Labor Pain

3

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3.1 Introduction

The pain experienced in labor by women has been described by some as the worst pain ever experienced [1]. Pain perception during labor changes in intensity and nature as labor progresses, and this is associated with the behavioral changes in the laboring woman. However, these behavioral changes are not uniform, suggesting that the perception and intensity of the pain may be modulated by various emotional factors. This chapter will discuss the basics relating to the transmission of pain signals from the periphery to the central nervous system as well as discuss the changing nature of labor pain. The ways in which labor pain perception can be measured and modulated will also be discussed.

3.2 Pain Pathways

Pain has been described as an "unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" [2]. As expected, the pathways, which transmit such complex sensations, are equally complex themselves. The major pathway which transmits pain (and temperature) from the body to the brain (Fig. 3.1) is known as the spinothalamic tract and consists of several components [3]:

1. Medium sized Aδ and small unmyelinated C nerve fibers transmit signals from peripheral nociceptors, which then enter the spinal cord through the lateral division of the dorsal horns. These axons then form the Tract of Lissauer which travels up and down for one or two spinal segments on the same

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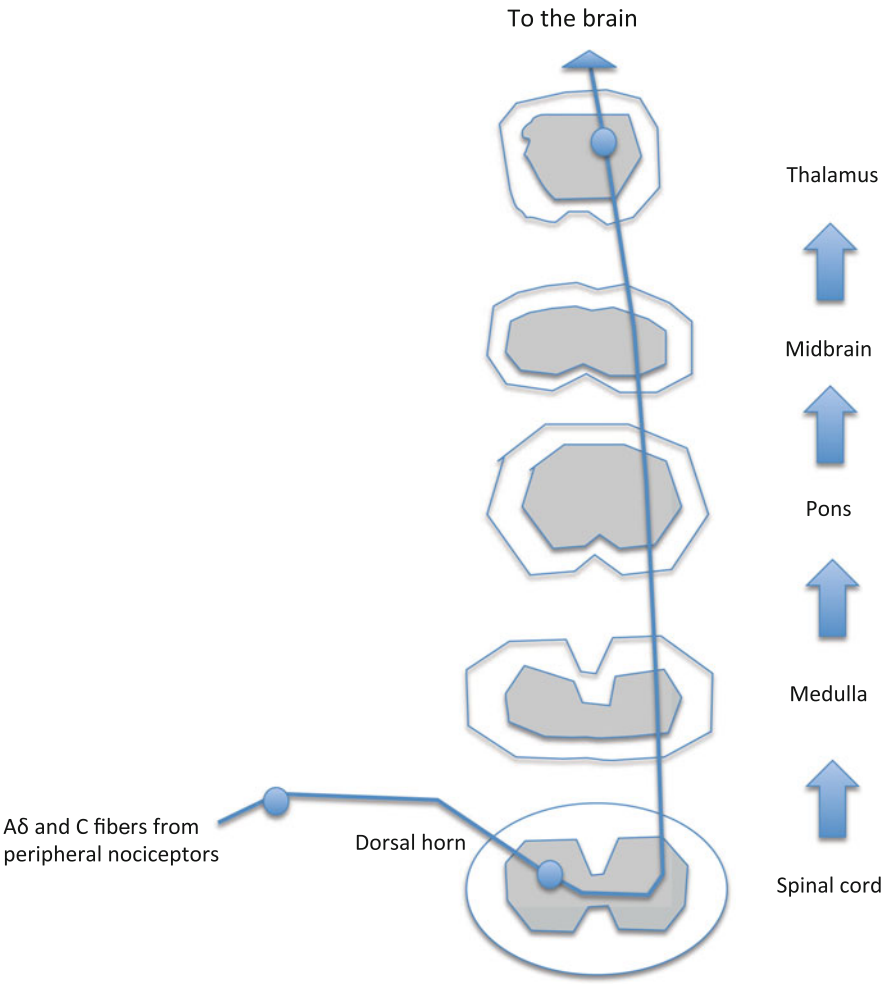


Fig. 3.1 The course of the spinothalamic tract

(ipsilateral) side of the spinal cord. These axons then enter the gray matter of the spinal cord and send projections to neurons in Rexed's laminae I (also known as the marginal zone), II (also known as the substantia gelatinosa), III, and IV (Fig. 3.2).

