract is well structured and reflects the key elements of the study. Key literature regarding vaginal breech birth is addressed in the introduction. The methods used were explained well. The findings are presented in an easy to understand manner. The discussion provides context for the findings, demonstrating a detailed knowledge of the field. The discussion is also used to further explore and theorise some of the unexpected findings of the study.

I have some suggestions for how I believe you can further strengthen the paper:

- You use the abbreviation VBB once in the introduction without having defined it, but then use vaginal breech birth for the remainder of the paper. Please edit this to achieve consistency throughout.
- You explain that the Algorithm was not in use at the site during the period when the births in this study occurred. It would be useful to have additional contextual information about whether other approaches to providing training for maternity staff in vaginal breech birth had been undertaken, and what policy guidance was in place at the site at the time.
- Can you please comment on whether there were challenges in ascertaining all the variables of interest? Was it standard practice to document the timing of each stage of emergence? Were there instances where data were missing and if so, how was this handled?
- I would appreciate further information about why admission to the nursery, and not another measure of morbidity, was chosen as the primary end point (in the absence of mortality data). It would also be of use to include further data about why cases were admitted, for how long, and whether there were morbidities related to the mode of birth and / or the techniques used to facilitate birth.

- Admission to the nursery is a clinical decision and therefore subjective. Given that cord blood gas results were better among cases, and not all cases appeared to have abnormal Apgar scores at 5 minutes of age, the reader is left wondering what prompted the decision for admission. A possible alternate explanation of your findings is that neonatal staff elected to admit infants after vaginal breech births that appeared to have been difficult or prolonged as a matter of precaution, rather than because of suspected or actual harm. It would strengthen your argument that delay was associated with poorer outcomes, if you were to show that there were indeed worse outcomes among those admitted to the nursery. At present, in the absence of this information, I think that the absence of additional evidence of harm due to delay should be acknowledged as a limitation of the study. Hopefully, you can provide additional data that will dispel this concern.
- In table 1 you refer to "intermittent monitoring". Do you mean intermittent auscultation / fetal heart rate monitoring? There are many forms of monitoring in labour so the term here is unclear. I would presume that during emergence that at least one maternity professional was present and constantly monitoring the overall situation.
- In the discussion, paragraph two begins with a suggestion to take a "more active" approach - which begs the question, compared to what? Simply stating that an active approach is supported would be as impactful, given that the algorithm provides clarity on when and what activity is advised.
- In the second paragraph of the interpretation section, you appear to say that a 13 minute delay after the birth of the pelvis is the same as head entrapment, and that this is what so many clinicians fear. Can you rephrase this sentence to be sure you are clearly expressing the point that was intended here? I believe the learning point (that inaction early in emergence contributes to poor tone and therefore difficulty in birthing the head) is an important one and it is slightly lost in the current wording of the sentence.
- You have acknowledged the limitations of using a retrospective case-control methodology. I do believe that the knowledge generated from this small retrospective study remains useful. Previous recommendations for the timing of intervention in vaginal breech birth guidelines were based on less evidence than this. You make it clear that further evaluation of the Algorithm is underway within the Optibirth randomised controlled trial. Prospective evaluation of the Algorithm will overcome the limitations inherent in this type of methodology.
- At present, your conclusion reflects a broad understanding of the potential for the Algorithm. I would like to see the conclusion instead focus more clearly on providing a summary of the findings of this particular piece of research and the implications for practice, education, and /or future research.

Thank you for the opportunity to review the paper.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Clinical expertise in physiological vaginal breech birth, doctorally qualified obstetrician. Intrapartum fetal heart rate monitoring.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 15 August 2022

<https://doi.org/10.3310/nihropenres.14421.r28738>

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Gerhard Bogner 

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The study aims to test a self-designed algorithm for the course of a vaginal breech delivery. In principle, it is a high goal to describe parameters that are associated with a poorer neonatal outcome, record them and prevent them through obstetric intervention. It is questionable to me whether the given study design answers the question of the role of the timing of birth and its impact on the perinatal outcome:

1. Retrospective data collection on a large cohort of births from large hospitals that do not appear to correspond to the hospitals where the authors work.
2. Data collection from a retrospective collective is always imprecise and mostly incorrect (missing documentation of interventions and times).

3. It is not possible to evaluate measures out of routine collection and documentation of timepoints of fetal pelvic entry, rumping, the emergence of the umbilical cord insertion, as well as timing of umbilical cord clamping and time to delivery are routinely not recorded in the birth report.
4. Even recording the birth phase and pressing phase is subject to inaccuracies.
5. As long as these times are only indirectly estimated with unclear methodology, conclusions about the calculated periods are implausible (I do not have access to the specified literature on the calculation of these parameters as indicated, "Maternity Crisis Management Training 2021").
6. Tools, that were developed to estimate timepoints of delivery out of an imprecise or incomplete report have to be validated.
7. Only a study with a prospective design and study protocol can accomplish this task.

Some results are open or questionable:

1. Why are the pH-values in the tested group (=cases with 100% transfer rate ad NICU) higher than in the comparison group (=controls)? Early umbilical cord clamping as an argument is not plausible. Is the transfer to NICU due to reduced APGAR a result of manual intervention?
2. Is a parameter to detect a higher neonatal transfer rate ad NICU with sensitivity of 66% a good parameter to recommend consequences in delivery management? Is the collective of 15 cases perhaps too small?
3. What were the actual reasons for transferring the children to the NICU (immaturity? infection? hypoglycemia? etc.)
4. In how many births could the necessary data not be read out from the documentation, or could it be read incompletely or with uncertainty?
5. Rapid, simple vaginal birth always tends to have a better outcome for the children, while protracted birth leads to a poorer outcome, with and without intervention. What weighs more heavily for the newborn poor outcome from intervention and/or acidosis?

As long as the collection of the data at the calculated times (timeline) is not comprehensible, this study cannot be approved for indexing in this form

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

No

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: fulfilled

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.
