## Abstract

### Background

The physiology of placental transfusion for preterm births is poorly understood. Optimal timing of umbilical cord clamping at preterm birth is uncertain. This study aimed to assess the volume and duration of placental transfusion at preterm birth.

### Methods

Women likely to have a healthy livebirth between 32 and 36 completed weeks gestation at three maternity units in England were eligible for recruitment. At birth, babies placed on high quality pharmacy scales (Mettler-Toledo) with the umbilical cord intact. The scales calculated an average weight twice every second, and were on a trolley beside the women. To ensure the baby was no higher than the level of the woman's abdomen, the bed or operating table was raised or lowered as necessary. The baby was monitored using temperature and saturation probes. Staff training was with term births.

### Results

Six infants (range $34^{+4}$ to $36^{+5}$ weeks) were weighed; three were vaginal births and three caesarean. Cord clamping was between two minutes and three minutes 57 seconds. For two babies, weight was not well recorded in the first minute while they were dried and probes applied. Therefore, an initial 10 seconds 'hands-off' period was adopted to obtain the baseline weight. Weight change appeared to range from a 20g decrease to a 128g increase. Placental flow appeared to continue for at least two minutes for all six babies.

### Conclusions

This study is small, nevertheless, there appears to be variation in the volume and duration of placental transfusion, and for some, net flow is to the placenta rather than the baby. For preterm births, placental transfusion may continue for longer than at term births.

**Background**

At birth, if the umbilical cord is not clamped blood flow between the baby and placenta may continue for several minutes.[1-4] This umbilical flow is part of the physiological transition from the fetal to the neonatal circulation, and for very preterm infants deferring cord clamping may improve resilience during this transition.[5-7] 'Placental transfusion' refers to the net transfer of blood to the baby between birth and cord clamping.

Cord clamping before umbilical flow ceases may restrict neonatal blood volume and red cell mass, and/or interrupt transition from the fetal to neonatal circulation. For term births, umbilical flow usually continues for two minutes, but may continue for over five minutes.[2,4] The mean volume of placental tranfusion at term is 100 ml, which is 29 ml/kg birthweight and 36% of neonatal blood volume at birth.[4] For preterm births, umbilical flow may continue for longer than for term births[8] and is incomplete if the cord is clamped in 30-90 seconds.[9] This corresponds with development during gestation, as at term two-thirds of the feto-placental circulation is in the infant, whilst below 30 weeks a greater proportion is in the placenta.[1] Also, preterm, the umbilical vein is smaller than at term, uterine contraction less efficient, and the transition from fetal the neonatal circulation may be slower.

To improve understanding of the physiology of placental transfusion and assess when might be the optimal time to clamp the cord for preterm births, we measured umbilical flow at preterm birth.

**Methods**

Women likely to have a healthy singleton livebirth between 32 and 36 completed weeks gestation at Nottingham City Hospital, Queen's Medical Centre (Nottingham) or Bradford Royal Infirmary were eligible for inclusion. Information about the study was given to women considered at risk of preterm birth. Eligible women were invited to participate either before labour, during the first stage of labour, or during preparation for caesarean section. Women who provided written consent were included. They were free to withdraw from the study at any time.

Staff training was with women having a term birth. Ethics approval required independent review of data from five term births before progressing to recruitment of women having a preterm birth. Following this review, the data monitoring committee agreed that women over

32 weeks gestation could be recruited. Recruitment from 28 weeks was planned, but not reached.

***Procedure for weighing***

Babies were weighed using digital scales (Mettler Toledo excellence XS precision balance Model: XS8001L, Im Langacher, CH-8606 Greifensee, Switzerland), which calculate an average weight twice every second, with data stored in a linked computer. Before the birth, the scales were zeroed to allow for the weight of any probes being used, a plastic tray and two towels (used to wrap the baby during weighing).

