Chapter 9

Feasibility of pulse oximetry for assessment of infants born in community based midwifery care

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ABSTRACT

Objective
To evaluate the feasibility of using pulse oximetry (PO) for evaluating infants born in community-based midwifery care.

Design
A prospective, observational study of infants born after midwifery supervised (home) births.

Setting
27 midwives from seven practices providing primary care in (home) births used PO at birth or the early puerperal period over a ten-month period. Data were obtained on the effect of PO on outcome, interventions and decision-making. Midwives were surveyed about applicability and usefulness of PO. Participants: 153 infants born in primary midwifery care.

Findings
All births were uncomplicated except for one infant receiving supplemental oxygen and another was mask ventilated. In 138/153 (90%) infants PO was successfully used and 88% of midwives found PO easy to use. In 148/153 (97%) infants PO did not influence midwives' clinical judgment and referral policy. In 5/153 (3%) infants, midwives were uncertain of the infant's condition, but PO measurements were reassuring. In case of suboptimal neonatal condition or resuscitation, 100% of midwives declared they would use PO again.

Key conclusions
It is feasible to use PO in community based midwifery care, but not considered an important contribution to routine evaluation of infants. Midwives would like to have PO available during suboptimal neonatal condition or when resuscitation is required.

Implications for practice
PO can be applied in community based midwifery care; it does not lead to insecurity or extra referral. Further research on a larger group of infants must show the effect of PO on neonatal outcomes.

INTRODUCTION

The Netherlands is one of few industrialised countries where community based midwifery-led (home) births still occur following low risk pregnancy. Almost one third of all births (32.9%) are supervised by a community-based midwife, without any obstetric involvement. [1] Only if complications occur, the obstetrician is consulted. After birth, placental oxygenation ceases, neonatal lungs expand and blood oxygenation is primarily provided by breathing. If this transition proceeds normally, neonatal organs are oxygenated and subsequently lead to high oxygen saturation (the percentage of haemoglobin binding sites in the bloodstream occupied by oxygen). Immediately after birth, an infant's condition is assessed by observation of breathing, heart rate, skin colour, muscle tone and reflexes (irritability), also known as the Apgar score. [2,3] It seems plausible that if a high Apgar score is assessed, it means that the actual oxygen saturation is also high. Studies have shown, however, that judging oxygen saturation based on the infant's colour can be very inaccurate. [4] Also, heart rate is often inaccurate and underestimated (lower than the actual heart rate) by auscultation or palpation. [5] Pulse oximetry (PO) offers objective and accurate values of oxygen saturation and heart rate and also, interventions (such as assisted ventilation) do not need to be interrupted by manual auscultation. [4,5] Therefore, PO could help to evaluate the need for, and response to resuscitation. The actual prevalence of neonatal resuscitation in community based midwifery care in the Netherlands is unknown. However, 0.9% of all infants born in community based midwifery care have an assessed Apgar score of <7 at 5 minutes after birth and a substantial number of these infants require some form of support and/or resuscitation. [1, 3] One can assume that in these cases, oxygen saturation was not optimal but it is unknown whether PO would have been helpful in these cases. Both the Dutch Association of Paediatricians (NVK) and the Royal Dutch Organization of Midwives (KNOV) recommend the use of PO when resuscitation is indicated. [3,6] International guidelines recommend PO when resuscitation can be anticipated, when positive pressure is administered for more than a few breaths, when cyanosis is persistent, or when supplementary oxygen is administered. [7] In addition, recent studies recommend PO as a screening tool for congenital heart disease and the need for implementation in practice. [8, 9, 10] In the Netherlands, however, this has not been implemented. Currently, midwives do not use PO as standard care, when resuscitation is necessary or for screening. This prompted us to perform a pilot study in the use of PO in midwifery supervised (home) birth. We aimed to assess the feasibility of a PO for midwives to assess neonatal condition after birth. We were interested in the applicability and usefulness of the device and if using a PO changed referral behaviour of the midwife in charge. Also, we aimed to explore whether midwives would like to incorporate PO routinely in their daily practice.

