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The addition of fetal scalp blood lactate measurement as an adjunct to cardiotocography to reduce caesarean sections during labour: The Flamingo randomised controlled trial

SHORT RUNNING TITLE

Fetal scalp blood lactate measurement in labour

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ACKNOWLEDGEMENTS

We thank the Clinical Research Midwives (Sue Duggan, Tracey Grainger, Jennifer Saal, Sue Veljanovski, Adrienne White), the Flamingo Study Group, Jo Bruhn, Project Officer, Pregnancy Research Centre, Department of Maternal-Fetal Medicine, Royal Women's Hospital who prepared the database and Mary Anne Biro, Senior Research Assistant, Monash University, who assisted with the analysis.

This study was funded by an Australian National Health and Medical Research Council (NHMRC) project grant (APP1026042). Christine East conducted this project as part of her NHMRC Career Development Fellowship. The NHMRC did not influence the conduct of the trial other than to provide some funding. The trial was registered with the Australian New Zealand Clinical Trials Register (ACTRN12611000172909) prior to commencement.

Conflict of Interest Statement: The authors report no conflicts of interest.

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Article type : Original Article

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Keywords

Fetal monitoring; caesarean; CTG; delivery; midwifery

Manuscript word count: 2497
Abstract word count: 249
Figure count: 1
Table count: 4, plus three Supplementary Tables

ABSTRACT

Background

Fetal scalp blood sampling for lactate measurement (FBSLM) is sometimes used to assist in identification of the need for expedited birth in the presence of an abnormal cardiotocograph (CTG). However, there is no randomised controlled trial evidence to support this.

Aim

To determine whether adding FBSLM reduces the risk of birth by emergency caesarean section in labours complicated by an abnormal CTG, compared with CTG without FBS.

Material and methods

Labouring women at a tertiary maternity hospital in Melbourne, Australia with a singleton, cephalic presentation, at ≥ 37 weeks' gestation with an abnormal CTG pattern were randomised to the intervention (n=61), with intermittent FBSLM in addition to CTG monitoring, or control (CTG without FBS, n=62). The primary outcome was rate of birth by caesarean section. Secondary outcomes included overall operative birth and fetal and neonatal safety endpoints. Trial Registration: ACTRN12611000172909

Results

The smaller than anticipated sample was unable to demonstrate an effect from adding FBSLM to CTG monitoring on birth by caesarean section vs monitoring by CTG without FBS (25/61 and 28/62 respectively, p=0.64, risk ratio (RR) 0.91, 95% confidence intervals (CI) 0.60-1.36). One newborn infant in the CTG group met the criteria for the composite neonatal outcome of death or serious outcome; neonatal encephalopathy, five-minute Apgar score <4, neonatal resuscitation, admission to neonatal intensive care unit for 96 hours or more.

Conclusion

We were unable to provide robust evidence of the effectiveness of FBSLM to improve the specificity of the CTG in the assessment of fetal well-being.

INTRODUCTION

Caesarean section rates vary widely in Organization for Economic Co-operation and Development (OECD) countries, ranging from 15% of live births in Israel to 53% in Turkey in 2017.[1] The low specificity of cardiotocography (CTG) recordings of the fetal heart rate during labour for hypoxia may be contributing to rising caesarean rates.[2] Intrapartum fetal monitoring is recommended in a wide variety of circumstances, ranging from concerns arising during the pregnancy, to those that may be considered to identify the at-risk fetus as labour progresses: for example, fetal growth restriction, induction of labour, epidural analgesia, to name just a few.[3-6] The presence of one or more features of an abnormal CTG may lead to urgently expedited birth in some situations and not others.[3-6]

Various tests have attempted to improve intrapartum evaluation of fetal welfare and in cases of an abnormal CTG, to distinguish between those at risk of hypoxia from those that can safely continue through labour without unnecessary interventions.[7-9]