At birth, babies were placed on the scales with the cord intact. The attending clinician and parents were asked not to touch the baby, the cord, or the scales until weighing was complete. If anything was touched or knocked, this was recorded. The scale pan for vaginal births was level with either the bed or the woman's abdomen, and for caesarean births it was level with either the bed or the woman's thighs. Once delivered, the placenta was placed in a funnel to drain any residual placental blood. All other aspects of care were at the discretion of the attending clinician. The cord was clamped early if requested by the woman or a clinician.

In accordance with the recommendation of the ethics committee, temperature and oxygen saturation probes were used to assess temperature and heart rate respectively. For the first two preterm births, weight was not well recorded in the first minute while they were dried and probes applied. Therefore the temperature probe was no longer used, and the saturation probe applied after a 'hands-off' period of 10 seconds to establish the baseline weight.

***Data collection***

Parity and gestation at birth were recorded. For vaginal births, data were collected on whether labour was induced or augmented, the use of analgesia, the mode of delivery and maternal position during the second and third stage. For caesarean births, data were collected on the indication for caesarean section and the type of anaesthesia. For all women, timing of the uterotonic drug, time of cord clamping, maternal blood loss during the third stage, length of the third stage and use of controlled cord traction were recorded. For the baby, information was collected on the time of birth (delivery of buttocks for cephalic births, and head for breech births), temperature after cord clamping, need for resuscitation at birth and whether

admitted to the neonatal unit. In addition, a log was kept for each weighing, which included events such as the scales being knocked or the cord touched. All data were anonymous.

***Statistical analysis***

Characteristics of the women and events during labour were described for women who had a vaginal birth and those who had a caesarean birth. The scales were activated to record weight as the baby was born, providing the data for each child's weight against time. Although the use of statistical methods to determine the best approximation to the weight gain was intended, visual examination and estimation of weight gain was required due to artefacts in the data. Two authors (JD, SO) independently assessed the weight change by inspecting the graphs, with information on the timing of clamping and when the baby was being handled. Differences were resolved by discussion. Due to the small sample, only descriptive statistics were used. Volume of placental transfusion was calculated based on 1 ml of blood weighs weighing 1.05 g.

**Results**

From July 2012 to February 2013, 97 potentially eligible women were approached, 33 of whom gave consent. Of these six were included, with gestation from $34^{+4}$ to $36^{+5}$ weeks (Table 1). For the 27 women with consent for whom the baby was not weighed, reasons were: pregnancy progressed beyond 36 weeks (n=10); research staff not available at time of birth as out of working hours (n = 6); birth too rapid for equipment to be set up (n=5); cord too short (n =2); woman withdrew consent (n=2); hardware problem (n = 1; and clinician felt not clinically appropriate (n =1).

**Table 1:** Characteristics of the women and events during labour and birth

| | | n=6 |
|---|---|---|
| Primigravid | | 3 |
| Gestation at birth (weeks) | $36^{+0} – 36^{+7}$ | 3 |
| | $35^{+0} – 35^{+7}$ | 2 |
| | $34^{+0} – 34^{+6}$ | 1 |
| Induction of labour | | 2 |
| Mode of birth | | |
| vaginal | | 3 |
| | Caesarean | 3 |
| *Third stage of labour* | oxytocin before cord clamping | 5 |
| | oxytocin after cord clamping | 1 |
| Estimated blood loss (ml) (median, range) | | 330 (200, 600) |
| Manual removal of placenta | | - |
| Residual placental volume (ml) (median, range) | | 11 (0, 40) |
| *Baby at birth* | | |
| Temperature after cord clamping ($^0$C) (mean, SD) | | 36.3 (0.46) |
| Resuscitation after clamping | | 2 |
| | tactile stimulation | 1 |
| | facial oxygen | 1 |
| Admitted to special care baby unit | | 2 |

Of the six births included, three were vaginal and three caesarean (Table 1). Two of the caesarean births were during labour. All births were cephalic presentation. Time from birth to the baby being on the scales was within three seconds for the caesarean births, but up to 37 seconds for the vaginal births. The estimated weight change ranged from a 20 gm decrease to a 128 gm increase. This equates to between a 19 ml decrease and a 122 ml increase.

