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Labor Pain Perception: a Narrative Literature Review

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Keywords

Labor pain; pain perception; genetic variation; anxiety

Abstract

Aim: Labor pain is one of the most intense and complex painful experiences, yet its perception varies widely among women. Traditional explanations based solely on nociceptive mechanisms are insufficient to account for these interindividual differences. Therefore, this review aims to summarize current evidence on the physiological, psychological, and genetic factors influencing labor pain perception, in order to better understand individual variability. **Materials and Methods:** A narrative review of the literature was conducted using recent peer-reviewed studies retrieved from PubMed, Scopus, and Web of Science. Articles exploring physiological mechanisms, psychological influences, and genetic polymorphisms associated with labor pain were included. **Results:** Labor pain arises from the interaction of nociceptive mechanisms, genetic variability (e.g., SERT, OPRM1, COMT polymorphisms), and psychological factors such as trait and state anxiety, fear of childbirth, coping strategies, and expectations. Social determinants, including prenatal education, partner and healthcare support, and cultural context, further modulate pain perception. Evidence supports significant gene–environment interactions, where genetic predispositions are amplified or buffered by psychological states and environmental influences. **Conclusion:** Labor pain is best understood within a biopsychosocial framework that integrates biological vulnerability, emotional regulation, and contextual factors. Identifying women at increased risk for heightened pain perception may facilitate personalized obstetric care, combining targeted psychological interventions, structured prenatal education, and, in the future, genetically informed pain management strategies.

Introduction

Childbirth is widely considered one of the most intense painful experiences in a woman's life; however, the perception of labor pain varies greatly among individuals. According to the International Association for the Study of Pain (IASP), pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage" [1]. This definition highlights pain as a multidimensional phenomenon involving sensory, affective, and cognitive components, making it particularly relevant in psychiatry and perinatal mental health.

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Labor pain represents a unique physiological process that, unlike other types of acute pain, is not primarily associated with tissue injury or pathology. Instead, it is characterized by a complex interplay of neurophysiological mechanisms, psychological factors - such as anxiety, expectations, and social support - and genetic influences that contribute to individual variability in pain perception [2].

The aim of this review is to summarize current insights into the biological, psychological, and genetic determinants of labor pain, with a particular emphasis on the role of serotonin transporter gene polymorphisms and maternal anxiety.

General physiological aspects of pain

Pain is a complex, multidimensional experience that involves the interaction of sensory, affective, and cognitive components [3]. From a physiological perspective, pain can be classified based on its duration (acute vs. chronic) and its pathophysiological mechanism (nociceptive vs. neuropathic).

Acute pain is usually short-lasting and serves a protective function by alerting the individual to potential or actual tissue damage [4]. It typically resolves once the underlying cause is treated or removed. In contrast, chronic pain is defined as pain persisting beyond normal tissue healing, usually lasting longer than three months [5]. Chronic pain often involves central sensitization, characterized by long-term structural and functional changes within the central nervous system (CNS), resulting in altered pain processing and persistent psychological and physiological consequences [6].

Nociceptive pain arises from the activation of peripheral sensory nerve endings (nociceptors) in response to actual or potential tissue damage [7]. These nociceptors are widely distributed throughout the body, including the skin, muscles, joints, viscera, and meninges, and are specialized to detect harmful stimuli such as intense mechanical pressure, extreme temperatures ($> 40 – 45°C$ or $< 15°C$), and chemical irritants. Two primary types of nociceptive fibers are involved: myelinated Aδ fibers, which transmit sharp, well-localized pain, and unmyelinated C fibers, which convey dull, diffuse, and lingering pain sensations. The resulting nociceptive signals are relayed to the dorsal horn of the spinal cord and ascend via the spinothalamic tract to higher cortical centers, where the location, intensity, and quality of the painful stimulus are processed [8]. In contrast, neuropathic pain is defined as pain caused by a lesion or disease of the somatosensory nervous system [9]. It frequently arises from conditions such as stroke, spinal cord injury, multiple sclerosis, diabetes, and peripheral nerve trauma, and is often experienced as part of chronic pain syndromes. Typical neuropathic symptoms include burning sensations, tingling, and electric shock-like pain [10]. Unlike nociceptive pain, neuropathic pain is characterized by structural and functional changes within the central nervous system that affect multiple levels of the nociceptive pathway, leading to persistent pain perception, heightened sensitivity to non-painful stimuli, and significant psychosocial consequences [11].