In the 1960s, Saling proposed the use of fetal scalp blood sampling (FBS) to test for pH as an independent measure of fetal wellbeing.[10] This test was subsequently considered as a potential adjunct to improve the low specificity of CTG monitoring.[2] The effect of FBS on caesarean section rates is assessed by only one published randomized trial from Colorado USA in 1979, that compared the use of continuous CTG monitoring with CTG plus FBS (pH) in high-risk pregnancies labouring from 34 weeks' gestation.[7] This study reported a trend toward fewer caesarean sections in the CTG plus FBS group (11.3%) than in the CTG group (17.6%: risk ratio 0.75, 95% confidence intervals 0.55-1.03, P=0.05).[7] This finding is of uncertain relevance currently, given that the caesarean section rate in the United States increased from 16.5% in 1980[11] to 32% in 2018.[12] Similar trends in caesarean section occurred in other countries such as Australia, with the rate of 11% in 1980[13] increasing to 35% in 2018.[14]

The lack of high-level evidence to guide practice has resulted in clinical uncertainty, with some guidelines in use both during the conduct of the trial reported herein and since, suggesting that the use of FBS be considered,[4, 5] while other clinicians suggest that FBS should not be undertaken unless or until high quality RCTs generate supportive evidence.[15]

There has been a shift away from using pH testing to lactate measurement over recent decades, augmented by the availability of rapid, accurate point-of-care analysers requiring a very small fetal blood sample.[16] The Cochrane systematic review found that both pH and lactate were comparable in terms of mode of birth and neonatal outcomes, with obtaining a successful sample more likely for lactate than for pH.[17] There were no published RCTs comparing outcomes when fetal blood sampling for lactate measurement (FBSLM) was or was not performed.[17]

This report describes the clinical outcomes from the world's first randomized controlled trial (RCT), the Flamingo Trial (Fetal LActate: MeasurING Outcomes) comparing the use of FBSLM with no FBS, in the presence of abnormal CTG patterns.[18]

MATERIALS AND METHODS

This trial was registered with the Australian New Zealand Clinical Trials Register (ACTRN12611000172909) prior to commencement and is reported following the CONSORT guidelines.[19] The methods for the Flamingo parallel group, prospective, unblinded randomized controlled trial are described in detail in the published protocol.[18] An Australian audit had previously determined that 38% of women in labour who have an abnormal CTG proceeded to giving birth by caesarean section.[20]

The primary aim was to determine whether adding FBSLM reduced emergency caesarean section births, compared with monitoring by CTG without FBS, in labours with an abnormal CTG. We hypothesised that FBSLM would reduce this from 38% to 25%, in a proposed sample size of 600 (alpha 0.049, power 90%).[18] Secondary outcomes included maternal and fetal/neonatal endpoints as described in the protocol.[18] We considered a composite fetal/neonatal endpoint of death or serious outcome for the infant, including one or more of fetal death after trial entry, death of a liveborn infant prior to hospital discharge, neonatal encephalopathy (stages II/III), Apgar score <four at five-minutes, care in neonatal intensive care unit >96 hours.[21, 22]

Participants

Women labouring at term (≥37 weeks) at a tertiary maternity hospital in Melbourne, Australia were eligible to participate if they met all the inclusion criteria and none of the exclusion criteria, with specified fetal heart rate patterns (Supplementary Table A).[18]

Ethical approval was granted by the Royal Women's Hospital Human Research Ethics Committee (HREC Project 11/56), initially for opt-in consent, with women approached during pregnancy or early labour and written, informed consent confirmed once a qualifying CTG pattern developed during labour. A sequentially numbered, sealed, opaque envelope was opened to reveal allocation to either the addition of FBSLM to CTG monitoring or CTG without FBS (ratio 1:1). The gap between requested and awarded research funding meant that fewer research personnel were available and recruitment was slower than expected, even when clinicians who were not directly involved in a woman's care were also encouraged to assist with recruitment. The Australian national ethics guide introduced specific circumstances for the use of opt-out consent in 2014.[23] The ethics committee approved this approach for the Flamingo trial. From September 2014, women were provided with at least

two sets of information about the study and opt-out procedures during their pregnancy and were able to indicate their plan to opt-out if a qualifying CTG pattern developed during labour. Standardised processes ensured clear communication of an opt-out decision when the women entered labour. Women not opting out also had to meet all the original inclusion and none of the exclusion criteria.[18]

Blinding

The nature of this study meant that the women and their clinicians were unblinded. The accompanying risks of bias were minimised by having routinely recorded clinical outcome measures as the primary and secondary endpoints (e.g. caesarean section, neonatal outcomes). A researcher not involved in recruitment or data collection conducted the unblinded data analysis.

RESULTS

Participant flow

In total, 123 of the proposed 600 women were enrolled into the Flamingo trial during the planned and (partially) funded recruitment phase of the study, between March 2012 and July 2015: 61 to the intervention group (FBSLM + CTG) and 62 to the control group (CTG without FBS) (Figure 1). Data on maternal characteristics were available for all those enrolled with few exceptions, for example, maternal BMI missing for four women: demographics and characteristics were similar for the two groups (Table 1). Outcome data were available for all participants. The CTG patterns that qualified entry into the study were similar for each group (Table 1). Similar proportions of participants demonstrated abnormal fetal heart rate patterns after randomisation and had interventions including changes in oxytocin infusion administration or maternal position changes (Table 2). Fetal scalp blood sampling was attempted for 31 of the 61 women allocated to this group with 24 (77%) of these returning a lactate value of <4.0 mmol/L and only five (16%) with an abnormal lactate of >4.8 mmol/L (Table 2). Subsequent FBSLM was undertaken for seven participants, with two returning lactate values >4.8 mmol/L (Table 2). There was no evidence of a difference in time from randomisation to birth according to whether FBSLM was undertaken or not for those assigned to the FBSLM group (p= 0.63, Supplementary Table B). No control group participants underwent FBSLM.

Primary endpoint

The caesarean section rates (for all indications) were similar for the two groups: CTG+FBSLM 25/61 (41%), compared with 28/62 (45%) in the CTG without FBS group, risk ratio (RR) 0.91, 95% confidence intervals (CI) 0.60-1.36, P=0.64 (Table 3).

Secondary endpoints

Maternal endpoints

There was no evidence of between-group differences in rates of overall operative birth (forceps+vacuum+caesarean section, RR 0.96, 95%CI 0.80-1.14), assisted vaginal birth (RR 1.02, 95%CI 0.64-1.61) or normal vaginal birth (RR 1.20, 95%CI 0.58-2.47, Table 3). The median number of minutes from randomisation to birth was 131 (95%CI 100-162) in the FBSLM group, compared with 103 (95% CI 55-151) in the CTG group (p=0.93, Kaplan Meier log rank (Mantel Cox)).

Fetal/neonatal endpoints

One infant in the CTG without FBS group was admitted to the neonatal intensive care unit (NICU) for 96.8 hours and thus met the pre-defined criteria for the composite fetal/neonatal endpoint (Apgar scores eight and nine at one- and five-minutes respectively, forceps for non-reassuring fetal status 3.5 hours after trial entry). He displayed signs of respiratory distress syndrome five hours after birth and received continuous positive airway pressure respiratory support for 48 hours and treatment for presumed sepsis. No infant in the CTG+FBSLM group met the fetal/neonatal endpoint criteria.

Other causes of neonatal morbidity were similar between the groups (Table 4) except for five-minute Apgar scores less than seven. All five babies with this result were from the CTG+FBSLM group. There was no clear explanation of this outcome: the length of time from randomisation to birth was variable; FBSLM was not undertaken in one; none of the babies required admission to the NICU; and all had a normal neonatal course (Supplementary Table C). Of note, there was no evidence of a difference in five-minute Apgar scores less than four between the FBSLM group compared with the control group (RR 1.69, 95%CI 0.42-6.7).

More babies were at the extremes of birthweight percentiles[24] in the CTG+FBSLM group than the CTG without FBS group. Exploratory sensitivity analysis found no evidence that adjustment for birthweight centiles influenced the caesarean section rate comparison between groups (data not presented here).

Length of neonatal hospital stay was similar for the two groups with a median of 69 hours for those in the FBSLM group and 62 hours in the CTG without FBS group (p=0.52, Table 4). No babies had FBS-related infections. One baby on whom FBSLM had been performed was found to have a "dry scaly rash on [the] left scalp resembling plaque" postnatally, which was later diagnosed by a dermatologist as a congenital sebaceous naevus[25]: it was therefore not considered to be related to the blood sampling.

Women's perceptions of their labour, fetal monitoring and research participation will be published separately. Resource limitations did not allow for the planned economic analysis.[18]

DISCUSSION

The relatively small sample meant that we were unable to generate robust evidence about the potential for the addition of fetal blood sampling for lactate measurement in the setting of concern about fetal welfare in labour to reduce the rates of emergency caesarean section. Indeed, the rate of emergency caesarean section in both groups exceeded the estimated baseline rate of 38% and the rate of 39% in the 192 women audited over three months during the trial period[26], most likely reflecting both the small sample size and progressively increasing rates across Australia.[14] An adequately powered trial would require ~4800 participants to detect the difference in caesarean section rate of 4% seen in our RCT.

The Flamingo trial used a similar composite neonatal outcome to other perinatal trials.[21, 22] This low-prevalence outcome occurred for one baby in the CTG without FBS group, who spent four days in the NICU. The lack of consistent patterns noted for babies with low five-minute Apgar scores and low prevalence for the other pre-specified poor neonatal outcomes reassure that neither performing nor not performing FBSLM caused harm in this small sample. These findings and the lack of differences in the time from randomisation to birth in the two groups (including whether or not FBSLM was undertaken within that group) are important when considered in the context of the time between the development of a CTG pattern that, while concerning, does not immediately trigger an expedited birth, or that further testing could delay appropriate intervention.[27] Neonatal sepsis may have been over-represented, with five of the 123 babies having positive blood cultures, compared with the published rate of 1% sepsis in term gestation admissions to Australian and New Zealand

neonatal nurseries.[28] The incidence of five-minute Apgar scores <seven and of neonatal sepsis may be further explored in adequately powered studies.

Equipoise is important in justifying clinical randomised controlled trials.[29] There were periods of lower- and higher recruitment rates to the Flamingo trial and of compliance with undertaking FBSLM when randomised to that group, despite engagement with clinical leaders. In this setting (and during the conduct of the Flamingo trial) clinical guidelines suggest but do not mandate FBSLM.[5] A three-month audit conducted during the trial identified 20% of the 192 women in labour who could have undergone FBSLM by clinical guidelines were offered this test and Flamingo trial participation was considered for six women, thus supporting the apparent equipoise surrounding FBSLM.[26] In both the audit and the Flamingo study, there were frequent occasions of the abnormal CTG reversing later to demonstrate features of a normally oxygenated fetus. It is possible that both the return to "normal" CTG and other less overt complexities influenced clinicians' decisions not to proceed with fetal scalp blood sampling.

Opt-out consenting processes attempted to improve recruitment. This concept is not new for using routinely collected health data and is generally viewed favourably by consumers.[30] Opt-out consenting processes were initiated within the Flamingo trial shortly after the national ethical guidelines were updated.[23] Approximately 30% of women provided with Flamingo material during pregnancy advised their wish to opt-out prior to labour. Around one-fifth of the final sample was recruited in this manner over three months: however, participation in the Flamingo trial once in labour declined in the final few months of the planned recruitment period.

Strengths and limitations

This report outlines the only RCT-evidence of the addition of FBSLM aiming to influence the specificity of the intrapartum CTG. The clinical outcomes, including caesarean section and neonatal course were abstracted from routinely collected data, thus reducing the likelihood of the unblinded nature of the intervention influencing the data analysis. Women giving birth in the publicly funded tertiary-level maternity service represent a diverse mix of cultural, linguistic, social and health characteristics. Maternal age and primiparity in the audit were similar to those enrolled in the RCT.[26] As such, the demographic may reflect the diversity of healthy women and those with comorbidities and complicated pregnancies in Australia.[14]

Recruitment was challenging, with only 20% of the sample required enrolled. The amount of funding awarded was insufficient to support the presence of research staff on the birth suite. A novel approach to recruitment using the opt-out approach provided evidence of some success, albeit limited, which may encourage others to explore this option. The fluctuations in enrolment rates throughout the conduct of the Flamingo trial may reflect variable clinical equipoise over time regarding an intervention for which there exists no high-level evidence. This may prompt clinicians' reflections on their conscious or unconscious biases that can influence clinical care and research.

The Flamingo randomised controlled trial was underpowered to provide evidence of any effect on caesarean section rates from the addition of FBSLM to CTG monitoring. The trial demonstrated that opt-out consent can be considered for future RCTs of the intervention which should be sufficiently powered to evaluate the utility of FBSLM. The search for an accurate test to augment the sensitivity of the CTG remains elusive.