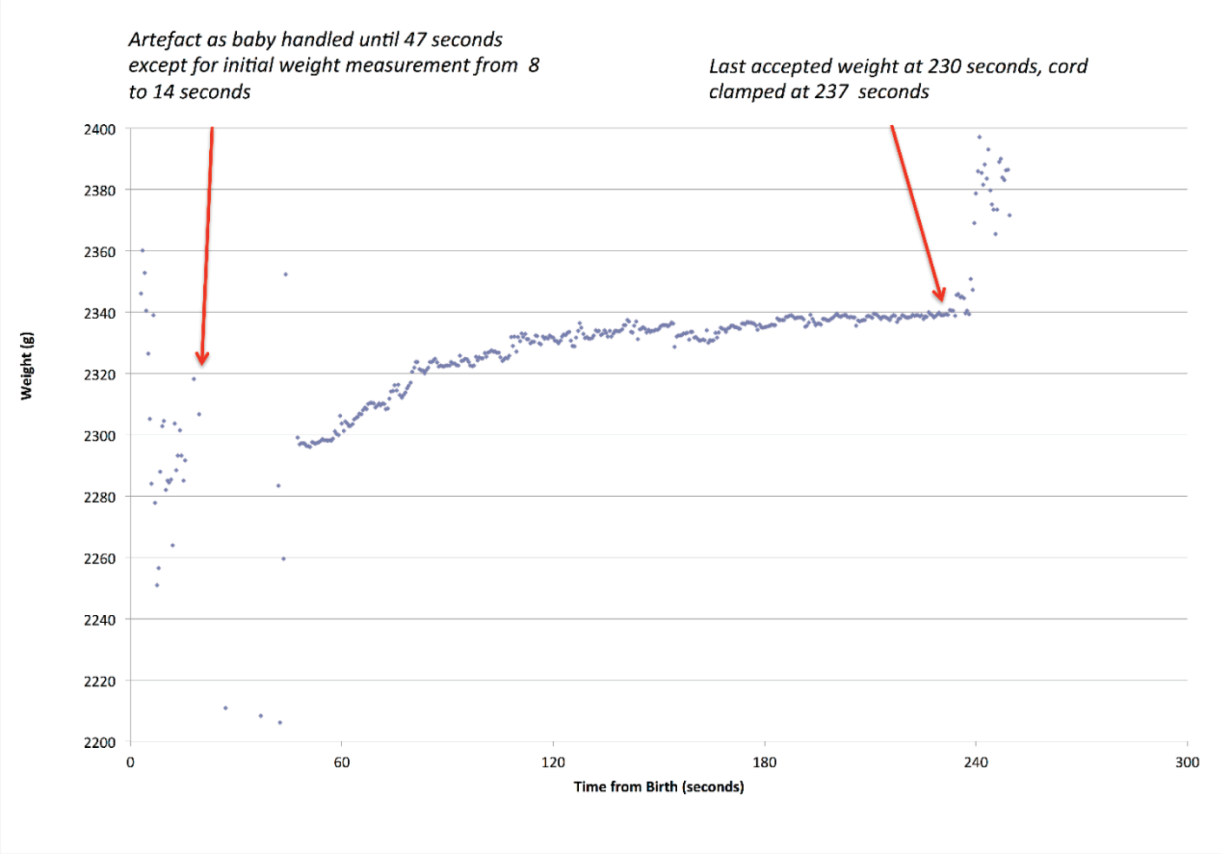
An example of weight change over time for one baby born at 35 weeks gestation is shown in Figure 1. For the remaining five babies, graphs are provided in the Supplementary material.

The time at which net placental flow appeared to cease was at or after two minutes for all six babies (see figure 1, and Supplementary material). For one baby the cord was clamped at two minutes but placental transfusion appeared to be continuing, for another weight change was static between two and three minutes, and for four babies umbilical flow appeared to continue for at least three minutes. For two babies net flow during the last minute before clamping appeared to be from the infant into the placenta.

**Discussion**

To assess the volume and duration of placental transfusion at preterm birth we weighed six premature infants before clamping the umbilical cord. Due to difficulties with recruitment and having research staff available out of hours we were only able to obtain data for a small number of births. Nevertheless, these data suggest that for preterm births placental transfusion may continue for longer than for term births. For five out of six babies weight change appeared to continue beyond two minutes, and for four beyond three minutes. The volume of transfusion was difficult to estimate. Handling the baby at birth to attach oxygen saturation and temperature probes led to considerable artefact in the weighing data.

**Figure 1:** Caesarean section at $35^{+6}$ weeks gestation. Weight gain estimated at 51 grams.




Although we improved on our speed of doing this, and started weighing the baby for 10 seconds before siting probes to obtain a better baseline weight, weight change was difficult to judge As placental transfusion may have a role in stabilising the cardiorespiratory circulation during transition from the fetal to neonatal circulation, the duration of time the cord is left unclamped may be as, or possibly more, important than the volume of any net flow.[5,7]

Despite the limitations of this study, these data helped inform the design of a pilot randomised trial of immediate versus deferred cord clamping at very preterm birth.[10] This trial compared clamping within 20 seconds with clamping after at least two minutes.[11] Other future trials evaluating deferred cord clamping at preterm birth should consider an intervention of two minutes or more, and if necessary providing neonatal care with the cord intact.

## References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## Supplementary Material

**Figure A1**: Caesarean section in labour, $35^{+6}$ weeks. Weight gain estimated at 14 grams.

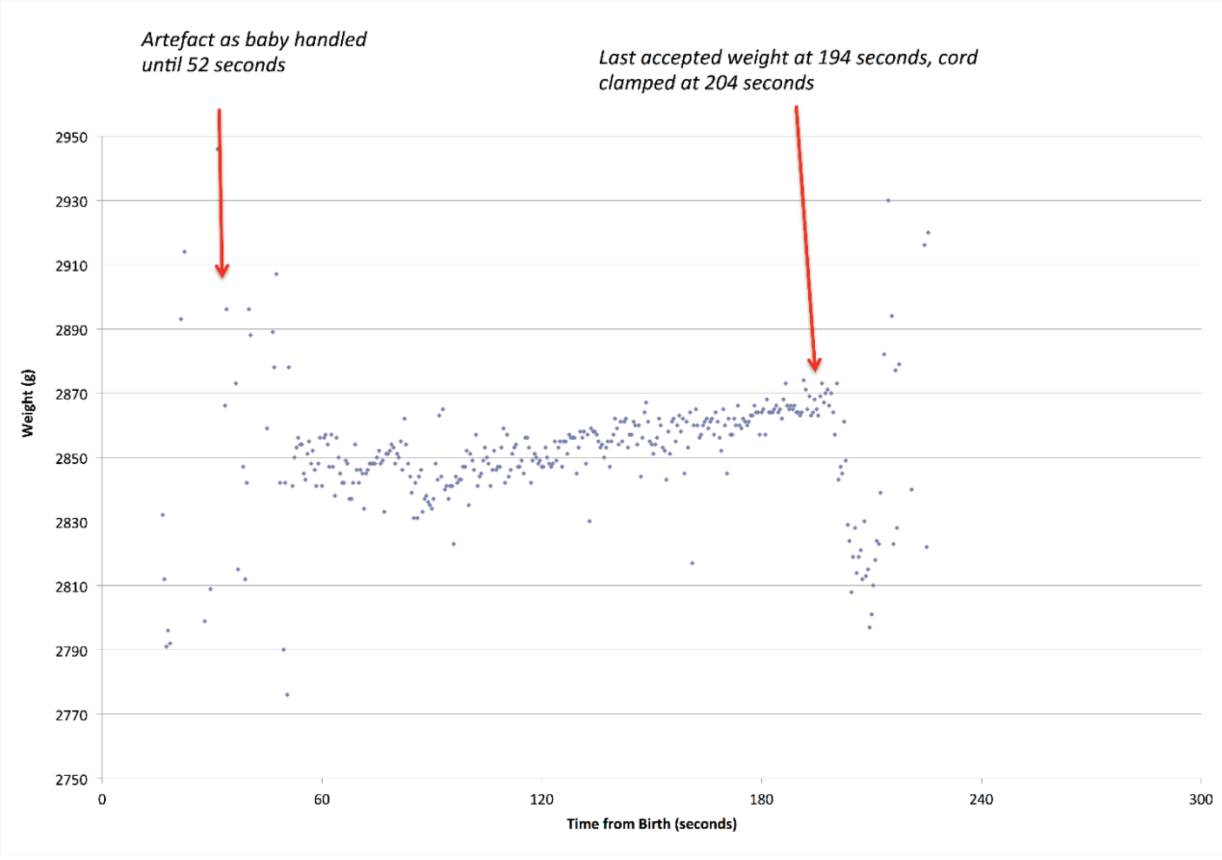

**Figure A2:** Induced labour with vaginal birth, $35^{+4}$ weeks. Weight gain estimated at 17 grams.

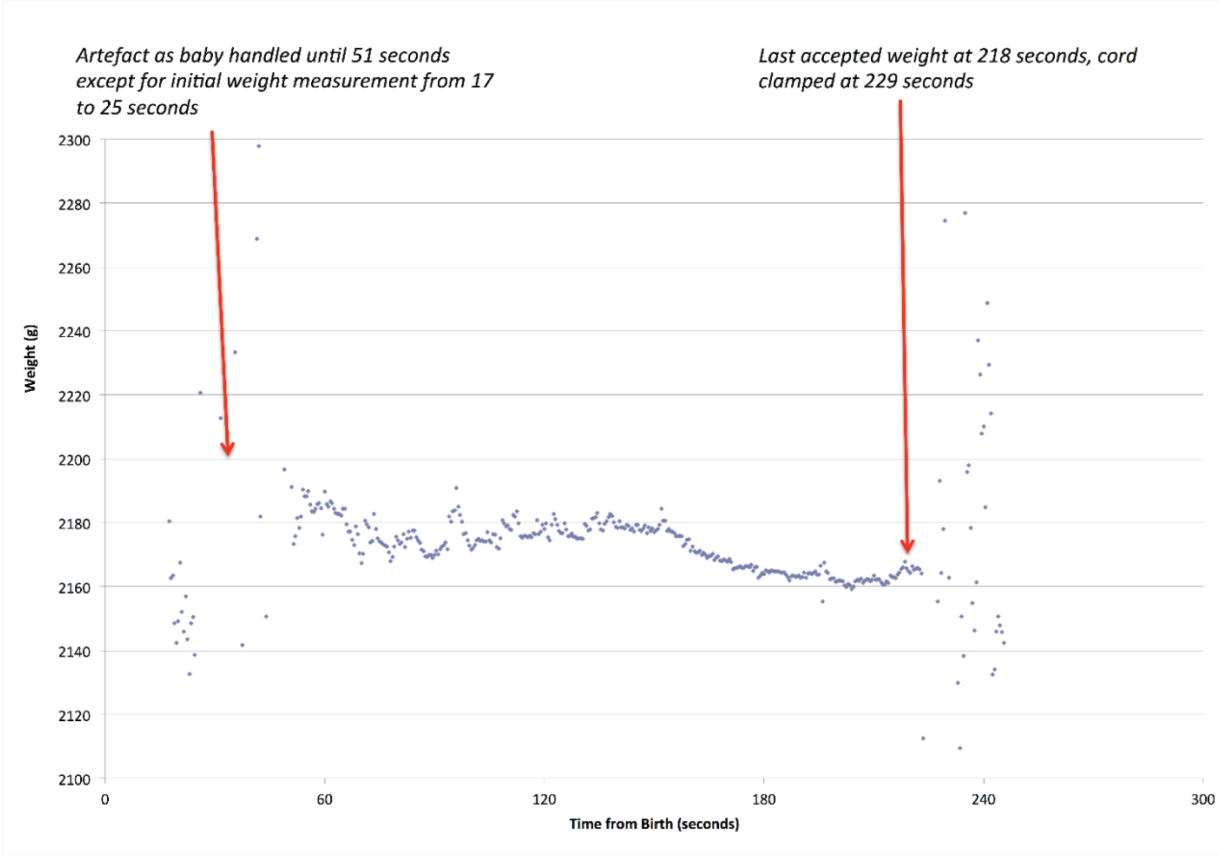

**Figure A3**: Vaginal birth, $36^{+1}$ weeks. Weight loss estimated at 20 grams.

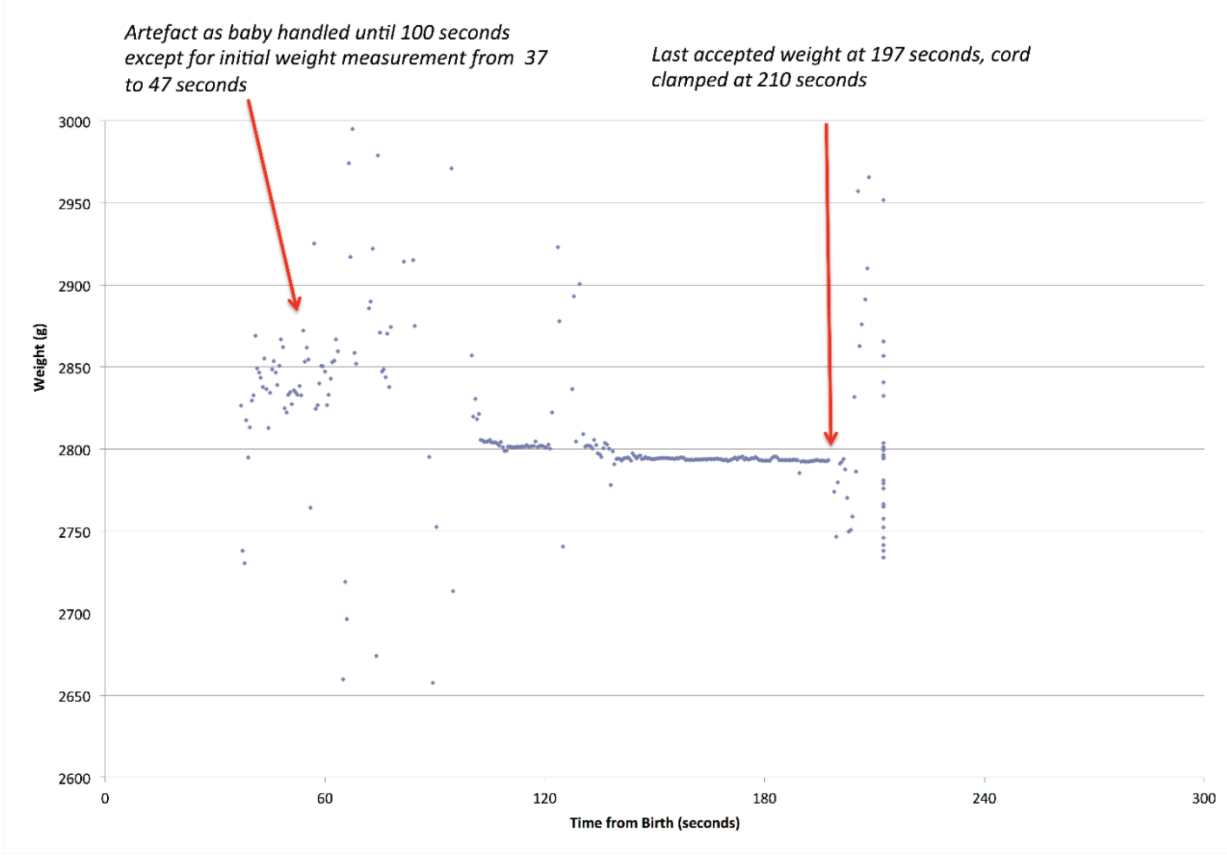