Beyond sensory processing, pain perception also involves substantial affective and cognitive components [12]. The affective-motivational dimension encompasses the unpleasantness of pain, feelings of fear, and the instinctive urge to escape or avoid the painful stimulus. This emotional response can be understood in two stages: an immediate unpleasantness, representing the initial affective reaction to pain, and sustained emotional responses, which include frustration, anxiety, depression, and anger. These emotional aspects are particularly pronounced in patients with chronic pain syndromes and are strongly shaped by psychological context, attentional focus, expectations, and previous pain experiences [13].

Serotonin and noradrenaline play key roles in descending pain modulation pathways [14]. Altered neurotransmitter activity explains, in part, why mood disorders such as depression and anxiety are frequently associated with altered pain perception. This also underlies the efficacy of certain antidepressants in the treatment of chronic pain syndromes [15].

Physiological aspects of labor pain

Labor pain represents a unique form of acute, predominantly nociceptive pain, as it arises from physiological processes rather than tissue injury or pathology. It involves a combination of visceral and somatic components, reflecting activation of nociceptors during uterine contractions, cervical dilation, and pressure on pelvic structures. During the first stage of labor, pain primarily originates from uterine contractions and cervical dilation, and is transmitted by visceral afferent fibers via the T10 – L1 spinal segments, typically being perceived as a diffuse, poorly localized discomfort in the abdominal or lumbar region. As the process progresses into the second stage of labor, somatic pain becomes predominant due to stretching and pressure on the vaginal walls, perineum, and surrounding pelvic structures. This component is mediated by the pudendal nerve and transmitted through the S2–S4 spinal segments. Nociceptive signals from both stages are conveyed via the spinothalamic tract to the thalamus and somatosensory cortex, where the sensory-discriminative aspects of pain, such as its location, intensity, and quality, are processed. At the same time, projections to the limbic system influence the affective and emotional dimensions of labor pain, which explains why the subjective experience of childbirth pain varies so widely among individuals [16].

A range of neurochemical mediators contribute to the modulation of labor pain, including serotonin, noradrenaline, prostaglandins, bradykinin, and other inflammatory molecules [17]. Among these, serotonin (5 - HT) plays a particularly important role in central pain modulation by acting on multiple receptor subtypes and influencing descending inhibitory pathways. Individual differences in serotonergic signaling, partly determined by SERT gene polymorphisms, may explain variations in both the sensory and affective components of pain.

Epidural analgesia remains the gold standard for labor pain management [18]. It provides highly effective analgesia for up to 90 % of women, offering superior pain relief compared to other pharmacological and non-pharmacological interventions. However, it does not fully predict maternal satisfaction with the childbirth experience, as psychological factors play a significant modulatory role [19]. While generally safe, epidural analgesia is associated with potential complications, such as maternal hypotension, urinary retention, and prolonged second-stage labor [20]. Importantly, even when effective analgesia is provided, the subjective experience of labor pain remains strongly influenced by emotional state, expectations, and prior experiences, underscoring the need for a biopsychosocial approach to perinatal care [2].

Psychological factors in labor pain perception

Labor pain is not merely a physiological event but a multidimensional experience strongly influenced by psychological, emotional, and social factors [16]. While nociceptive mechanisms explain the sensory transmission of painful stimuli, the subjective perception of pain during childbirth is largely shaped by a woman's emotional state, coping strategies, prior experiences, and expectations [21]. Understanding these psychological determinants is crucial, as they not only modulate the perception of pain but also affect overall satisfaction with the childbirth experience and maternal mental health outcomes.

Among all psychological factors, anxiety is one of the most consistent predictors of heightened labor pain [22]. