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An Investigation of the Effects of Pitocin for Labor Induction and Augmentation on Breastfeeding Success

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An Investigation of the Effects of Pitocin for Labor Induction and Augmentation on Breastfeeding Success

A Thesis Presented

By

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Of Claremont McKenna, Pitzer, and Scripps Colleges
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Table of Contents

Abstract.....	1
Introduction.....	2
Figure 1. Oxytocin release from the hypothalamus and posterior pituitary	3
Figure 2. The Fergusson reflex	5
Figure 3. The milk ejection reflex.....	7
Table 1. Summary of literature review	22
Aims and Predictions	25
Methods.....	27
Table 2. LATCH scoring system	28
Discussion.....	30
Acknowledgments.....	42
References.....	43

Abstract

Rates of labor induction and augmentation have been increasing in recent decades (Glantz, 2005). According to the Listening to Mothers II survey, half of all labors in the U.S. are induced or augmented with Pitocin or other synthetic form of the hormone oxytocin (Declercq et al., 2006). Oxytocin, a naturally occurring hormone released in the pituitary gland, is involved in the stimulation of uterine contractions during labor and in the milk ejection reflex during breastfeeding, and research suggests it also has various effects on the brain, such as eliciting maternal behavior. However, studies have shown that exogenous oxytocin can interfere with the natural production and regulation of oxytocin and can have adverse effects on the fetus and mother. Therefore, I predict that the induction or augmentation of labor with Pitocin will negatively affect breastfeeding following birth. The proposed study will compare LATCH scores, used in hospitals to measure postpartum breastfeeding success, of dyads exposed to intravenous Pitocin prior to birth with control dyads that had no exposure to Pitocin during labor. It is hypothesized that dyads exposed to Pitocin will have significantly lower LATCH scores than controls. Given the countless health benefits of breastfeeding for both mother and infant, the results of this study will have important implications for the evaluation of common practices during labor and birth.

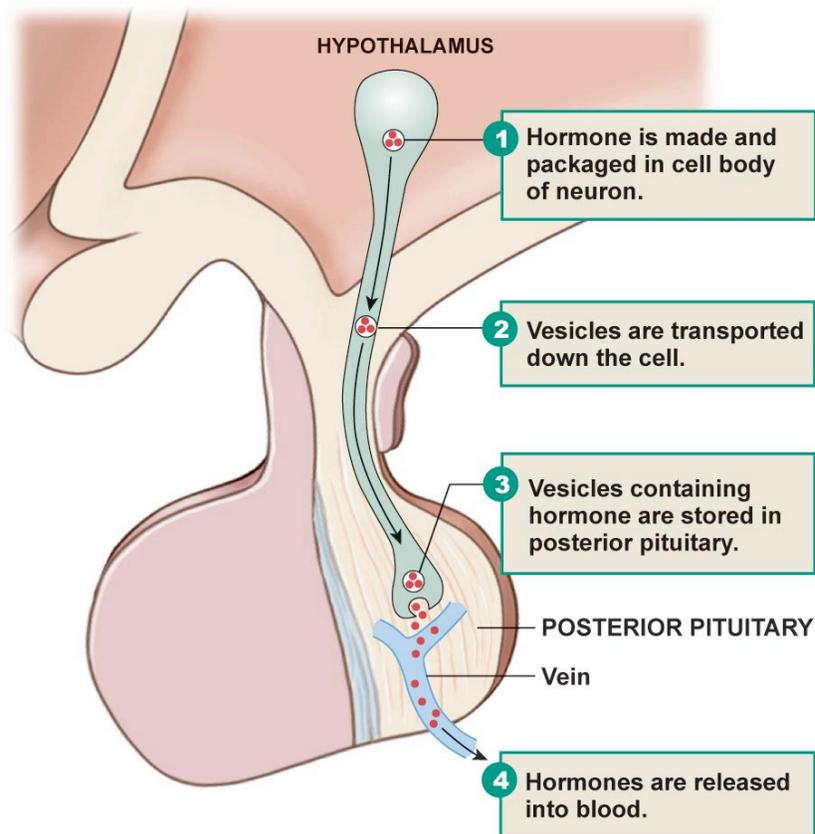
Introduction

The use of drugs and other interventions during labor and birth in the U.S. is becoming increasingly common. One such intervention is induction of labor for either elective reasons, such as discomfort from pregnancy or for convenience, or due to medical reasons, such as preeclampsia (high blood pressure) or gestational diabetes when it is deemed medically necessary to deliver the baby. In spontaneous labor, the naturally occurring hormone oxytocin helps stimulate uterine contractions, whereas for most labor inductions, a synthetic form of oxytocin is administered intravenously in order to artificially stimulate contractions (the brand names of synthetic oxytocin include both Pitocin and Syntocinon, but for simplicity it will be referred to here as Pitocin). Pitocin is also used to augment labor that is not progressing quickly enough, and it is often injected intramuscularly following delivery during the third stage of labor to prevent post-partum hemorrhage. According to the Listening to Mothers II survey, 50% of women giving birth in hospitals in the U.S. received Pitocin for either induction or augmentation of labor (Declercq et al., 2006).

Although induction or augmentation with Pitocin is regarded by many hospitals as a relatively safe and routine intervention, Pitocin can have different physiological effects on the mother and fetus than endogenous oxytocin. These effects can interfere with breastfeeding in the early postpartum period, potentially having an adverse effect on long-term breastfeeding success and thus the overall health of the mother and infant.

The Physiology of Oxytocin

Naturally occurring in all mammals, oxytocin is a peptide hormone that has various effects on both the brain and peripheral systems during and after birth. It is produced in the magnocellular nuclei of the supraoptic nucleus (SON) and paraventricular nucleus (PVN) of the hypothalamus, and it is stored in and released into circulation from the posterior pituitary gland (reviewed in von Bohlen und Halbach and Dermietzel, 2002) (Figure 1). In addition to acting as a hormone in the peripheral system, oxytocin is also released directly in the central nervous system from the cell bodies and dendrites of oxytocin-producing neurons to act as a neuromodulator in areas of the brain containing oxytocin receptors, such as the amygdala and



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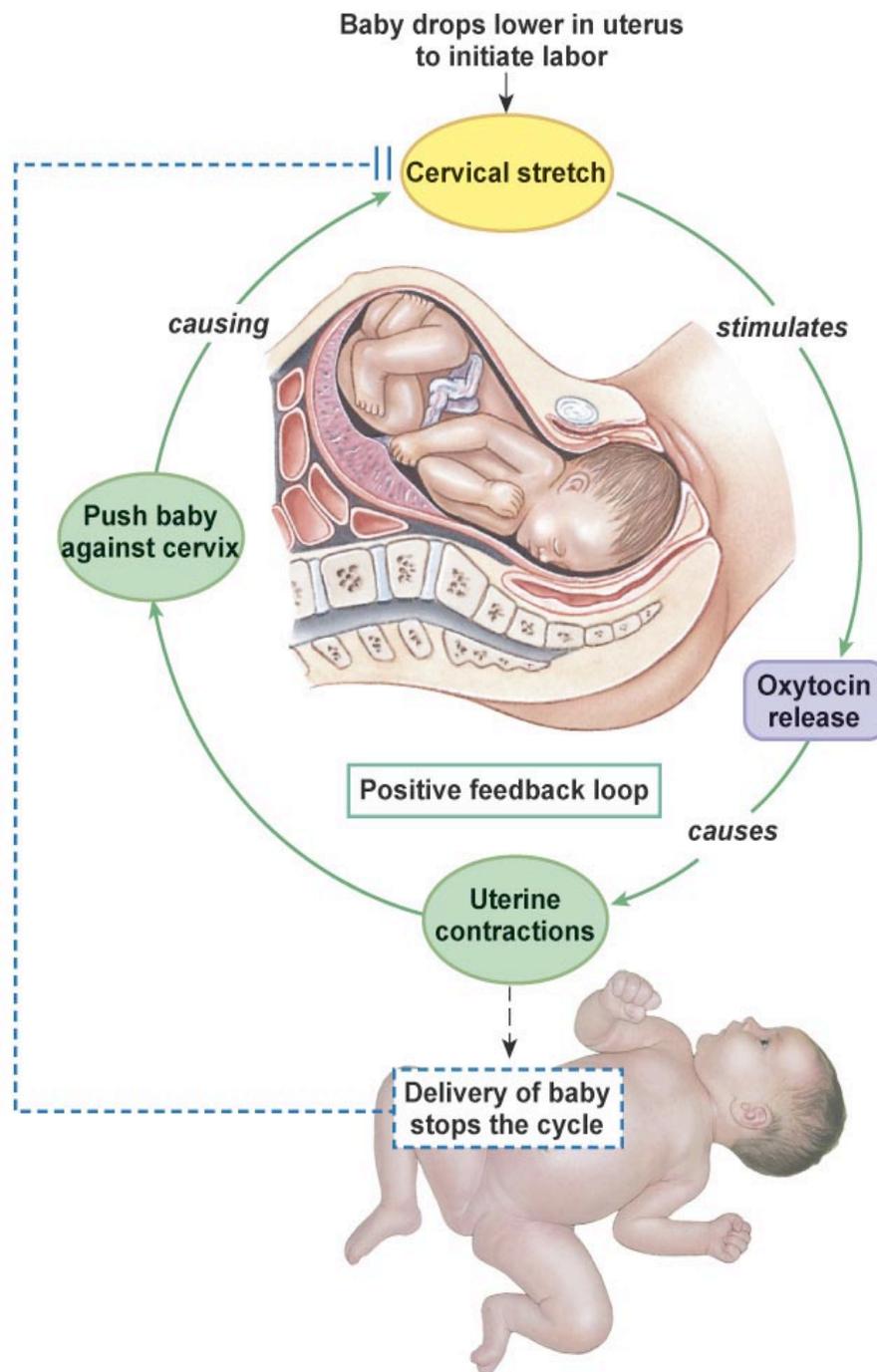
Figure 1. Oxytocin release from the hypothalamus and posterior pituitary (Silverthorn et al., 2013)

hippocampus (Jonas, 2009; von Bohlen und Halbach and Dermietzel, 2002). Oxytocin release is controlled by a positive feedback mechanism; for example, oxytocin release in the PVN stimulates further release of oxytocin by neurons in the same region (reviewed in Kendrick, 2000).

Once oxytocin is released, it binds to oxytocin receptors (OTRs) located in neural tissue in the central nervous system and in the myoepithelial (smooth muscle) cells of the uterus and mammary glands in the peripheral system (Leng et al., 2008). OTRs are G-coupled receptors, and the binding of oxytocin to OTRs on these myoepithelial cells causes a rise in intracellular calcium levels to facilitate contraction of the smooth muscle tissue (von Bohlen und Halbach and Dermietzel, 2002).

The Role of Oxytocin in Labor and Birth

During labor and birth, the primary role of oxytocin is to bind to OTRs on the uterus to stimulate uterine contractions, which helps expel the fetus from the womb. Once labor begins, oxytocin release is regulated by a positive feedback mechanism in which pressure from the head of the fetus on the cervix and vagina creates a reflex (called the Ferguson reflex) that travels primarily via the pelvic and vagal nerves, spinal cord, and brainstem nuclei to stimulate the release of oxytocin from the posterior pituitary (Kendrick, 2000). This release of oxytocin then stimulates more uterine contractions, leading to more pressure on the cervix and vagina, and so on until the fetus is delivered (Figure 2). The release of oxytocin and the resulting uterine contractions occur in pulses approximately 4-8 minutes apart, becoming closer together as labor progresses until a peak in oxytocin at the time of delivery helps expel the baby from the uterus and birth canal (Fuchs et al., 1991).



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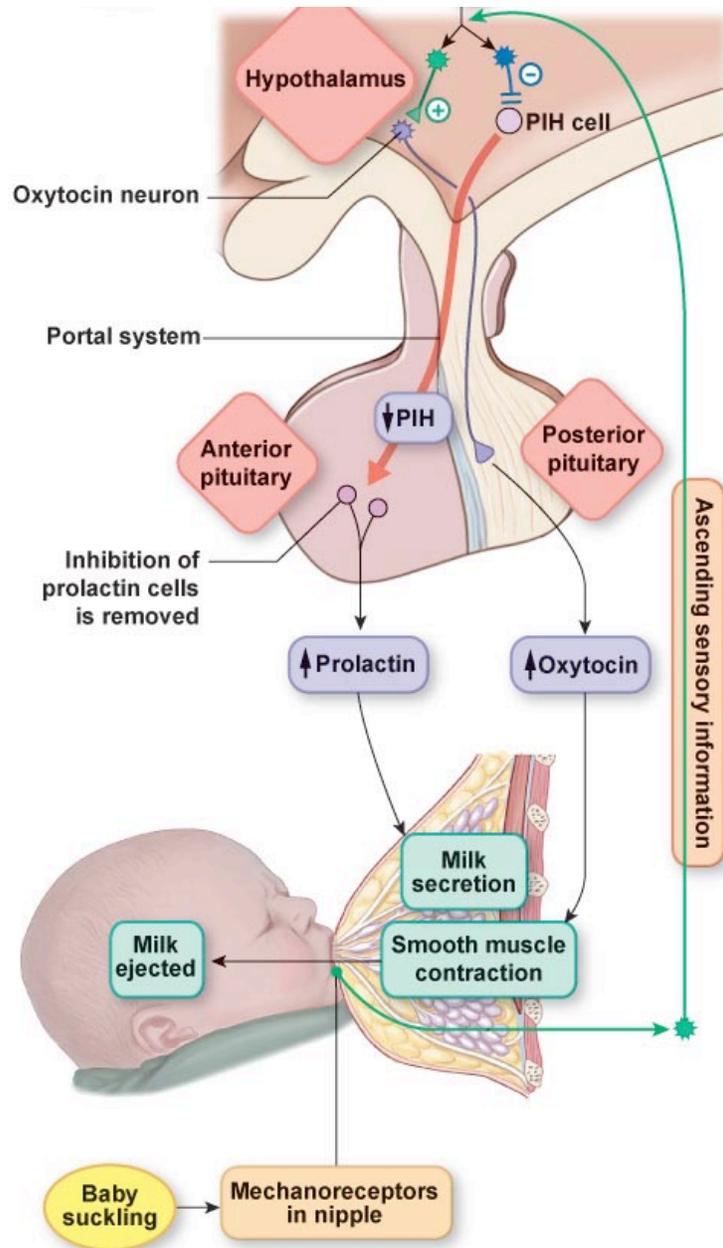
Figure 2. The Ferguson reflex (Silverthorn et al., 2013)

Facilitated by rising estrogen levels, uterine OTRs increase in number and sensitivity leading up to the time of parturition, and evidence suggests that the onset of labor is related more to the increased sensitivity of these receptors than to increased circulating levels of oxytocin (Blanks and Thornton, 2003; Jonas, 2009; Soloff et al., 1979). This change in uterine OTRs is also accompanied by an increase in the production of OTRs in the hypothalamus and other areas of the brain (e.g. olfactory bulbs and the amygdala) on the day of parturition so that these neurons are more sensitive to the release of oxytocin (reviewed in Leng et al., 2008). Thus as the body prepares for delivery of the baby, it becomes more physiologically receptive to the stimulatory effects of oxytocin during labor and birth.

The Role of Oxytocin in Lactation

In addition to the role of oxytocin in the stimulation of uterine contractions during labor and delivery, oxytocin continues to play an important role in lactation after birth. Stimulation of the nipple by suckling sends a signal via the spinal cord to the hypothalamus to induce the release of oxytocin from the pituitary into circulation (Neumann et al., 1996). The oxytocin then binds to OTRs on the smooth muscle cells of alveoli in the mammary glands, causing them to contract and eject milk into the ducts and cisterns in what is referred to as the milk ejection reflex (Figure 3). Just as OTRs in the uterus become more sensitive to oxytocin prior to birth, the sensitivity of OTRs in the mammary glands also increases leading up to delivery to make the mother more physiologically responsive to circulating oxytocin (Soloff et al., 1979). Furthermore, by binding to OTRs on prolactin-releasing cells in the anterior pituitary gland, oxytocin also stimulates the release of prolactin, a hormone

responsible for milk production (Jonas, 2009). Thus oxytocin plays a crucial role not only in labor and delivery, but also in lactation following birth.