**Figure A4:** Vaginal birth, $36^{+5}$ weeks. Weight gain estimated at 128 grams.

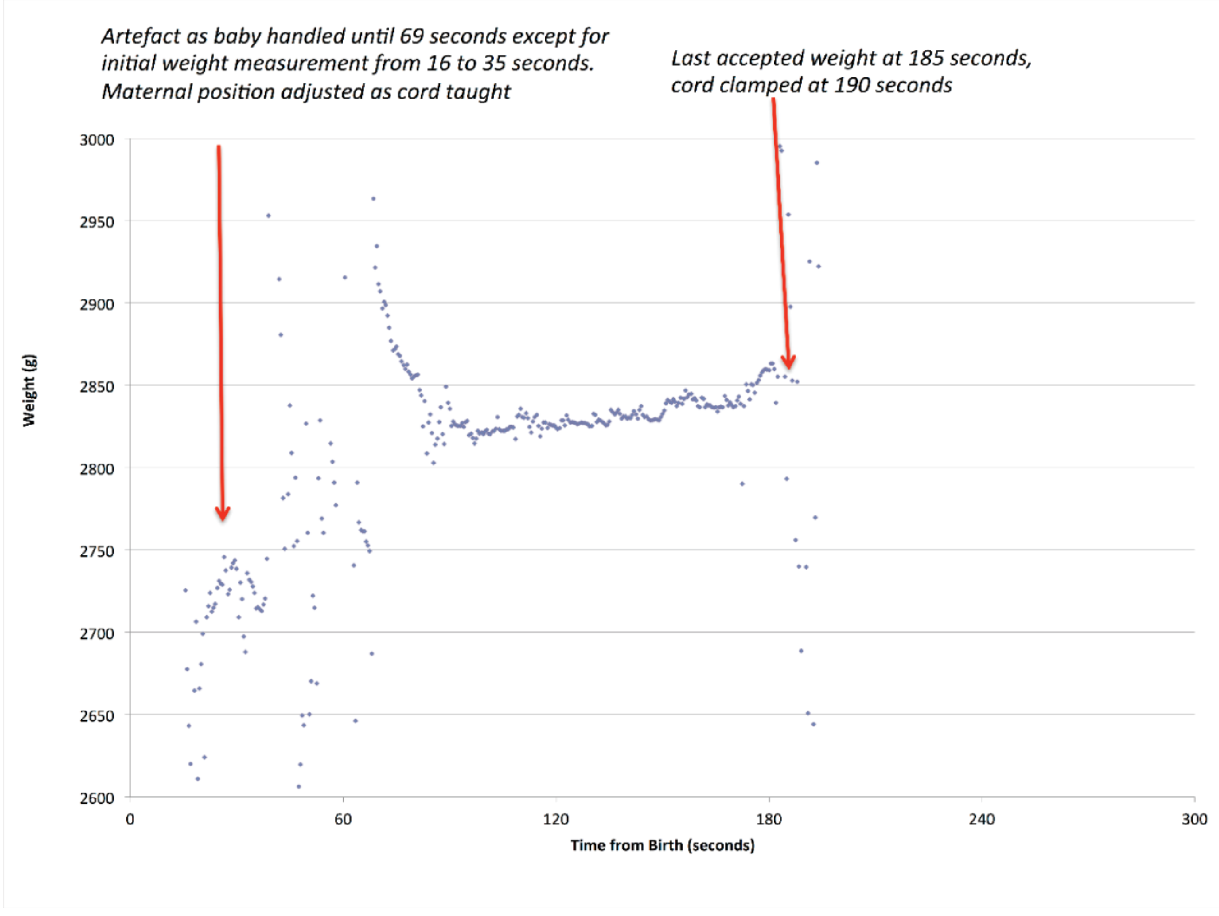

**Figure A5:** Caesarean birth, $34^{+4}$ weeks. Weight gain estimated at 63 grams.