Table 1: Participants' demographics and characteristics

	CTG plus lactate (n = 61)	CTG without FBS (n = 62)
Maternal age (years)	32.2 (5.2)	30.4 (5.0)
BMI (kg/m^2) n (%)[†]		
- Underweight (<19)	4 (7%)	3 (5%)
- Normal (19 – 24.9)	20 (34%)	22 (37%)
- Overweight (25 - 29.9)	20 (34%)	23 (38%)
- Obese (>30)	20 (34%)	12 (20%)
Gestation (weeks)	39.8 (1.3)	39.7 (1.2)
Nulliparous	53 (87%)	54 (87%)
Cervical dilatation on admission to Birth Centre (cm)	n=43	n=43
	2 (1-3)	2 (1-3)
Station on admission VE (cm)	n=43	n=43
	-2 (-3 to -2)	-2 (-3 to -2)
Previous operative birth	1 (2%) Vacuum	1 (2%) C/S
Maternal antepartum risk factors ≥ 1[‡]	13 (22%)	14 (23%)
Maternal intrapartum risk factors ≥ 1[§]	48 (79%)	41 (66%)
Fetal risk factors ≥ 1[¶]	20 (33%)	13 (21%)
Induction of labour	47 (77%)	47 (76%)

Prostaglandin	25 (41%)	29 (47%)
Oxytocin infusion	57 (93%)	58 (94%)
Artificial rupture of membranes	39 (64%)	40 (65%)
Meconium stained amniotic fluid	19 (31%)	17 (27%)
Epidural analgesia	50 (82%)	50 (81%)
Abnormal fetal heart rate patterns at randomisation		
Baseline FHR between 100-109 or 161-170	4 (7%)	4 (7%)
Baseline FHR <100 beats per minute (bpm) or >170 bpm	1 (2%)	1 (2%)
Variability absent (<3 bpm for 40 mins)	4 (7%)	2 (3%)
Baseline FHR variability 3-5 bpm for 40 mins	9 (15%)	8 (13%)
Complicated variable decelerations	46 (75%)	50 (81%)
Prolonged deceleration (>90s and <5 min)	16 (26%)	18 (29%)
Late decelerations	7 (12%)	7 (11%)
Sex		
- Male	38 (62%)	39 (63%)
- -Female	23 (38%)	23 (37%)
Birthweight (g)	3426 (525)	3437 (345)
Birthweight > 4000g	11 (18%)	2 (3%)
Birthweight centiles[24]		
- <3rd	5 (8%)	0

- 3rd to <10th	5 (8%)	0
- 10th to <25th	11 (18%)	7 (11%)
- 25th to <90th	33 (54%)	46 (74%)
- ≥90th	7 (12%)	1 (2%)

Data are number (percent), mean (standard deviation) or median (interquartile range)

Abbreviations: bpm beats per minute; BMI body mass index; cm centimetres; CTG cardiotocograph; FBS fetal blood sample; FHR fetal heart rate; IQR interquartile range; g grams; kg kilograms; m metres; min minutes; s seconds; VE vaginal examination

† BMI was not available for two women in each group

‡One or more of: essential hypertension, pregnancy-induced hypertension, pre-eclampsia, eclampsia, pre-pregnancy diabetes, gestational pregnancy, no prenatal care, maternal cardiac disease, maternal renal disease.

§One or more of: maternal pyrexia, ruptured amniotic membranes>18 hours, Group B streptococcus positive, meconium-stained amniotic fluid, intrapartum bleed, haematuria, other risk factors.

¶One or more of: birthweight <10th centile[24], polyhydramnios, oligohydramnios, >=42 weeks' gestation, <37 weeks' gestation, maternal substance use (alcohol, drugs, smoking).

Table 2: Post-randomisation fetal heart rate patterns, labour interventions and fetal evaluations

	CTG plus lactate (n =61)	**CTG without FBS (n =62)**	**p-value†**	**Relative risk 95% CI**
Abnormal fetal heart rate patterns AFTER randomisation				
Baseline FHR between 100-109 or 161-171	16 (26%)	11 (18%)	0.26	