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Figure 3. The milk ejection reflex (Silverthorn et al., 2013)

The Role of Oxytocin in the Brain

In addition to oxytocin's functions in the uterus and mammary glands, it has been found to act on the brain to influence maternal and bonding behaviors. For example, intracerebroventricular (ICV) infusions of oxytocin can elicit maternal behaviors in virgin animals in as little as 30 seconds, and oxytocin antagonists can inhibit maternal behaviors in animals following delivery of their offspring. In sheep, ICV infusions of oxytocin facilitate olfactory recognition of offspring following birth (reviewed in Kendrick, 2000), and evidence for oxytocin's role in the onset of maternal behavior has also been found in primates (Kendrick, 2000; Saltzman and Maestriperi, 2011). Furthermore, oxytocin has been found to affect social bonding in animals. After mating, prairie voles are known to form strong pair-bonds with their mates, and pair-bonding can be elicited in these animals following ICV infusions of oxytocin even when no mating has occurred (reviewed in Kendrick, 2000).

The behavioral effects of oxytocin in the human brain are more difficult to study, as ICV infusions cannot be performed for ethical reasons, but evidence suggests that oxytocin influences maternal behaviors in humans. Oxytocin concentrations in cerebrospinal fluid increase during labor, indicating its release in the brain, and increased plasma concentrations of oxytocin following birth are associated with positive feelings and reduced anxiety (reviewed in Kendrick, 2000). It is possible that these effects may facilitate early breastfeeding by making the new mother more relaxed and confident in her ability to successfully nurse her infant.

As discussed, oxytocin plays an important role before, during, and after delivery by stimulating uterine contractions to facilitate expulsion of the fetus from the womb, by

stimulating the milk ejection reflex, and by influencing maternal behaviors following birth. However, administering exogenous oxytocin intravenously can affect the body differently than endogenous oxytocin and can have adverse effects on the mother and infant.

Characteristics of Pitocin

When Pitocin is used for induction or augmentation of labor, it is administered as a continuous intravenous drip, usually starting with small doses (0.5-1 mU/min) and gradually increasing the dose every 30-60 minutes until adequate uterine activity is established (“Pitocin,” 2009), although specific dosage and protocols often vary by hospital (Miller, 2009). While Pitocin is similar to endogenous oxytocin in that it binds OTRs on the uterus to produce contractions, there are differences in its effects on the body. According to some research, infusion rates of up to 6 mU/min lead to the same plasma concentrations that occur during spontaneous labor (“Pitocin,” 2009). However, whereas endogenous oxytocin is released in pulses every 4-8 minutes, intravenous Pitocin is administered as a continuous drip. Next, natural labor involves the release of β -endorphin, an endogenous opioid also produced in the hypothalamus. β -endorphin helps block pain and regulates the release of oxytocin to manage the pace and intensity of labor (Keverne and Kendrick, 1994), but continuously administered Pitocin is not subject to this natural regulation. In addition, the sensitivity of OTRs can vary greatly between women, so even a standard dose of Pitocin can affect individual women differently (“Pitocin,” 2009). In fact, one study measured plasma concentrations of oxytocin during intravenous infusion and found no association between plasma levels and uterine pressure, suggesting that the intensity of contractions may have more to do with OTR sensitivity than with circulating levels of oxytocin (Perry et al., 1996).

So although hospitals usually administer standard doses of Pitocin designed to match the levels of oxytocin in spontaneous labor, the variation in sensitivity to Pitocin will thus cause variation in how each patient reacts to the drug. And while hospitals do often monitor uterine contractions and adjust doses accordingly, exogenous Pitocin is not subject to the endogenous mechanisms that regulate oxytocin release.

One consequence of this lack of natural physiological regulation of exogenous oxytocin release is uterine contractions that are stronger, more painful, and closer together, with increased uterine resting tone between contractions (e.g. Buckley, 2002; Miller, 2009; Kroeger, 2004). One study measured various characteristics of uterine contractions, including pressure and duration, in spontaneous and augmented labors and found that on average, contractions stimulated by intravenous oxytocin are stronger and have a different wave form than spontaneous contractions, indicating that Pitocin affects the body differently than endogenous oxytocin (Seitchik and Chatkoff, 1976). Additionally, if doses are improperly administered, uterine hyperstimulation can occur, potentially leading to uterine rupture in severe cases (Ibrahim, 2009; "Pitocin," 2009). This is one reason why synthetic oxytocin is listed as one of the Institute for Safe Medication Practices' high alert medications (Miller, 2009), which are medications that have a greater risk of causing significant patient harm if used improperly (ISMP, 2011).

The effects of intravenous oxytocin on the brain and behavior are not well understood, and there is a lack of research on the effects of Pitocin on maternal behavior. Oxytocin, whether naturally released from the posterior pituitary or administered in its synthetic form as Pitocin, cannot cross the blood-brain barrier to enter the brain (Lothian, 2005). Although synthetic oxytocin can reach the brain when administered intranasally, the

mechanism for intranasal delivery is different than that of intravenous delivery. When a drug is administered intranasally, it can travel through the fluid-filled perineural channels created by the cells ensheathing the olfactory receptor neurons, which go through the cribriform plate in the skull to directly reach the central nervous system (Dhuria et al., 2010). However, when oxytocin is given intravenously, the blood-brain barrier would prevent any significant amount of the drug from reaching the brain. It is possible, however, that oxytocin levels in the CNS are different when labor is induced than when it begins spontaneously. As previously discussed, the mechanism by which oxytocin is released directly into the brain is different than the mechanism by which it is released into circulation from the posterior pituitary. Studies in rats and sheep found that peripheral levels of oxytocin do not always correlate with levels in the brain, suggesting that the two systems may be controlled independently (reviewed in Saltzman and Maestriperri, 2011). Therefore, although uterine contractions produced by Pitocin would activate the Ferguson reflex in order to stimulate the release of oxytocin into circulation from the posterior pituitary, intravenous Pitocin does not necessarily cause a rise in oxytocin levels within the brain, especially in cases of labor induction when the body has not initiated the release of oxytocin on its own. If it is true that Pitocin administered for induction or augmentation is associated with lower levels of oxytocin released in the central nervous system, there may not be the same effects on maternal behavior (e.g. reduced anxiety) that are associated with the natural release of oxytocin in the central nervous system. However, there are currently no known studies directly examining the effect of Pitocin on the release of oxytocin within the brain.

Although there is no direct evidence that Pitocin affects oxytocin release within the brain, evidence from a study on the release of β -endorphin in the brain during labor does

suggest that augmentation of labor with exogenous oxytocin affects the brain differently than natural labor (Genazzani et al., 1985). As previously discussed, β -endorphin helps regulate the release of oxytocin during spontaneous labor, and β -endorphin levels rise in relation to the frequency and intensity of uterine contractions, binding to opioid receptor sites on the uterus to reduce contractions and relieve some of the pain associated with labor. In the study, blood samples taken from women with spontaneous labor were compared to those requiring augmentation to treat uterine hypocontractility. It was found that while β -endorphin levels rose significantly throughout labor until the time of delivery in women with spontaneous labor, the levels remained constant in women with augmented labor and were 30% lower at the time of delivery (Genazzani et al., 1985). Although the authors point out that the lack of a rise in these hormones could have been related to the uterine hypocontractility itself rather than an effect of intravenous oxytocin, their results are consistent with those of another study which found that oxytocin inhibits the release of adrenocorticotrophic hormone (ACTH) (reviewed in Genazzani et al., 1985). ACTH is another hypothalamic hormone that regulates the release of cortisol in response to stress, and like β -endorphin, it is regulated by corticotropin releasing factor (CRF). The authors postulate that intravenous synthetic oxytocin causes a decrease in both β -endorphin and ACTH by interfering with the release of CRF (Genazzani et al., 1985), indicating that Pitocin does affect the normal functioning of the central nervous system by inhibiting the release of other hormones. In addition, because β -endorphin helps reduce contractions, the lack of a rise in β -endorphin levels after administration of intravenous oxytocin may help explain why the drug often produces stronger and more frequent uterine contractions (Genazzani et al., 1985).

While Pitocin does mimic endogenous oxytocin by binding to OTRs to stimulate uterine contractions during labor, the evidence described suggests that Pitocin affects the body differently than endogenous oxytocin and that it can interfere with the release of other hormones. Further evidence described below suggests that these differences in the way Pitocin affects the body can lead to negative effects on the neonate and the mother that may interfere with breastfeeding success.

The Effects of Pitocin on the Mother, Newborn, and Breastfeeding

Pitocin can affect the mother and infant in ways that can potentially interfere with breastfeeding success. First, the strong and frequent contractions produced by Pitocin can cause hyperstimulation of the uterus and can have adverse effects on the fetus, such as reduced blood flow (Buckley, 2002). In a study measuring the association between umbilical artery pH and uterine activity, it was found that fetal acidosis (defined as umbilical artery pH of 7.11 or less), which can be a reflection of poor fetal oxygenation, was significantly associated with higher uterine activity (Bakker et al., 2007). This finding is notable, as even a slightly reduced blood pH can lead to problems in the newborn, including a greater likelihood of requiring assisted ventilation (Bakker et al., 2007). Furthermore, it has been suggested that the strong contractions resulting from induction or augmentation can put more pressure on the occipital portion of the fetus' head, potentially increasing the risk for cranial molding, asymmetry, and cranial base misalignment, all of which could negatively impact the functioning of the six cranial nerves involved in sucking and swallowing during breastfeeding (Kroeger, 2004).

Next, induction has been found to be associated with lower Apgar scores, which may be related to the effects described above. At 1 and 5 minutes after birth, a newborn is assigned an Apgar score from 0-10 based on its heart rate, breathing effort, reflexes, muscle tone, and skin color; a score of 7 or higher indicates that the infant is in good condition, whereas a lower score indicates that the infant may need more medical attention (Zieve and Kaneshiro, 2011). Although some studies have found no effect of induction or augmentation on Apgar scores (Ounsted et al., 1978; Belsky, 1982), others have found significant effects. One study found that a 1-minute Apgar score of ≤ 3 was significantly more likely after elective induction than after spontaneous labor (Beebe et al., 2007), and an analysis of 8 Latin American countries from the World Health Organization (WHO) Global Survey for Maternal and Perinatal Health found that infants born to mothers whose labor was induced had twice the risk of a 5-minute Apgar score of < 7 compared to those who were not induced (Guerra et al., 2009). Low Apgar score can potentially interfere with breastfeeding, as Dewey et al. (2003) found that a 1-minute Apgar score of < 7 was associated with increased risk of suboptimal infant breastfeeding behavior (SIBB) 3 days after birth, and a similar study with a different population found that after adjusting for other factors, a 1-minute Apgar score of < 8 was the main predictor of delayed onset of lactogenesis (OL) (Matias et al., 2010). Although evidence varies, this research suggests that induction of labor can potentially affect the fetus enough to result in a lower Apgar score, which can in turn put the mother-infant dyad at greater risk for breastfeeding problems.

Other adverse neonatal outcomes associated with induction or augmentation of labor include hyperbilirubinemia, or jaundice, neonatal resuscitation, shoulder dystocia (failure of the infant's shoulders to pass through the pubic bone during delivery), admission to a

neonatal special care unit, and abnormal fetal heart rate (e.g. bradycardia) (Cartwright 1979; Romano and Lothian 2008; Ounsted et al., 1978; Glantz, 2005; Belsky, 1982; Yudkin et al., 1979). Because successful breastfeeding requires the infant to be motivated and alert with coordinated sucking and swallowing, these outcomes, which can cause increased stress for the infant and reflect some impairment of physiological functioning, could have a negative impact on breastfeeding. This is especially true if the newborn is separated from the mother in an intensive care unit. While it is possible that these effects of induction and augmentation are more related to the underlying reason for induction or augmentation, it has been found that the severity of the reason for induction was not related to the differences in neonatal outcomes between spontaneous and induced groups, suggesting that the differences between these groups was more likely to be an effect of induction (Ounsted et al., 1978). Similarly, another study found that a low 1-minute Apgar score was more common after elective induction than non-elective induction (Beebe et al., 2007); if the lower Apgar scores had been a result of the antenatal conditions requiring non-elective induction, it would be expected that low Apgar scores would be more common in the non-elective group. The fact that the opposite was true in the study suggests that the adverse neonatal outcomes are not merely a result of some pre-existing condition, but are, in fact, related to the induction itself.

Pitocin can also have effects on the mother that can potentially interfere with breastfeeding. First, exogenous oxytocin may cause desensitization or downregulation of OTRs. Studies have found that *in vitro*, OTR responsiveness decreases with prolonged exposure to oxytocin. In one such study, cells were isolated from myometrial tissue samples obtained from women undergoing a C-section and were then exposed to oxytocin for 1-6 hours. Cell response to oxytocin was tested using calcium fluorescence techniques to

measure the rise of intracellular calcium levels. The authors found that exposure to oxytocin inhibited cells responsiveness time-dependently; while 3 hours of exposure to oxytocin resulted in almost no inhibition, responsiveness decreased thereafter until full inhibition was reached at 6 hours (Robinson et al., 2003). Therefore, prolonged exposure to a continuous IV drip of Pitocin could have an effect on the body's responsiveness to Pitocin or endogenous oxytocin, in which case greater doses of Pitocin may be required.

Although desensitization of OTRs is more difficult to study *in vivo*, evidence from one study suggests that OTR desensitization does occur in women exposed to exogenous oxytocin for labor induction or augmentation (Phaneuf et al., 2000). Using a cross-sectional study design, authors compared the number and sensitivity of OTRs from myometrial samples taken from women before the onset of labor, after onset of spontaneous labor, or after induced or augmented labor. While results indicated that receptor desensitization occurs in both spontaneous and induced or augmented labors, there was a significant decrease in oxytocin binding in relation to the duration of oxytocin infusion, and there was a much lower concentration of oxytocin mRNA following induced labor than spontaneous labor. Because of the cross-sectional design of the study, it cannot be known with certainty that the desensitization was a direct result of oxytocin infusion, but the fact that oxytocin binding decreased as a function of the duration of infusion suggests that it was a result of the infusion. There is little, if any, research on desensitization of OTRs in mammary glands, but given that desensitization does occur in myometrial tissue, it is presumable that oxytocin infusion also causes desensitization in mammary tissue. This could impact breastfeeding after birth by inhibiting the oxytocin-induced milk ejection reflex.

Additionally, Pitocin can have antidiuretic effects on the mother, potentially leading to breast engorgement, which can have a negative impact on breastfeeding. Oxytocin and Pitocin molecules resemble vasopressin, a hormone that is also produced in the hypothalamus and released from the posterior pituitary. Vasopressin is an antidiuretic hormone acting on receptors in the kidney, and because of their similar structure, oxytocin and Pitocin can also bind to these receptors to produce an antidiuretic effect. Because Pitocin is often administered in relatively high doses, it can lead to breast engorgement, which interferes with breastfeeding by making it more difficult for the breast to conform to the baby's mouth and for the baby to adequately latch on to the breast (Cotterman, 2004).

Another way that Pitocin could impact breastfeeding success is that it can increase the stress felt by the mother during labor. The stronger and more painful contractions produced by the drug can lead to greater anxiety (Kroeger, 2004), and according to Genazzani et al. (1985), clinical observations have suggested that induction of labor leads to "tocophobia," or anxiety and fear of childbirth, which may be related to the lower β -endorphin levels in augmented labor observed in Genazzani et al.'s (1985) study. In addition, research suggests that oxytocin infusion during labor interacts with the body's stress response system, as one study found that oxytocin infusion elevates the reactivity of the hypothalamic-pituitary-adrenal (HPA) axis, which controls the stress response (Jonas, 2009). Further evidence shows that these effects can impact breastfeeding. For example, numerous studies have found an association between the stress felt by the mother during labor and delivery and delayed onset of lactogenesis (reviewed in Matias et al., 2010). Second, stress during labor and delivery can also make the infant weaker or more tired (Dewey et al., 2001), which could presumably impact motivation and ability to breastfeed. Thus Pitocin can have a negative effect on

breastfeeding not only by increasing the stress felt by the mother during labor, but also by disrupting the natural physiological response to this stress.

Literature Review: Associations Between Pitocin and Breastfeeding Outcomes

Studies specifically examining the association between labor induction or augmentation and breastfeeding outcomes have had somewhat varying results, but evidence tends to suggest that induction and augmentation can have a negative impact on breastfeeding. In some studies, the outcome variable is simply whether or not mothers are breastfeeding following labor. For example, Yudkin et al. (1979) conducted a retrospective study analyzing breastfeeding rates at hospital discharge in mothers with spontaneous deliveries compared with those who were induced, primarily by oxytocin infusion, and the authors found no significant difference in the proportion of women breastfeeding at discharge between the two groups. Similarly, Cartwright (1979) found that women who were induced had similar rates of breastfeeding as those who were not induced. However, both of these studies also included women who were induced by artificial rupture of the membranes (ARM), in which the membranes of the amniotic sac are ruptured to induce labor, so it is possible that the studies would have found significant results if only women induced with Pitocin were included in the study.

In a similar study, Jordan et al. (2009) analyzed the Cardiff Birth Cohort to compare breastfeeding rates at 48 hours after birth in women given oxytocin infusion with those who had received no oxytocin. The authors did not find a significant effect of oxytocin given for induction or augmentation on breastfeeding at 48 hours. However, women who had received oxytocin during the third stage of labor for the prevention of postpartum hemorrhage were

significantly less likely to be breastfeeding at 48 hours, suggesting that exogenous oxytocin can have an effect on breastfeeding. Furthermore, the authors excluded from their analysis any infants with Apgar scores less than 4. As previously discussed, low Apgar scores are associated with Pitocin administration and can affect breastfeeding. Although a low Apgar score could be caused by something unrelated to Pitocin, such as a pre-existing condition, excluding those infants eliminates some subjects that may have exhibited an association between Pitocin and breastfeeding, potentially altering the findings of the study.

Other studies have found a significant association between Pitocin and breastfeeding. A secondary analysis of the WHO Global Survey for Maternal and Perinatal Health found that induction led to an increased risk of delayed initiation of breastfeeding (Guerra et al., 2009). Although this study also included subjects who were induced by means other than intravenous Pitocin, the authors state that the majority of inductions were performed using Pitocin or other form of synthetic oxytocin. Similarly, Ounsted et al. (1978) found that although all mothers in their study had similar intentions to breastfeed, significantly more women who were induced switched to bottle-feeding while still in the hospital or soon after discharge. Interestingly, the differences between groups were only significant when the authors combined the various methods of induction (oxytocin or prostaglandins) and were not significant when they compared each induction group individually with the spontaneous group (e.g. oxytocin vs. spontaneous). However, this may have been due to the smaller sample sizes when each group was compared individually.

Out et al. (1988) found that women whose labors were electively induced with Pitocin were more likely than those with spontaneous labor to give up their intention to breastfeed 1-2 months after delivery, although women with medically induced or augmented labors did

not show the same effect. The authors suggest that one possible explanation for this finding has to do with motivational factors, such that the women who chose to be electively induced had less trust in the natural ability of their bodies to initiate labor and to nourish their infants. This idea is supported by another study that found psychological differences between mothers who were electively induced and those with spontaneous onset (reviewed in Out et al., 1988). Also, certain physiological factors that lead to the spontaneous onset of birth may also prepare the body for breastfeeding, so mothers who are electively induced may be less physiologically prepared to nurse and thus have difficulty after labor (Out et al., 1988).

All of the above studies used a binary outcome variable of whether or not mothers were breastfeeding. Other studies, however, have used outcome variables that measure more specific aspects of breastfeeding. Dewey et al. (2003) assessed breastfeeding success in dyads from northern California using the Infant Breastfeeding Assessment Tool (IBFAT), which assigns a score based on newborn arousal, rooting behavior, time required to latch and feed well, and suckling abilities. Any infant with an IBFAT score of ≤ 10 (out of 12) was defined as having Suboptimal Infant Breastfeeding Behavior (SIBB). Another measure of breastfeeding was delayed onset of lactogenesis (OL), defined as the mother not perceiving fuller breasts by 3 days postpartum. Labor augmentation with Pitocin was not significantly associated with SIBB on day 0, 3, or 7, although the trend was that the percentage of infants with SIBB on each of the three days was somewhat higher in the augmentation group. Augmentation was, however, significantly associated with delayed OL, indicating that Pitocin can influence breastfeeding success. This study only included labors that were augmented but not induced, though, so it is not known whether that would have had an association with SIBB or delayed OL.

Matias et al. (2010) conducted a nearly identical study in a population of Peruvian primiparous mothers. The results were the same; augmentation of labor with Pitocin was significantly associated with delayed OL, though the association between Pitocin and SIBB did not reach significance. The authors suggest that the delayed OL may have been related to the amount of stress felt by mother and infant during labor, as augmentation was the only variable associated with low Apgar score, which can reflect fetal stress during labor. In contrast to the results of Dewey et al. (2003) and Matias et al. (2010), however, Chapman and Perez-Escamilla (1999) found that induction of labor with oxytocin was not significantly associated with delayed OL.

Finally, Jonas et al. (2009) studied plasma oxytocin levels in women who received Syntocinon either intravenously for labor augmentation or intramuscularly for prevention of post-partum hemorrhage (PPH). Between 24 and 48 hours after delivery, the infant was placed skin-to-skin on the mother's chest, and blood samples were taken at regular intervals once the infant began suckling. Results showed that women who had received intravenous oxytocin during labor had lower median plasma oxytocin levels during breastfeeding, with a negative correlation between the dose of Syntocinon and plasma levels of oxytocin during the sampling period (i.e. the greater the dose of Syntocinon, the lower the endogenous levels of oxytocin). According to the authors, these results suggest that exogenous oxytocin administered during labor does interfere with natural feedback mechanisms that control the release of oxytocin, and this effect lasts for at least two days after delivery.

Although some studies have not found a significant effect of labor induction or augmentation on breastfeeding, the evidence overall suggests that induction or augmentation of labor can negatively influence breastfeeding (Table 1).

Table 1. Summary of Literature Review

Study	Results	Sig. Effect of Induction or Augmentation?
Ounsted et al., 1978	- Induced mothers were more likely to switch to bottle-feeding	Yes
Guerra et al., 2009	- Induction associated w/delayed initiation of breastfeeding	Yes
Jonas et al., 2009	- IV oxytocin during labor associated w/lower plasma oxytocin levels 24-48 hrs postpartum	Yes
Out et al., 1988	- Elective induction associated with lower breastfeeding rates 1-2 months after delivery - Medical induction & augmentation had no effect on breastfeeding rates	Yes and No
Dewey et al., 2003 & Matias et al., 2010	- Augmentation associated with delayed onset of lactogenesis - Labor augmentation not associated with SIBB on day 0, 3, or 7	Yes and No
Jordan et al., 2009	- Women given oxytocin during 3 rd stage of labor had lower breastfeeding rates - Breastfeeding rates at 48 hours similar among women given oxytocin infusion during labor and those without it	Yes and No
Cartwright, 1979	- Induced and spontaneous mothers had similar rates of breastfeeding	No
Yudkin et al., 1979	- At hospital discharge, mothers with induction and spontaneous labor had similar breastfeeding rates	No
Chapman and Perez-Escamilla, 1999	- Labor induction was not associated with delayed onset of lactogenesis	No

The Importance of Breastfeeding

Exclusive breastfeeding has numerous benefits for infants, including lower morbidity and mortality, lower incidence of diarrhea, lower blood pressure and cholesterol levels later in life (Bai et al., 2009), reduced risk of developing allergies like asthma, and enhanced immune protection against various illnesses, such as respiratory diseases, ear infections, colds, viruses, and SIDS, as well as cognitive benefits. Breastfeeding also provides benefits

for the mother, including lower risk of developing type 2 diabetes later in life and reduced likelihood of breast and ovarian cancer (“La Leche,” 2011). Furthermore, a recent study calculated that based on the costs of treating health problems associated with non-exclusive breastfeeding, the U.S. would save \$13 billion per year and prevent 911 excess deaths (primarily infant deaths) if 90% of infants were exclusively breastfed for six months (Bartick & Reinhold, 2010).

The establishment of successful breastfeeding in the first days following birth is critical. First, if a mother and newborn encounter problems breastfeeding early on, the newborn may not receive enough milk and therefore experience excessive weight loss, dehydration, and other complications (Dewey et al., 2003). Studies have also shown that breastfeeding problems shortly after birth, such as poor positioning and ineffective sucking and latch, are associated with shorter overall duration of breastfeeding (Kronborg and Vaeth, 2009; Santo et al., 2007; Cernadas et al., 2003). Breastfeeding problems within the first week after birth is even associated with decreased likelihood of successful breastfeeding with subsequent children (reviewed in Dewey et al., 2003). Furthermore, Chapman and Perez-Escamilla (1999) found that among women who intended to breastfeed for longer than 6 months, those who had delayed OL had significantly shorter breastfeeding duration than mothers with earlier OL. One reason for this finding may be that mothers with delayed OL experienced more problems nursing and had less confidence in their ability to produce enough milk and were thus more likely to switch to bottle-feeding sooner.

Early Breastfeeding Assessment

A commonly used method to assess breastfeeding after birth is the LATCH scoring system. The LATCH score is a 10-point measure modeled after the Apgar score and is often used in hospitals and birth centers to identify dyads that need more assistance to establish successful breastfeeding (Table 2). The score is based on five dimensions of breastfeeding: infant latch (L), audible swallowing (A), type of nipple (T), comfort of breast/nipple (C), and hold/positioning (H) (Jensen et al., 1994). LATCH scores have been found to be associated with breastfeeding duration (Kumar et al., 2006). In one study, Kumar et al. (2006) measured LATCH scores at regular intervals during the first 3 days postpartum and found that at 6 weeks after birth, mothers who were still breastfeeding their infants had received significantly higher LATCH scores 0-48 hours after birth than mothers who were not breastfeeding at 6 weeks. The study also found that mothers who had a LATCH score of 9 or higher at 16-24 hours postpartum were 1.7 times more likely to still be breastfeeding at 6 weeks than mothers who had lower scores during that time period. In another study, it was found that LATCH score was inversely related to non-exclusive breastfeeding at the time of discharge from the hospital, and the mean score of dyads exclusively breastfeeding at discharge was significantly higher than the mean score of those who were not exclusively breastfeeding (Tornese et al., 2012). These findings all underscore the importance of establishing successful breastfeeding in the immediate postpartum period.

Aims and Predictions

To date, there have been no studies examining the association between Pitocin administration and LATCH scores. The goal of the present study is to compare LATCH scores in women receiving intravenous Pitocin for induction or augmentation of labor with those of women who received no Pitocin prior to delivery. The primary aims are as follows:

- To determine whether Pitocin has an effect on overall LATCH score following birth
- If there is an effect on LATCH score, to determine if Pitocin primarily affects the mother, the infant, or both
- To determine if there is an effect of Pitocin on the infant's Apgar score, and if so, if that leads to lower LATCH score.

Based on the evidence that Pitocin can lead to adverse neonatal and maternal outcomes that can impact breastfeeding, I hypothesize that mother-infant dyads exposed to intravenous Pitocin will have significantly lower LATCH scores following birth than dyads that were not exposed to Pitocin. I also predict that if, as studies suggest, Pitocin has adverse effects on the infant, such as poorer oxygenation and increased stress during labor, the "Latch" and "Audible swallowing" components of the LATCH score will be lower in the Pitocin group. If Pitocin impacts maternal behaviors or causes the mother greater stress or anxiety following birth, I expect to find that the Pitocin group will have lower scores on the "Hold" component of the score. Furthermore, because the antidiuretic effects of Pitocin can lead to edema and thus breast engorgement (Cotterman, 2004), I expect that mothers who received Pitocin will have lower scores on the "Comfort" component of the LATCH score. However, I do not expect to see an effect of Pitocin on "Type of nipple."

I will also control for overall condition of the newborn, measured by Apgar score, in the analyses as a factor that could influence LATCH scores and potentially interact with the effects of synthetic oxytocin to influence breastfeeding success. It is expected that if Pitocin impacts LATCH score by negatively affecting the health of the neonate, this would result in a significant interaction effect between Pitocin, Apgar and LATCH score.

Given the life-long health benefits of breastfeeding and the importance of establishing successful breastfeeding in the early postpartum period, along with the rising rates of Pitocin use in hospitals, the results of this study may have implications for hospital practice in the U.S. by identifying dyads that are more at risk for breastfeeding problems and by providing more evidence about the impacts of Pitocin use.

Methods

Subjects

For this study, retrospective data for mother-infant dyads will be obtained from de-identified electronic medical records (EMRs) at Loma Linda University Medical Center, a large university hospital in southern California. Dyads will be selected based on the following criteria: singleton birth, vaginal delivery with no major complications (e.g. postpartum hemorrhage, admission to the NICU, etc.), no pain medications given (e.g. epidural analgesia), ≥ 37 weeks gestational age, ≥ 5.5 lbs birth weight, and exclusive breastfeeding. A preliminary power analysis will be conducted to determine the number of subjects needed for the study.

Variables

The independent variable in this study is the use of Pitocin prior to delivery. All mothers in the treatment group will have received intravenous Pitocin for induction or augmentation of labor, whereas mothers in the control group will have received no Pitocin or other medications prior to delivery.

The outcome variable is LATCH score assessed during the first feeding after birth (Table 2). At Loma Linda, it is standard protocol for nurses trained in LATCH scoring to assess breastfeeding postpartum. The first two dimensions of the LATCH score (latch and audible swallowing) are based on the newborn's behavior, while the other three (type of nipple, comfort, and hold) are based on characteristics of the mother. Each dimension has a possible score of 0-2 (Table 2), and the overall LATCH score can range from 0-10, with a score of 10 representing the most successful breastfeeding. In addition, one covariate that

will be used in the study is Apgar score at 1 and 5 minutes, which will be included in the analyses in order to determine whether an effect of Pitocin on Apgar score may then influence LATCH score.

Table 2. LATCH Scoring System

	0	1	2
L: Latch	- Too sleepy or reluctant - No latch achieved	- Repeated attempts - Hold nipple in mouth - Stimulate to suck	- Grasps breast - Tongue down - Lips flanged - Rhythmic sucking
A: Audible Swallowing	- None	- A few with stimulation	- Spontaneous and intermittent < 24 hours - Spontaneous and frequent > 24 hours old.
T: Type of Nipple	- Inverted	- Flat	- Everted (after stimulation)
C: Comfort (Breast/nipple)	- Engorged - Cracked, bleeding, large blisters, or bruises - Severe discomfort	- Filling - Reddened/small blisters or bruises - Mild/moderate discomfort	- Soft - Non-tender
H: Hold (positioning)	- Full assist (staff holds infant at breast)	- Minimal assist - Teach 1 side; mother does other - Staff holds and then mother takes over	- No assist from staff - Mother able to position/hold infant

Table copied from Jensen et al. (1994)

Statistical Analyses

Using SPSS statistical software version 19.0, the association between administration of Pitocin and LATCH score will be analyzed with a generalized linear model, with an ordinal distribution and logistic link. In this model, the ordinal response variable is total

LATCH score of 0-10; predictors are Pitocin administration (yes, no) as a fixed factor, Apgar score as an ordinal covariate, and the interaction between Pitocin and Apgar score.

In addition to the model for the total LATCH score, each of the five dimensions of the LATCH score will be analyzed separately using a generalized linear model. In each of these models, the ordinal response variable is a score between 0-2 for the various dimensions of the LATCH score (e.g. latch, audible swallowing, etc.), and the predictor and interaction variables are the same as in the model for total LATCH score.

Discussion

Expected Results

If mother-infant dyads exposed to Pitocin during labor have significantly lower overall LATCH scores compared to those not exposed to Pitocin, these results would indicate that Pitocin does have an effect on breastfeeding, supporting my hypothesis. However, analyzing only the overall LATCH score does not provide information about why Pitocin impacts breastfeeding, so it is more useful to compare individual components of the LATCH score.