METHODS

Twenty-seven midwives in Leiden region agreed to participate in the study. The study was conducted from April 2011 to February 2012. We requested midwives to use PO in all births they supervised in primary care. Midwives were asked to use the PO for evaluating all infants after birth, and were encouraged to use the device when in doubt of the infant's clinical condition (directly after birth or in the early puerperal period) or when support of transition or resuscitation was needed. As this study aimed to assess the feasibility of PO in daily midwifery practice, no exclusion criteria were applied. The midwives received an update in neonatal resuscitation and were trained in using PO and interpreting its measurements and how to proceed in case of alarm messages displayed on the device. Using previously published percentiles for heart rate and oxygen saturation by Dawson et al., we defined 10th percentile values as pre-lower limit (Fig. 1). [11,12]

There were a limited number of Masimo hand held pulse oximeters (Masimo Corporation, Irvine, California) available and it was not possible to equip every midwife with a device. Therefore, we allocated one PO to each midwifery practice. The community based midwife 'on call' had a device at her disposal as often as possible. Initially, a Masimo Rad-5 was used but replaced by Rad-8, because of technical problems and frequent false alarms with the Rad-5. Both devices contained identical software (Signal Extraction Technology, SET, V.7.8.0.1.) and were set to read measurements with 2-second averaging intervals and maximal sensitivity. [12] When PO was used directly after birth, the midwives were instructed not to let the device interfere with normal procedures, such as skin-to-skin contact or immediate breast feeding. The umbilical cord was clamped in adherence to the normal procedures. In the Netherlands, late-cord clamping is generally applied; this involves clamping the umbilical cord at least one minute after birth or when cord pulsation has ceased. [13] In adherence to other studies conducted on PO in term infants, midwives were instructed to place a disposable sensor (Masimo Low Noise Cable Sensor (LNCS®) Newborn Sensor) around the infant's right wrist. [12,14] PO was switched on after applying the sensor to the infant; this offers the quickest display of data. [4,12,14] A preductal oxygen saturation and heart rate were obtained for a minimum of ten consecutive minutes. Preductal oxygen is the highest oxygenated blood in the infants' circulation due to the preferential flow through the foramen ovale to the left atrium. [15] Apgar scores were assigned by the community based midwife in charge. Interpretation and action based on the obtained data was also at the discretion of the midwife in charge. After use of PO, participants were requested to fill in a case report form (CRF), containing characteristics of mother and infant, place of birth, interventions after birth and, if applicable, referral to the paediatrician. Subsequently, midwives were surveyed concerning usefulness, applicability and decision-making when using PO. Also, in case PO was not used, we

requested the community based midwife to report the reason(s) on a separate form. After the ten-month study period, an evaluation questionnaire was sent to all participants. Specific questions on practical use of PO and possible implementations in practice were asked. Furthermore, data on all deliveries and neonatal referral during the study period of all practices were obtained in order to compare groups. Approval for this study was obtained by the Leiden Medical Ethics Committee in February 2011. In all midwifery practices, clients were informed about the study through wall posters in waiting rooms and flyers were distributed antenatally. Midwives informed and subsequently asked clients and their partners to participate in the study. Verbal parental consent was obtained by the community based midwife, prior to the onset of birth. Also, all paediatricians in Leiden region were informed via e-mail regarding this study and possible referrals based on PO results. Data collected on the devices were downloaded using TrendCom Trend Download Software and stored using Excel. Analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 17 (SPSS Inc., Chicago, IL, USA). Analyses were conducted using the $\chi 2$ test. Statistical significance was considered if $p<0.05$.

Findings

During the study period from April 2011 to February 2012, the seven participating practices recorded a total of 2665 births. Of this group, 819 (32%) births occurred in community based midwifery care of which 401 (49%) children were born at home and 418 (51%) were born in hospital or birth clinic. In 666/819 deliveries (81%), PO was not used. Reasons were: device not in possession at time of birth (37%), no time to prepare the oximeter due to fast birth (16%), forgot to use the device (26%) or device malfunctioned (battery empty) (21%). Thus, PO was used in 153/819 (19%) infants, of these, 95 (95/153) (62%) were born at home and 58 (95/153) (38%) were in hospital or birthing clinic. There were no differences in clinical characteristics between the PO group and the group where no PO was used; however there were more home births in PO group (Table 1).

In 144/153 (94%) infants the oximeter was solely used for research purposes. In this group 5/144 (3%) infants were referred to hospital for paediatric consultation (three infants needed glucose monitoring for large for gestational age), in one infant neonatal infection was suspected and one infant had an irregular heartbeat during second stage. All PO measurements were within the normal ranges and the midwives stated that PO measurements had not influenced their decision to refer these infants.