2. Axons in Rexed's laminae I–IV synapse with second-order neurons in Rexed's laminae V, VI, VII, and VIII, which are collectively known as the nucleus proprius. Some of the axons in Rexed's lamina I synapse with second-order neurons located within the same lamina. These second-order neurons from Rexed's laminae V–VIII along with second-order neurons from Rexed's lamina

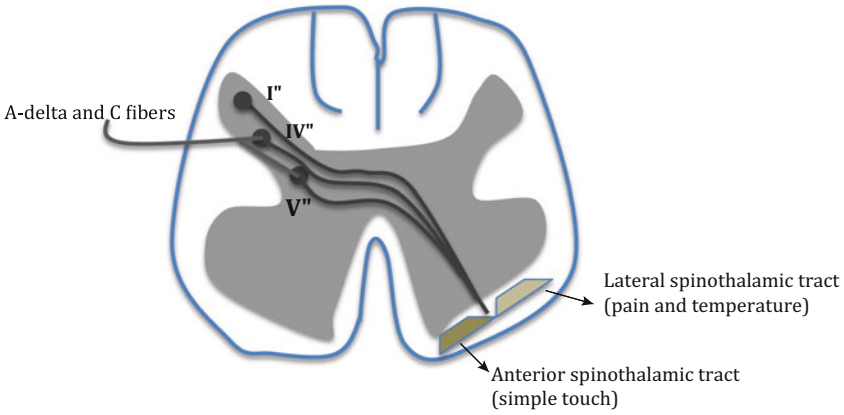


Fig. 3.2 Spinothalamic tract

I have axons, which cross the midline in the anterior white commissure and ascend to the brainstem and thalamus in the anterolateral quadrant on the contralateral half of the spinal cord as the spinothalamic tract. Pain fibers from the sacral and lower areas of the body are located laterally in the spinothalamic tract, whereas those transmitting pain from the upper half of the body are found on the medial side of the tract.

3. Once in the brain, the second-order neurons synapse and terminate with neurons found in the ventro posterolateral nucleus (VPL) of the thalamus. These third-order neurons have projections to various parts of the brain such as the frontal cortex and the anterior cingulate gyrus which then modulate both the emotional and behavioral response to pain via descending pathways.

A similar pathway known as the trigeminal pain and temperature system carries pain and temperature sensations from the face to the brain.

There are two types of pain which are experienced in pregnancy:

- *Visceral pain*—this is the pain transmitted by nociceptors from internal organs and may be referred to areas of the body distant to the organ. This type of pain is typically vague and difficult to localize.
- *Somatic pain*—this is the pain transmitted by nociceptors in the skin and deep tissues. The pain by comparison with visceral pain is localized to the area where the nociceptors have been stimulated.

3.3 Innervation of the Uterus and Cervix During Pregnancy and Labor

The uterus is functionally formed of two components: the cervix and the body (corpus uteri). The uterus is supplied by both somatic and autonomic nerve fibers from the hypogastric plexus. The hypogastric plexus is a continuation of the aortic plexus and is found anterior to the terminal aorta, fifth lumbar vertebra, and the sacral promontory [4]. The afferent (sensory) fibers, which transmit pain from the uterus, travel in close association with sympathetic nerve fibers in the hypogastric plexus to the sympathetic chain before entering the spinal cord [5, 6]. In addition, efferent nerve fibers travel from the spinal cord via the hypogastric plexus to modulate smooth muscle activity in the cervix [7–10]. The parasympathetic supply to the uterus is from the second, third, and fourth sacral segments, collectively known as the pudendal nerve [4].

As pregnancy progresses, the nerve supply to the uterus undergoes extensive changes. The corpus uteri becomes progressively denervated as the gravid uterus increases in size, but the dense network of nerves from the hypogastric plexus to the cervix remains unchanged.