Baseline FHR <100 beats per minute (bpm) or >170 bpm	7 (12%)	3 (5%)	0.21	
Variability absent or <3 bpm for 40 mins	1 (2%)	3 (5%)	0.62	
Baseline FHR variability 3-5 bpm for 40 mins	18 (30%)	17 (28%)	0.84	
Variable decelerations	27 (44%)	28 (45%)	0.92	
Complicated variable decelerations	52 (85%)	54 (87%)	0.77	
Prolonged deceleration (>90s and <5 min)	24 (39%)	26 (42%)	0.77	
Late decelerations	12 (20%)	12 (19%)	0.97	
Sinusoidal	0	0		
Change in oxytocin administration response to abnormal CTG	26 (43%)	31 (50%)	0.41	0.85 (0.58 - 1.25)
Tocolytic administration in response to abnormal CTG	3 (5%)	5 (8%)	0.48	0.61 (0.15 - 2.4)
Maternal position adjustment in response to abnormal CTG	37 (61%)	40 (65%)	0.66	0.94 (0.72 - 1.24)
Intravenous hydration in response to abnormal CTG	9 (15%)	16 (26%)	0.13	0.57 (0.27 - 1.19)
Correction of hypotension	2 (3%)	3 (5%)	1.00	0.68 (0.12 - 3.91)
Vaginal examination in response to abnormal CTG	53 (87%)	46 (74%)	0.08	1.17 (0.98 - 1.40)
Scalp lactate (mmol) (Sample 1) (n=30)				
- < 4.0	24 (80%)			

- 4.0 – 4.8	2 (7%)
- > 4.8	4 (13%)
Scalp lactate (mmol) (Sample 2) (n = 8)	
- < 4.0	4 (50%)
- 4.0 – 4.8	1 (13%)
- > 4.8	3 (38%)
Scalp lactate (mmol) (Sample 3) (n = 4)	
- < 4.0	4 (100%)

Data are number (percent)

Abbreviations: bpm beats per minute; CTG cardiotocograph; FBS fetal blood sample; FHR fetal heart rate; min minutes; s seconds

†Chi-squared / Fisher's exact

Table 3: Maternal outcomes	**CTG plus lactate (n =61)**	**CTG without FBS (n =62)**	**p-value†**	**RR (95% CI)**
Caesarean section	**25 (41%)**	**28 (45%)**	0.64	0.91 (0.60 - 1.36)
- For NRFS	8 (13%)	16 (26%)	0.08	0.51 (0.23 - 1.10)
- For dystocia/FTP	0	1 (2%)	1.0	Unable to calculate
- Combined NRFS & FTP	7 (11%)	7 (11%)	0.97	1.02 (0.38 - 2.73)
- NRFS and/or FTP and other‡	10 (16%)	4 (7%)	0.07	2.54 (0.84 - 7.77)

Operative delivery (vacuum/forceps/ caesarean section)	**48 (79%)**	**51 (82%)**	0.62	0.96 (0.80 - 1.14)
- For non-reassuring fetal status (NRFS)	25 (41%)	34 (55%)	0.12	0.75 (0.52 - 1.09)
- For dystocia/failure to progress (FTP)	0	1 (2%)	1.0	Unable to calculate
- Combined NRFS & FTP	10 (16%)	9 (15%)	0.77	1.13 (0.49 - 2.59)
- NRFS and/or FTP and other‡	13 (21%)	7 (11%)	0.13	1.89 (0.81 - 4.41)
Normal vaginal birth	**13 (21%)**	**11 (18%)**	0.62	1.20 (0.58 - 2.47)
Assisted vaginal birth (vacuum/forceps)	**23 (38%)**	**23 (37%)**	0.94	1.02 (0.64 - 1.61)
- For NRFS	17 (28%)	18 (29%)	0.89	0.67 (0.54 - 1.68)
- For dystocia/FTP	0	0		
- Combined NRFS & FTP	3 (5%)	2 (3%)	0.68	1.52 (0.26 - 8.1)
- NRFS and/or FTP and other‡	3 (5%)	3 (5%)	1.0	1.02 (0.21 - 4.84)
Length of time from randomisation to birth (minutes)	131 (100 – 162)	103 (55 – 151)	0.93	
Maternal length of hospital stay after birth (hours)	67 (50.6 – 83.4)	63 (48.5 – 77.5)	0.85	

Data are number (percent) or median (95% confidence intervals)

Abbreviations: CTG cardiotocograph; FBS fetal blood sample; FTP failure to progress; NRFS nonreassuring fetal status

† Categorical data - Chi-squared / Fisher's exact test; length of time data Kaplan Meier log rank (Mantel Cox)