In eight out of 153 (6%) births PO was used because the infant's condition was considered suboptimal. In five (5/8) infants there was uncertainty regarding the infant's colour (ranging from 'grey' to 'pale-blue', from directly post-partum or later up to eight days post-partum); one infant had a short period of cyanosis after regurgitating; the midwife

was reassured by quick recovery and normal PO values. In three (3/8) infants breathing was considered suboptimal; of which one infant received supplemental oxygen directly after birth for a short period. In these cases, oxygen saturation and heart rate values were within normal ranges and the midwives were reassured. In six (6/8) infants the midwives decided not to refer. In one infant, the paediatrician was consulted by phone, and it was decided not to refer. The infant that became cyanotic after regurgitation was referred on parent's explicit request, but observation in hospital was uneventful. According to the midwives, the reassuring PO measurements contributed to the decision not to refer in three (3/8) infants. In the other five (5/8) infants, the midwife stated the measurements did not influence their decision at all.

In one (1/153) infant PO was used because the infant was born asphyxiated and resuscitation was needed. The midwife considered PO very useful as feedback regarding the effect of resuscitation; it gave her reassurance that mask ventilation was adequate. Admission to the neonatal intensive care followed with quick recovery (Sarnat score 1) and the infant was discharged three days after birth. Besides one case where resuscitation was needed, no major events or morbidities were found in the rest (152/153 (99%)) of the infants. Also, in the puerperal period, no subsequent neonatal referrals in this group were reported.

Midwives reported feeling insecure after using PO in 3/153 (2%) infants. In one infant measurements were normal, but PO was used for the first time. In two infants PO frequently alarmed for low heart rate, while this could not be confirmed by auscultation. In all three infants the midwives decided not to refer the infant.

In 15/153(10%) infants PO measurements, or parts of it, were considered unreliable as extreme values were recorded in otherwise clinically stable infants. In all these infants a 'low signal' alarm was frequently given. None of these measurements led to referral, but in two cases midwives and parents were agitated by the alarms.

The majority of midwives (88%) found the device 'quite easy' or 'very easy' to use (Table 2).

Midwives felt that PO provided useful information in 23% of the occasions and indicated that they would use PO again if they had one available in 42%. PO was used by 56% of midwives between three to six times per ten births and 11% of midwives used PO more than six times per ten births. One midwife did not use the device at all and the remainder (33%) used the device sometimes or rarely. In 96% PO was considered user-friendly. Midwives experienced that most parents (89%) were positive about PO use. In none of the occasions, midwives received negative feedback from parents about PO use. Answers to questions concerning its use in daily practice can be seen in Fig. 2. Midwives would use the device when resuscitation is needed (100%), in preterm delivery (56%), when sepsis is suspected (61%), to support decision to refer (56%) or not to refer (44%), in

prolonged second stage (33%) and unexpected meconium stained liquor at birth (33%). In case of suboptimal colour or breathing, the majority (82%) indicated to use PO (Fig. 3) Only one of seven practices is currently considering purchasing a pulse oximeter. In four practices its purchase has been discussed but decided not to buy one and two practices have not yet discussed this. The midwives indicated in the questionnaire that the costs of purchase, maintenance and actual weight and size of the device might contribute to the reluctance of purchasing a PO.

DISCUSSION

We observed that it was feasible for midwives to use PO in community based midwifery care PO only influenced decision making when it was used on indication and its use could prevent unnecessary referral. We observed that the midwives found the PO easy to implement in their daily practice. The midwives would like to have a pulse oximeter to their disposal when in doubt of neonatal condition, and they all prefer to have the device when neonatal resuscitation is indicated. In almost all infants measurements were within normal ranges and this confirmed the midwife's clinical evaluation. In a few occasions (15/153) heart rate was unexpectedly outside the normal range, leading to some insecurity. However, in these isolated cases the midwives still preferred to rely on their clinical judgment. We anticipated on increased referral to paediatricians at regional hospitals during the time of this study due to odd heart rate or oxygen saturation. However, this did not occur. PO was used in response to a suboptimal clinical condition in only a few occasions (8/153). In these cases, PO values were reassuring, supporting the midwife's decision not to refer the infant. One infant was successfully resuscitated and referred to the paediatrician. One infant was referred on specific request of the parents, but evaluation of the paediatrician was uneventful. During the study period we found a very low prevalence of compromised infants; only one infant needed resuscitation (0.7%). In addition, when a midwife was in doubt of the infant's condition, PO results showed reassuring values. Both findings are likely the result of a good risk selection of pregnancies by the community-based midwives for midwifery led births. Currently, in the clinical setting, a shift in policy is taking place in favour of PO. Before this study, the magnitude of the effect of PO in low risk infants born in community based midwifery care has never been explored. Despite lacking evidence supporting the use of PO in primary care, the national resuscitation guidelines of the Royal Dutch Organization of Midwives (KNOV) recommend using PO in case of resuscitation. [3] Apparently this recommendation has not been put into practice. The reason for this is unclear, but the very low incidence of resuscitation, as confirmed in this study, probably plays a role in this. However, in the case where resuscitation was needed the midwife considered

PO very helpful for evaluating the effect of mask ventilation. Midwives participating in this study using PO confirmed that they predominantly rely on clinical findings and did not consider PO as a valuable asset. However, in contrast to this is the paradoxical finding that midwives would like to have a pulse oximeter at their disposal in cases of suboptimal condition or when resuscitation is required. Apparently PO is appreciated in the few occasions when reassurance or confirmation of clinical assessment or intervention is needed. Traditionally, midwives are trained in clinical evaluation of the infant without the use of any technical device. However, as technology and screening devices are increasingly introduced in medical practice, the findings of this study could start a discussion introducing PO as part of the standard equipment in midwifery practice. Also, as 89% of parents were positive on PO use, it might also meet a need from the parents' perspective and contribute to the sense of safety in birth in primary midwifery care. However, neonatal resuscitation in primary care practices is rare and practical matters such as purchase costs and weight of the device could make midwives reluctant to purchase a PO. A recent meta-analysis showed that routine PO was found to be a highly specific tool with very low false positives to detect congenital heart disease. [16] The American Academy of Paediatrics recommends using PO for screening. [8] The different set-up of perinatal care of low risk infants raises issues concerning the expediency of this screening in the Netherlands. One of those issues concern logistics as most low-risk infants are not born or checked in hospital setting. This implicates that midwives and family doctors, who are predominantly responsible for the assessment of infants at birth and later on, need to be trained and have access to PO for screening, and so far this has not been implemented in the Netherlands. Cost-effectiveness of PO for screening purposes in midwifery practice in the Netherlands should be further explored. If a pulse oximeter would be used as a screening for congenital heart diseases as well, practical concerns would perhaps be less of an issue.

This is the first study exploring PO use in community based midwifery care. Therefore, comparison with studies in this primary care setting cannot be made. Sample size is too small to draw conclusions on the effect of using PO on referral and neonatal outcomes. Although our results suggest a reduction in neonatal referral due to PO use, further research must be performed on a larger group of infants. This study provided sufficient rationale to further explore the use of PO in community based midwifery care.

Conclusions

It is feasible to use PO in community based midwifery care, especially when in doubt of neonatal condition or in case of resuscitation. Use of PO did not lead to insecurity or extra referral. Future research must show whether the use of PO has effect on neonatal outcomes.

Conflict of interest statement
None.

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Table 1. Characteristics of births supervised by a community based midwives during the study period, divided in pulse oximeter use and no pulse oximeter use.

Birth characteristics	Pulse oximeter use n = 153 (%)	No pulse oximeter use n=666 (%)	p-value
Place of Birth	Home 95 (62. 1) Hospital/birthing clinic 58 (37.9) Total 153(100)	Home 306 (45. 9) Hospital/birthing clinic 360 (54.1) Total 666 (100)	< 0.05
Gestational age, mean (range), week	39+6 weeks (37+3 - 41+6)	39+5 weeks (37+2 - 41+6)	Not significant
Birthweight, mean, ± SD, grams	3542 gram (± 462)	3573 gram (± 425)	Not significant
Apgar Score at 1 min, median (IQR)	9 (9-9)	9 (9-9)	Not significant
Apgar Score at 5 min, median (IQR*)	10 (9-10)	10 (10-10)	Not significant
Apgar Score at 10 min, median (IQR)	10 (10-10)	10 (10-10)	Not significant

* Interquartile range

Table 2. Results of questions after every use of the pulse oximeter concerning applicability and decision-making

			Scoring, %					**Total %**
Question	**N**	**Mean Score ± SD**	**1 Yes, absolutely**	**2**	**3**	**4**	**5 No, totally not**	
1. The pulse oximeter is easy to use	135	1.7 (±0.98)	53.3	34.8	3.0	6.7	2.2	100
2. The pulse oximeter provides additional useful information	149	3.46 (±1.31)	10.1	13.4	26.2	21.5	28.9	100
3. Use of the pulse oximeter makes me insecure	150	4.61 (±0.76)	1.3	0.7	6.7	18.0	73.3	100
4. My decision to refer to a paediatrician or not was influenced by use of the pulse oximeter	148	4.59 (±0.90)	2.7	0.7	10.1	7.4	79.1	100
5. I would use the pulse oximeter again in a similar situation	151	2.86 (±1.51)	29.1	12.6	23.2	13.2	21.9	100

Figure 1. Based on previously published percentiles by Dawson et al., [11,12] defined 10th percentiles for oxygen saturation and heart rate used as reference by midwives in preductal measurements in infants.

Minutes after birth	1 minute	2′ minutes	5′ minutes	7′ minutes	>10′ minutes
Spo2 (%)	**35**	**40**	**75**	**85**	**90**
Heart Rate (bpm)	**30**	**80**	**120**	**120**	**120**

Figure 2. Midwife responses for reasons they would use a pulse oximeter directly after birth.

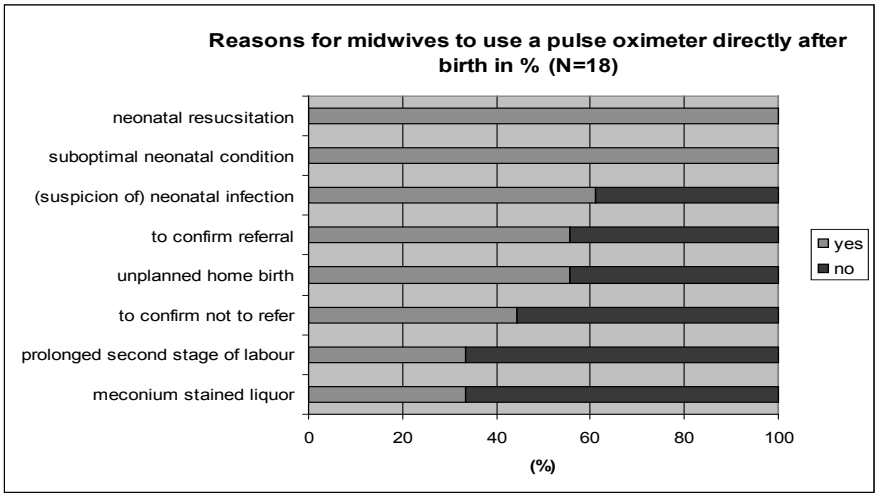
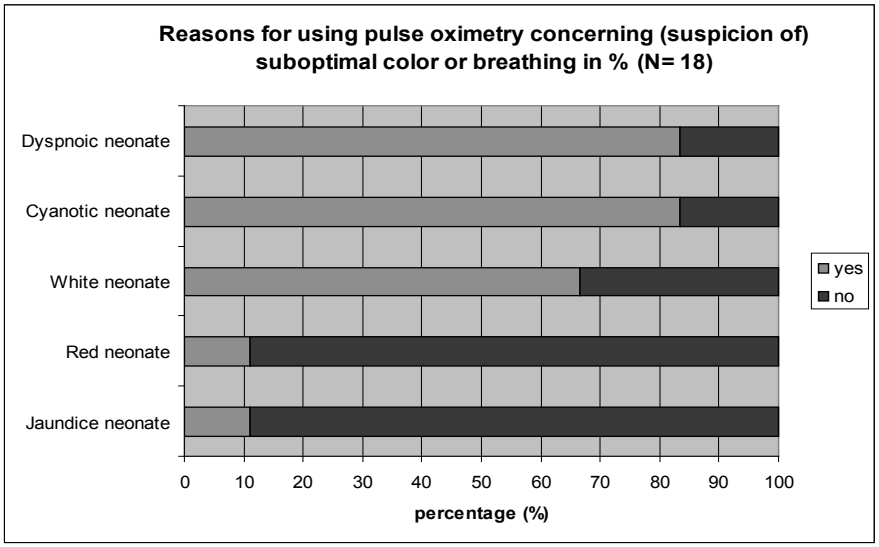


Figure 3. Evaluation questionnaire after the study period; reasons for midwives for using a pulse oximeter in case of (suspicion) of suboptimal colour.



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