Throughout pregnancy, the cervix remains a rigid, immobile structure, which is closed and acts to protect the developing fetus from the external vaginal environment. At the onset of labor, the cervix undergoes extensive remodeling to become soft and progressively dilates to facilitate the delivery of the fetus. This process of cervical change in preparation for delivery is known as cervical ripening. What has been shown is that as cervical dilatation progresses throughout labor, the intensity of pain experienced by women increases [11]. Rat models have demonstrated increased expression of cFos, a protein, which is found in spinal cord neurons in response to painful stimuli, with progressive cervical dilatation [12]. Transection of the hypogastric nerve in rats has been associated with prevention in the increase of pain intensity as labor progresses [13] along with altered behavioral changes [14] and reduced pain perception following dilatation of the uterus [15].

The transient receptor potential vanilloid receptor subtype 1 (TRPV1) is a receptor, which exists in sensory nerve endings and plays a role in the transmission of nociceptive stimuli. The receptor responds primarily to capsaicin, an active component in chili peppers, and heat, and its presence continues to be observed in the cervix throughout pregnancy, cervical ripening, and labor [16]. Application of capsaicin to TRPV1 receptors in the cervix in mice shows a biphasic response: there is an initial burning sensation associated with nerve depolarization followed by a reduction in labor pain behavioral activity as a result of decreased nerve transmission [17].

The process of cervical ripening has been observed to be an immune-mediated inflammatory process [18–20] with the migration of macrophages [21] and inflammatory mediators [22–26] to the cervix as it undergoes extensive changes. This process appears to be mediated by nerve fibers separate to the hypogastric plexus as

transection of the plexus in pregnant mice did not stop the onset of labor and delivery of pups [27].

3.4 Neuroendocrine Aspects of Labor Pain

The pain experienced by women during labor is a complex process with both sensory and affective components, and studies have shown a variable response to pain between parturients [1, 28]. Melzack and Wall described how the perception and interpretation of pain could be modified by various behavioral, hormonal, and emotional factors by describing their Gate Control Theory [29] and introducing the concept of the Neuromatrix [30, 31]. The Neuromatrix or rather the Pain Matrix as it is known now [32] is a collection of different regions of the brain with neuronal inputs to the periaqueductal gray (PAG), which modulates the descending pain pathways to produce a response to the noxious stimulus. Imaging of the brain has shown that by distracting subjects when applying heat stimuli can actually lower their response to pain, and this is reflected in altered signals in different regions of the pain matrix [33].

During labor, there is an increase in plasma catecholamines in response to the pain and anxiety felt in labor. The uterus has both α- and β-adrenergic receptors to which both adrenaline (epinephrine) and noradrenaline (norepinephrine) may bind. Studies in pregnant rats have shown that when levels of adrenaline and noradrenaline rise to levels seen in times of stress, they have a tocolytic effect on uterine contractions [34]. Uterine contractions return when levels of catecholamines are reduced or their effects are antagonized through the use of propranolol or phentolamine [34]. This implies that high levels of stress and anxiety have a negative effect on the progress of labor, and any measure which can reduce the levels of stress such as effective labor analgesia could be beneficial.

Oxytocin is a peptide made up of nine amino acids. It is secreted by the posterior pituitary gland, and studies in rabbits [35], sheep [36], cows [37], and rhesus monkeys [38] have shown a pattern of secretion which is pulsatile and is maximal at the time of delivery of the fetus. Oxytocin binds to the oxytocin receptor, which is found in the uterine tissues and stimulates uterine contractions. The secretion of oxytocin is enhanced by Ferguson's reflex where sensory stimuli transmitted by sacral afferents travel to the midbrain to increase oxytocin release. This reflex is disrupted in spinal cord injury [39]. The use of epidural analgesia has also been shown to reduce the secretion of oxytocin [40] and therefore potentially delay the progress of labor.