‡ Includes non-reassuring fetal status AND/ OR dystocia/failure to progress AND any other indication for operative birth (suspected fetal growth restriction; failed induction; failed vacuum; hypertension; malpresentation; other)

Table 4: Fetal/neonatal outcomes

	CTG plus lactate (n =61)	**CTG without FBS (n=62)**	**p-value†**	**RR (95% CI)**
-			0.94	--
1-min Apgar <4	5 (8%)	3 (5%)	0.49	1.69 (0.42 - 6.78)
5-min Apgar <7	5 (8%)	0	0.03	Unable to calculate
Umbilical arterial lactate (mmol/L)	n=5	n=9		--
	4.6 (1.5)	4.8 (3.2)	0.9	
Umbilical venous lactate (mmol/L)	n=7	n=10		--
	4.3 (1.2)	4.4 (1.8)	0.96	
Umbilical arterial pH	n=49	n=51		
<7.15	11 (22%)	6 (12%)	0.19	1.91 (0.76 - 4.76)
<7.00	1 (2%)	0	0.49	Unable to calculate
Umbilical venous pH	n=53	n=56		
<7.15	0	2 (4%)	0.17	Unable to calculate
<7.00	1 (2%)	0	0.49	
Umbilical arterial base excess	n=48	n=51		

< -10	39 (81%)	47 (92%)	0.11	0.88 (0.75 - 1.03)
< -16	9 (19%)	4 (8%)	0.14	2.39 (0.79 - 7.25)
Umbilical venous base excess	n=52	n=56		
< -10	45 (87%)	53 (95%)	0.15	0.91 (0.81 - 1.04)
< -16	7 (14%)	3 (5%)	0.19	2.51 (0.69 - 9.21)
Bag and mask IPPV	11 (18%)	8 (13%)	0.43	1.40 (0.60 - 3.24)
Admission to NICU	0	2 (3%)	0.50	Unable to calculate
Admission to SCN	5 (8%)	2 (3%)	0.27	2.54 (0.51 - 12.60)
Neonatal encephalopathy (Stage II/III)	0	0		
Neonatal sepsis (blood culture positive)	3 (5%)	2 (3%)	0.68	1.52 (0.26 - 8.81)
Neonatal birth trauma[§]	1 (2%)	1 (2%)	1.0	1.02 (0.07 - 15.89)
Neonatal death	0	0		--
Intrapartum stillbirth	0	0		--
Composite fetal/neonatal endpoint[¶]	0	1 (2%)[††]	1.0	Unable to calculate
Length of hospitalisation (, hours)	69 (57.5 – 80.5)	62 (49.5 – 74.5)	0.52	

Data are number (percent), mean (SD) or median (95% confidence intervals)

Abbreviations; CTG cardiotocograph; FBS fetal blood sample, IPPV, intermittent positive pressure ventilation; IQR interquartile range; L litre; mmol millimols; NICU, Neonatal Intensive Care Unit; SCN, Special Care Nursery; SD standard deviaion

†Categorical data - Chi squared or Fisher's exact test; continuous data – unpaired t-test; length of time data - Kaplan Meier log rank (Mantel Cox)

[§]Cephalhaematoma (CTG + lactate); Left-sided bruising to face from forceps (CTG group)

¶Endpoint includes fetal death after entry to the trial, death of liveborn infant prior to hospital discharge, neonatal encephalopathy (stages II-III), care in neonatal intensive care unit > 96 hours

††NICU admission 96.8 hours (Forceps 3.5 hours after randomisation for non-reassuring fetal status; 1-min Apgar = 8; 5-min Apgar = 9; umbilical arterial pH 7.22; umbilical venous pH 7.3; developed respiratory distress at 5 hours of age; treated for sepsis)

‡‡

Figure legend

Figure 1: Flamingo Trial CONSORT Flow Diagram

Footnote to figure: There were insufficient resources to collect data about eligibility for all women giving birth during the study period