“Latch”

The first component of the LATCH score is “Latch,” which measures the infant’s ability to latch on to the breast (Table 2). Significantly lower scores on the “Latch” component of the LATCH score for infants exposed to intravenous Pitocin compared to those that were not would indicate that infants in the Pitocin group tend to have difficulty latching on to the breast during breastfeeding, supporting my hypothesis. In order for the neonate to establish an adequate latch, it must be able to create enough suction to hold the areola and nipple in its mouth, which requires proper oral and facial muscle tone (Radzynski, 2005). The “Latch” component also measures whether the infant displays rhythmic sucking while maintaining latch, which requires coordination of sucking, swallowing, and breathing. The inability of the newborn to maintain adequate latch and coordination may reflect poor neurobehavioral functioning. Several cranial nerves, including the facial and accessory nerves, control the muscles involved in latching on to the breast (Radzynski, 2005), and as previously mentioned, it has been suggested that the stronger uterine contractions produced

by Pitocin can interfere with the proper functioning of these cranial nerves (Kroeger, 2004). In order to achieve adequate latch, the newborn must also be alert and willing to nurse (Radzynski, 2005). It has been suggested that stress to the fetus during labor and/or birth can interfere with motivation to breastfeed (Chen et al., 1998) or cause it to be weak and tired (Dewey, 2001), which could result in a score of 0 on the “Latch” component if the infant is too sleepy or reluctant to latch. Jaundice, which is associated with Pitocin use (Cartwright, 1979), can also cause an infant to be sleepier (La Leche League International, 2004). Moreover, according to clinical observations, newborns with hypoxia, which can result from the strong uterine contractions caused by Pitocin, tend to breastfeed poorly (Walker, 1989), which could be reflected by a lower “Latch” component score.

The inability of a newborn to attain adequate latch could also reflect a disorganized behavioral state. Newborns normally cycle through various behavioral states, from deep sleep to quiet alert to crying, with quiet alert being the ideal state for adequate latch (Karl, 2004). However, newborns that have trouble regulating their autonomic nervous system, which includes heart rate and respiration, may also have difficulty organizing their behavioral state and reaching a quiet alert state. Stress and overstimulation can lead to a disorganized state characterized by loss of motor organization, decreased muscle tone, or a “closedown” reaction, in which the newborn closes its eyes and remains still in order to shut out negative stimuli (Karl, 2004). Therefore, because Pitocin use is sometimes associated with abnormal heart rate (e.g. bradycardia) (Belsky, 1982; Glantz, 2005) and other stressors at the time of delivery (e.g. shoulder dystocia, assisted ventilation) (Romano & Lothian, 2008), the newborn may then be in a disorganized behavioral state that negatively impacts its ability to achieve proper latch.

Furthermore, if Pitocin was used for induction of labor (as opposed to augmentation), an alternative explanation for a newborn's inability to establish adequate latch is that the newborn may be "near-term" rather than full-term. Even if a fetus's size and gestational age suggest that it is full-term, inducing labor rather than letting it begin spontaneously is more likely to result in the birth of a near-term baby. Although a near-term newborn may look similar to a full-term infant, it may not be fully mature and may have a less-developed ability to latch on to the breast and coordinate sucking and swallowing (Lothian, 2006). Thus a low score on the "Latch" component can be explained as a result of a near-term delivery, as well as a result of stress felt by the neonate during labor and delivery and poor neurobehavioral functioning caused by excessively strong uterine contractions.

"Audible Swallowing"

The second component of the LATCH score is "Audible swallowing," which measures whether or not swallowing is heard as a short, forceful expiration of air during breastfeeding (Jensen, 1994). Audible swallowing is the main indicator of milk intake and indicates that the milk ejection reflex has occurred (Jensen, 1994). A lower score on this component would suggest that the infant is not adequately taking in milk, which could be a result of inadequate suckling technique, such as poor coordination of sucking, swallowing, and breathing or the inability to compress the areolar tissue in order to express milk from the breast. A lack of milk expression could also indicate a problem with the milk ejection reflex; as previously discussed, the primary role of oxytocin in breastfeeding is stimulating the alveoli within the breast to contract and eject milk into ducts in response to suckling. If, as hypothesized, dyads exposed to Pitocin have significantly lower "Audible swallowing"

scores, this could suggest that Pitocin affects the infant's ability to properly grasp the breast and coordinate sucking and swallowing in order to take in milk in the same ways that it could affect its ability to maintain adequate latch, as discussed above. A lower "audible swallowing" score could also mean that Pitocin interferes with maternal release of oxytocin, which stimulates the milk ejection reflex. This would be consistent with the finding that mothers exposed to Pitocin had lower levels of endogenous oxytocin released during breastfeeding 24-48 hours after birth (Jonas et al., 2009). Alternatively, animal studies have shown that the stress response can interfere with milk ejection (e.g. by vasoconstriction within the mammary glands) (reviewed in Lau, 2001), and because intravenous Pitocin has been found to increase the reactivity of the HPA axis involved in the stress response (Jonas, 2009), the milk ejection reflex of mothers who received Pitocin may be affected by this heightened reactivity of their stress response. If this were the case, the infant may not receive as much milk during feeding and would thus not exhibit audible swallowing.

"Comfort of Breast/Nipple"

The fourth component of the LATCH score is "Comfort of the breast/nipple," which is hypothesized to be significantly lower in women exposed to Pitocin. Breast engorgement, mild to severe overall discomfort when nursing, nipples with redness, small to large blisters or bruises, cracking or bleeding will result in a "Comfort" score of only 0 or 1. Soreness or other problems with the nipple can result from improper infant latch and sucking – for example, if the nipple is sucked in rather than placed far back in the baby's mouth (La Leche League International, 2004). Thus, if this were the reason for lower scores on "Comfort," it would be expected that the "Latch" component score would also be lower. Another possible

reason for a lower “Comfort” score is breast engorgement related to the antidiuretic properties of oxytocin and Pitocin (Cotterman, 2004). While naturally-produced oxytocin can produce this effect, the somewhat higher levels of Pitocin administered during labor induction or augmentation may be more likely to cause edema and breast engorgement, thus resulting in a lower “Comfort” score.

“Hold”

The “Hold” component of the LATCH score assesses how well the mother holds her infant during breastfeeding, and its main purpose is to determine how much assistance and teaching the mother requires from hospital staff (Jensen, 1994). If the mother is not able to position and hold her infant without help from staff, she will receive a lower score. If the hypothesis that the “Hold” component of the LATCH score would be lower in the Pitocin group is supported, there are several possible explanations for this finding. First, as discussed previously, it may be possible that when labor does not begin on its own, there is a difference in the amount of oxytocin released within the brain compared to spontaneous labor. Because oxytocin is known to influence maternal behavior, if a mother has lower levels of oxytocin released within the central nervous system as a result of labor induction, her own maternal behaviors may be impacted in such a way that she is less able to position and hold her infant on her own during breastfeeding, especially if she has had no prior experience breastfeeding.

A second explanation for a lower “Hold” score in the Pitocin group is that these women have less confidence in their ability to nurse their infants as a result of induction or augmentation and thus require greater assistance to hold and position the newborn. One study of women’s breastfeeding self-efficacy in the immediate postpartum period, which is related

to overall duration of breastfeeding, found that a woman's sense of control during labor and her satisfaction with pain relief were correlated with her breastfeeding self-efficacy, and mothers with more interventions during labor and delivery had lower self-efficacy scores (Dennis, 2006). Because Pitocin often causes stronger, more frequent, and more painful uterine contractions, a woman whose labor is induced or augmented may feel less control and greater pain during labor, thus reducing her sense of breastfeeding self-efficacy and causing her to require greater assistance to hold and position the infant, resulting in a lower "Hold" score.

Apgar Score

If the interaction between Pitocin and Apgar score is found to significantly affect LATCH score, as hypothesized, this would indicate that Pitocin affects the health of the infant, reflected in the Apgar score, in a way that negatively impacts breastfeeding ability. For example, as previously discussed, Pitocin has been found to be associated with fetal acidosis (Bakker et al., 2007), bradycardia (Belsky, 1982; Glantz, 2005), and neonatal resuscitation (Romano and Lothian, 2008). These outcomes could result in a lower Apgar score and thus LATCH score, as lower Apgar scores can be associated with breastfeeding problems (Dewey et al., 2003; Matias et al., 2010). Alternatively, if labor is induced when the fetus is near-term rather than full-term, it could be less developmentally prepared for extrauterine life, which could result in both a lower Apgar score and a lower LATCH score. On the other hand, if a medical condition of the fetus necessitated induction of labor with Pitocin, both low Apgar and LATCH score could be results of the antenatal condition leading to induction rather than results of Pitocin itself. While some studies control for Apgar score

by excluding from analyses infants with low scores, analyzing the interaction between Pitocin and Apgar score as a predictor of LATCH score provides a way to determine if poor neonatal health following birth, as measured by Apgar score, helps explain lower LATCH score.