At a molecular level, the transmission and propagation of pain from peripheral receptors to nerve fibers depend on the expression of various neurotransmitters at the nerve terminals. Substance P and vasoactive intestinal peptide (VIP) are examples of such neurotransmitters, which are involved in response to painful stimuli. They have been found in the nerve terminals of the hypogastric plexus

supplying the cervix [41, 42] and were originally believed to be involved in the transmission of pain experienced during labor. However, subsequent work has suggested that in the later stages of pregnancy there is a reduction in the level of plasma Substance P not associated with hemodilution [43], and that during acute labor pain, the plasma levels of Substance P appear unchanged [44].

In times of stress, the hypothalamic–pituitary axis (HPA) is activated to produce an increase in the so-called stress hormones, which prepare the body for "fight–flight". The pain experienced in labor produces a similar response where corticotrophin-releasing factor (CRF) is produced by the hypothalamus to cause an increase in the production of the peptides β-endorphin (a neurotransmitter which modulates pain by binding to opioid receptors) and adrenocorticotropic hormone (ACTH). β-Endorphin is also produced by the human placenta in pregnancy [45]. Studies have shown that levels of both β-endorphin and ACTH rise during pregnancy, peak at the time of delivery, and fall in the first 24 h postpartum [46, 47]. Women who had lower levels of β-endorphin toward the end of pregnancy tended to experience more pain and were more likely to request other forms of analgesia [47]. Conversely, women who exercised during pregnancy and consequently had higher levels of β-endorphin experienced less pain than those who had not exercised [48]. The analgesic effects of β-endorphin can be abolished through the administration of an opioid antagonist [49, 50]. Interestingly, the use of transcutaneous electrical nerve stimulation (TENS) therapy for labor analgesia is thought to work through a rise in β-endorphin levels [51].

Another neurohumoral change in pregnancy, which affects the perception of pain, is progesterone. Not only is the plasma concentration of progesterone raised in pregnancy, so too is the cerebrospinal fluid (CSF) concentration, and it may be this which is responsible for the reduced requirement for local anesthetic during pregnancy. Datta et al. demonstrated that the levels of progesterone in the CSF were eight times higher in pregnant women compared with nonpregnant women and that this decreased postpartum. They also demonstrated that the changes in CSF progesterone levels were inversely correlated with the dose of local anesthetic required in the neuraxial block and postulated that this was a direct effect of progesterone on the ability of the nerves to conduct painful stimuli [52]. The reduced need for a local anesthetic during pregnancy is well known [53] and may directly result from increased CSF progesterone.

3.5 Topography of Pain During Different Stages of Labor

The pain in labor is not a uniform pain experience; rather, it changes depending on the stage and progress of labor. Classically labor is divided into three stages:

1. *First stage of labor*—this stage begins with cervical ripening and lasts until the cervix is 10 cm dilated. This pain results from the physical stretching and distension in the lower uterine segment and cervix. Pain signals are conveyed

by unmyelinated slowly conducting C visceral fibers [54], which pass through both the superior and inferior hypogastric plexus to sympathetic ganglia at T10—L1. Early on in the first stage of labor, the pain is initially referred to the T11 and 12 dermatomes with progression to T10 and L1 dermatomes as cervical dilatation continues [55].

2. *Second (expulsive) stage of labor*—this stage lasts from full cervical dilatation to the delivery of the baby. The presenting part of the fetus causes distension and stretching of the pelvic floor vagina and perineum. Small myelinated Aδ nerve fibers [54] transmit pain sensation via the pudendal nerve located at S2–4. The pain of the second stage of labor is localized to the vagina and the perineum.
3. *Third stage of labor*—this stage covers the delivery of the placenta.

3.6 Labor Pain Evaluation

The pain experienced by women in labor not only has a sensory component but also has an affective element to it. Because this affective element is so subjective and dependent on the individual, this has made the pain in labor difficult to quantify; it makes comparisons between groups of parturients difficult [56]. There are various different methods used in the literature, which attempt to quantify the intensity of labor pain.

The visual analogue pain scale (VAPS) is a method used to assess pain other than that experienced in labor. The scale consists of a 10 cm vertical or horizontal line where at one end it is marked "no pain" and the other end is marked "severe pain". Subjects are then asked to put a mark on the line where they believe the severity of their pain in question lies and the mark is measured from the end marked "no pain" and the distance to the closest 0.5 cm gives the severity of pain. The VAPS is a simple research tool which can be applied to the obstetric population [57], but it only gives a measure of pain intensity and does not give a measure of any of the characteristics of pain.