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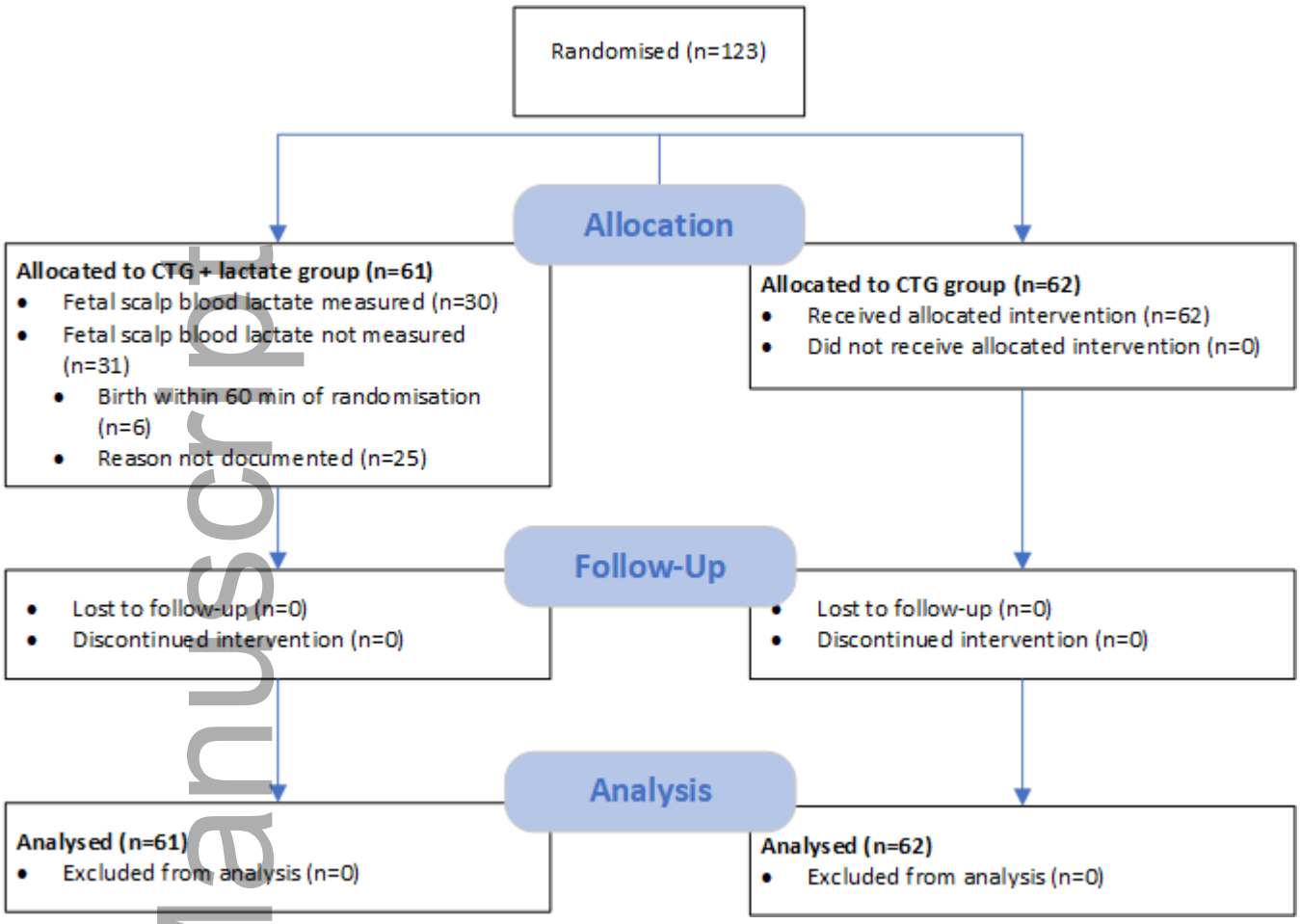

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Title:
The addition of fetal scalp blood lactate measurement as an adjunct to cardiotocography to reduce caesarean sections during labour: The Flamingo randomised controlled trial

Date:
2021-03-23

Citation:
East, C. E., Davey, M. -A., Kamlin, C. O. F., Davis, P. G., Sheehan, P. M., Kane, S. C. & Brennecke, S. P. (2021). The addition of fetal scalp blood lactate measurement as an adjunct to cardiotocography to reduce caesarean sections during labour: The Flamingo randomised controlled trial. AUSTRALIAN & NEW ZEALAND JOURNAL OF OBSTETRICS & GYNAECOLOGY, 61 (5), pp.684-692. https://doi.org/10.1111/ajo.13327.