Alternative Results

The third component of the LATCH score is “Type of nipple,” with flat or inverted nipples receiving a lower score than everted nipples. It is hypothesized that Pitocin would not have an effect on “Type of nipple” score, because inverted nipples are often caused by adhesions binding the skin of the nipple and areola to the underlying tissue (Smith, 2012), which is unlikely to be related to Pitocin use. However, if scores for this component are found to be lower in women who received Pitocin, one possible explanation is breast engorgement. As mentioned, the antidiuretic effects of Pitocin can lead to fluid retention and breast engorgement, which can then result in flat nipples that do not protrude when stimulated during breastfeeding (“Flat and Inverted Nipples,” 2011) and thus a score of 1 on the “T” component of the LATCH score.

It is also possible that this study will not find a significant association between Pitocin administration and overall LATCH score. If this were the case, a possible explanation would be that, contrary to my hypothesis, Pitocin did not affect the dyads in the study sample in a way that interferes with breastfeeding. On the other hand, it is possible that Pitocin affects breastfeeding in ways not measurable by the LATCH scoring system. For example, studies have found that labor augmentation with Pitocin is significantly associated with delayed OL (Dewey et al., 2003; Matias et al., 2010), but because OL does not occur until around 3 days

postpartum, LATCH scores assessed within the first several hours following birth would not measure delayed OL.

Another explanation for lack of a significant association between Pitocin and LATCH score could be related to the fact that Loma Linda University Medical Center is a Baby Friendly Hospital. Hospitals with the UNICEF/WHO Baby Friendly designation demonstrate routine practices known to promote breastfeeding, including giving the infant no food or drink other than breastmilk unless medically indicated and allowing the mother and infant to remain in the same room together 24 hours a day. Therefore, some of the potentially negative effects of Pitocin on breastfeeding may be mitigated by these practices that are designed to promote optimal breastfeeding. Future studies should look at data from hospitals without the Baby Friendly designation and with lower breastfeeding rates than Loma Linda, where potentially small effects of Pitocin could have a greater impact on breastfeeding since mothers are not receiving as much breastfeeding support.

Another explanation for a finding of no association between Pitocin and LATCH score is that at Loma Linda, like many hospitals in the U.S., it is routine practice for mothers to receive an intramuscular injection of Pitocin following delivery for PPH. Jordan et al. (2009) found that the use of Pitocin after delivery for this purpose was associated with lower breastfeeding rates at 48 hours. Therefore, even if Pitocin given for PPH does have a negative effect on LATCH score, there would not be a significant difference between the control and Pitocin groups if all mothers are given Pitocin for PPH. Future studies should obtain data from control groups that have not been exposed to Pitocin for PPH in order to control for the possible confounding effects of this routine practice.

If, contrary to my hypothesis, LATCH scores are significantly lower in the Pitocin group without a significant interaction between Pitocin and Apgar score, this could indicate that lower LATCH scores have more to do with characteristics of the mother, such as breast engorgement. Or, it could mean that the cause of the infant's difficulty breastfeeding is not measured by Apgar score. For instance, sleepiness resulting from jaundice or a problem with the cranial nerves controlling muscles used in latching on would not be likely to result in a lower Apgar score, even though they could result in lower LATCH score.

Although unlikely, it is possible that mothers receiving Pitocin will have *higher* LATCH scores than the control group, contrary to my hypothesis. One conceivable explanation is that the stronger and more frequent contractions caused by Pitocin somehow stimulate a greater release of oxytocin from the posterior pituitary via the Ferguson reflex and that higher levels continue to be released even after birth in response to suckling. This could then stimulate the milk ejection reflex, which would most likely result in a higher "Audible swallowing" score, as discussed above. This would, however, be inconsistent with Jonas et al.'s (2009) finding that women exposed to intravenous oxytocin had lower circulating levels of oxytocin during breastfeeding 24-48 hours postpartum. It could also be possible that the higher circulating levels of Pitocin during labor resulting from induction or augmentation compared to circulating levels of oxytocin during spontaneous labor somehow enhances the milk ejection reflex after birth, although this, too, would be unlikely given that the half-life of oxytocin (and thus Pitocin) in circulation is only 1-2 minutes (Jonas, 2009). Finally, although the blood-brain barrier prevents oxytocin/Pitocin from entering the brain, higher LATCH scores in the Pitocin group could result from a very small percentage of

Pitocin reaching the brain from the peripheral circulation and stimulating release of oxytocin into circulation or enhancing maternal behaviors.

Future Studies

There are many possibilities for future studies to further investigate the impact of labor induction on breastfeeding. For example, because previous studies have found that there are sex differences in neonatal response to certain stressors (Davis and Emory, 1995), it would be interesting to study whether there is a sex difference for the effects of Pitocin on the neonate. Future studies could also investigate whether there is a difference in the effect of Pitocin on breastfeeding between primiparas and multiparas; it would make sense that because multiparas have likely had prior experience breastfeeding, they would be less susceptible to some of the potentially negative effects of Pitocin and would have higher LATCH scores, especially for the “Hold” component. And although it is not possible in the proposed study to determine solely from the electronic medical records whether Pitocin is given for induction or for augmentation, future studies that have access to this information should investigate whether there is a difference in the effects of Pitocin on LATCH score between induced and augmented labors. A finding that LATCH scores are lower when labor is induced compared to when it is augmented would suggest that the adverse effects are because the mother and/or infant are less physiologically and developmentally prepared for breastfeeding (e.g. the neonate is “near-term” rather than full-term).

Future studies should also examine the interaction between Pitocin and other drugs commonly administered during labor, such as epidural for pain management. Many studies have found that epidurals have adverse effects on breastfeeding, so it would be important to

further investigate the combined effects of Pitocin and other drugs. Finally, because there is minimal research on the direct effects of Pitocin on maternal behavior, this is another area for future study. Although the “Hold” component of the LATCH score provides some measure of maternal behavior, futures studies should explore other aspects of maternal behavior to determine whether Pitocin interferes with the role of endogenous oxytocin in facilitating maternal behaviors following birth.

Implications

Given the widespread and routine use of Pitocin in hospitals across the U.S., the results of this study will have broad implications for maternal and neonatal health. Although there are many known health benefits of breastfeeding, less than half of mothers in the U.S. breastfeed exclusively for the first six months as recommended by the American Academy of Pediatrics and the World Health Organization (Bai et al., 2009). Therefore, it is even more important to identify factors that can have adverse effects on breastfeeding. Even though this study will only look at breastfeeding success immediately following birth, mothers who experience problems at this early stage may have less confidence in their ability to breastfeed and may be more likely to give up breastfeeding sooner if they do not receive adequate support to resolve early problems.

The results of this study will have practical applications in clinical settings. First, if Pitocin is found to be associated with lower LATCH scores, this knowledge would help hospital staff identify dyads that are more at-risk for breastfeeding problems and may need extra support to ensure the establishment of successful breastfeeding routines. Second, if Pitocin is found to be associated with poorer breastfeeding outcomes, it would be an

important factor to consider when mothers and health care professionals are deciding whether or not to use Pitocin. There certainly are instances in which the use of Pitocin is medically necessary and the benefits outweigh the potential risks. However, induction and augmentation with Pitocin has become a nearly routine practice in many hospitals and is often done without real medical necessity. For example, the Listening to Mothers II survey found that a maternal health problem was a reason for induction less than 20% of the time, and concern for the baby's health was cited as a reason less than 10% of the time (Declercq et al., 2006). Hospitals must reevaluate their practices in order to prevent the overuse of interventions like intravenous Pitocin that have the potential to be detrimental to both the short- and long-term health of the mother and infant.

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