The verbal rating scale (VRS) is similar to the VAPS in that it measures pain intensity rather than characteristics. Instead of asking subjects to mark on a 10-cm line the severity of the pain, the subjects are asked instead to rate their pain using qualitative words such as "mild," "moderate," or "severe" (Fig. 3.3).

The numeric rating scale (NRS) again is similar to VAPS, but instead of marking a point on a 10-cm line, patients are asked to provide a numerical value to quantify their pain. As labor is a dynamic process and the intensity of the pain may change very quickly, the use of both VAPS and VRS may not capture the magnitude of change during each contraction as both these scales are applied at discrete times during labor, e.g., at a specific cervical dilatation [58]. Bonnel looked at the use of a Behavioral Index (BI, Fig. 3.4) which could be used during each contraction to objectively gauge the severity of the pain experienced by the parturient [59]. In this study, obstetricians or midwives were given a five-point scale on which they grade

No pain Worst pain imaginable

Numerical Rating Scale (NRS)

Score (out of 10)	Severity of pain
0	No pain
1,2,or 3	Mild pain
4,5, or 6	Moderate pain
7,8,9, or 10	Severe pain

Fig. 3.3 VAPS, VRS, and NRS

Intensity of labor pain	Observed behavior
0	Normal respiration, no grasping, or agitated behavior seen
1	Rate and depth of respiration changes with labor contractions, all behaviors are attributed to pain, whether intentional (as a result of antenatal training) or reactional
2	As 1, signs of tension during contractions including grasping of bed, sheets, or another person's hand, these behaviors stop when contraction has ended
3	As 2, but grasping reaction persists even after contraction has ended
4	Signs of agitation occur during and even between contractions

Fig. 3.4 Behavioral changes seen with increasing labor pain intensity

the behavioral response exhibited by the women during the contractions. The authors found that as cervical dilatation increased and labor progressed, the observed behavior was placed in the higher two categories which correlate with severe pain and increased levels of anxiety in the parturient. However, although the BI may be considered an objective measure of pain severity in labor, its reliance on the observer who may also be the main care provider to the parturient in labor can be subject to an ethnic variation [60].

The McGill Pain Questionnaire (MPQ, Fig. 3.5) is made up from 20 descriptors which assess the characteristics of pain and a present pain intensity (PPI) index which incorporates five graded words to gauge current pain severity. This multidimensional questionnaire was first described by Melzack in 1975 and consists of 20 words which have been derived to represent different pain severities and are also considered to relate to three components of pain: sensory, affective, and evaluative [61]. The MPQ takes about 5–10 min to complete and has been used to assess pain in labor where women rate the pain they experienced highly, only superseded by digit amputation and complex regional pain syndrome (causalgia) [62]. Niven also used the MPQ to assess labor pain and noted in her study that if the parturients had previous experience of pain unrelated to labor or childbirth, their perception of pain was less when compared with women who had not experienced any pain previously [63].

However, if the MPQ is to be used to assess pain in labor, then a questionnaire, which may take up to 10 min to complete, may be considered cumbersome and may not accurately reflect the changes in pain as labor progresses. With this in mind, a shortened form of the MPQ (SF-MPQ) was developed and validated for use in pain research [64] (Fig. 3.6). The SF-MPQ comprises 15 descriptors (11 sensory and 4 affective), PPI, and a VAPS and takes 2–5 min to complete. The SF-MPQ has been used to study pain in the obstetric population by Capogna where he found that in nulliparous women in the early stages of labor, the intensity of affective and evaluative descriptors was greater than in multiparous women. In both groups, the intensity of both pain and sensory descriptors strongly correlated with the intensity of both VAPS and PPI as labor progressed [65].

3.7 Cognitive and Functional Aspects of Labor Pain

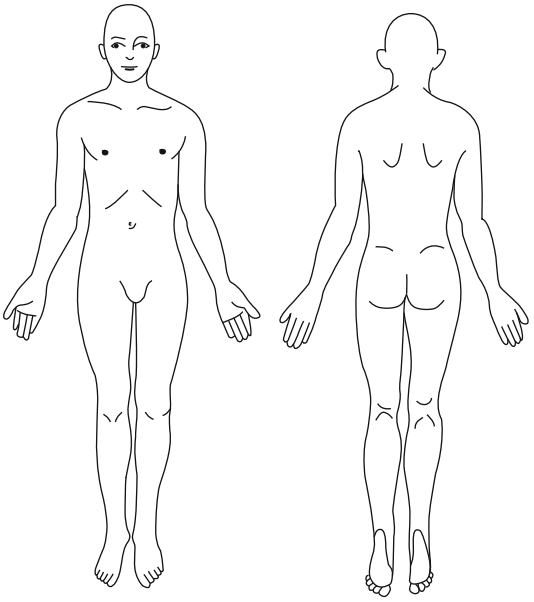
Dick-Read introduced the concept of “Childbirth without fear” [66] where it was hypothesized that increased fear led to increased muscular tension which in turn prolonged labor and increased pain. By educating the expectant women, it was postulated that tension and fear could be reduced through relaxation and breathing techniques. “Childbirth without pain” was a concept introduced by Lamaze [67]

What does your pain feel like?

1. Flickering ___ Quivering ___ Pulsing ___ Throbbing ___ Beating ___ Pounding ___	11. Tiring ___ Exhausting ___
2. Jumping ___ Flashing ___ Shooting ___	12. Sickening ___ Suffocating ___
3. Pricking ___ Boring ___ Drilling ___ Stabbing ___ Lancinating ___	13. Fearful ___ Frightful ___ Terrifying ___
4. Sharp ___ Cutting ___ Lacerating ___	14. Punishing ___ Grueling ___ Cruel ___ Vicious ___ Killing ___
5. Pinching ___ Pressing ___ Gnawing ___ Cramping ___ Crushing ___	15. Wretched ___ Blinding ___
6. Tugging ___ Pulling ___ Wrenching ___	16. Annoying ___ Troublesome ___ Miserable ___ Intense ___ Unbearable ___
7. Hot ___ Burning ___ Scalding ___ Searing ___	17. Spreading ___ Radiating ___ Penetrating ___ Piercing ___
8. Tingling ___ Itchy ___ Smarting ___ Stinging ___	18. Tight ___ Numb ___ Drawing ___ Squeezing ___ Tearing ___
9. Dull ___ Sore ___ Hurting ___ Aching ___ Heavy ___	19. Cool ___ Cold ___ Freezing ___
10. Tender ___ Taut ___ Rasping ___ Splitting ___	20. Nagging ___ Nauseating ___ Agonizing ___ Dreadful ___ Torturing ___
	How strong is your pain? 0 No pain 1 Mild 2 Discomforting 3 Distressing 4 Horrible 5 Excruciating

Fig. 3.5 (continued)

Where is your pain?
Please mark on the drawings where you feel pain.



Accompanying Symptoms		**Duration**		**Activity**	
Nausea	___	Constant	___	Good	___
Headache	___	Periodic	___	Some	___
Dizziness	___	Brief	___	Little	___
Drowsiness	___	**Sleep**		None	___
Constipation	___	Good	___	**Food intake**	
Diarrhea	___	Fitful	___	Good	___
		Can't sleep	___	Some	___
				Little	___
				None	___

Fig. 3.5 McGill Pain Questionnaire [61]. Copyright: Dr. R. Melzack, 1970, 1975. Reprinted with permission

where it was believed that by using relaxation techniques and breathing exercises, it would be possible to block or inhibit the pain signals associated with uterine contractions. Researchers have yet to provide conclusive evidence that such cognitive techniques are wholly effective [62]. However, studies looking at behavioral aspects of women in preparation for labor and childbirth have shown that the negative experience and pain of labor and childbirth could be reduced by encouraging women to believe they can cope with the pain [68–73], having the presence of

Pain descriptors – sensory dimension	None	Mild	Moderate	Severe
Throbbing	0) _____	1) _____	2) _____	3) _____
Soothing	0) _____	1) _____	2) _____	3) _____
Stabbing	0) _____	1) _____	2) _____	3) _____
Sharp	0) _____	1) _____	2) _____	3) _____
Cramping	0) _____	1) _____	2) _____	3) _____
Gnawing	0) _____	1) _____	2) _____	3) _____
Hot – burning	0) _____	1) _____	2) _____	3) _____
Aching	0) _____	1) _____	2) _____	3) _____
Heavy	0) _____	1) _____	2) _____	3) _____
Tender	0) _____	1) _____	2) _____	3) _____
Splitting	0) _____	1) _____	2) _____	3) _____
Pain descriptors – affective dimension				
Tiring – exhausting	0) _____	1) _____	2) _____	3) _____
Sickening	0) _____	1) _____	2) _____	3) _____
Fearful	0) _____	1) _____	2) _____	3) _____
Punishing – cruel	0) _____	1) _____	2) _____	3) _____

Visual analogue scale

No pain Worst possible pain

Present pain intensity

0	No pain	____
1	Mild	____
2	Discomforting	____
3	Distressing	____
4	Horrible	____
5	Excruciating	____

Fig. 3.6 Short form McGill Pain Questionnaire [64]. Copyright: Dr. R. Melzack, 1984, 1987. Reprinted with permission. *Note*: Each descriptor is ranked on an intensity scale of 0 = none, 1 = mild, 2 = moderate, 3 = severe. The Present Pain Intensity (PPI) of the standard long-form McGill Pain Questionnaire (LF-MPQ) and the visual analogue (VAS) are also included to provide the overall intensity scores

a birthing partner in the delivery room [74, 75], and reducing anxiety levels [76]. Education of women to expect pain during labor may reduce the need for labor analgesia [77], and this may be in the form of antenatal classes. Capogna found that women who attended such classes tended to be more motivated and came from higher socioeconomic backgrounds [78].

3.8 Physical Factors Affecting Pain Perception

There are several physical factors which have been shown to affect pain perception:

- *Age*–older, nulliparous women experience a longer, more painful labor than their younger counterparts [79]
- *Parity*–researchers have consistently shown that nulliparous women experience a more intense sensory pain in the early stages of labor than multiparous women [80–84]
- *Obesity*—Melzack noted that women with a larger body mass index (BMI) experienced more pain in labor [85]. However, a later study did not find a correlation between a higher BMI and severity of labor pain [86]
- *History of previous pain or dysmenorrhea*—women who have had experience of severe pain, which may be non-obstetric in origin, have reduced pain scores during labor [87, 88]
- *Condition of the cervix at the time of labor*—the cervix of the nulliparous women tends to soften before the onset of labor and appears to be less sensitive to nociceptive stimuli compared with multiparous women [79]
- *Relationship of the size and position of the fetus in the birth canal*—pain scores were noted to be higher in nulliparous women when the fetal head was lower in the birth canal [65]
- *Maternal position*—while in labor, women may find walking, sitting on a birthing ball, or remaining upright helpful in labor. While there are no conclusive studies favoring one position for labor, investigators have found that those women who remained in an upright position in labor rather than a recumbent one had a short labor and were less likely to request epidural analgesia [89]
- *Immersion in water*—the use of birthing pools has been known anecdotally to ease the pain during labor, but the exact mechanism of this is presently unknown. Previous studies have observed that the use of birthing pools is associated with faster labors and a reduced requirement for labor analgesia [90] as well as a reduced rate of perineal trauma [91] and obstetric involvement with the delivery [92]. A Cochrane review found that although the use of birthing pools was associated with a significant decrease in the requests for neuraxial analgesia in labor, there were no differences in the rates of assisted or operative deliveries, perineal trauma, or infection [93]

3.9 Conclusion

The complex nature of pain in childbirth is made up from a variety of anatomical, physical, and emotional components. A variety of different strategies may be employed to lessen the intensity of pain and to improve the experience of childbirth for women. However, as yet, there is no one single strategy which is proven in the literature to be consistently successful in reducing the intensity of labor pain.

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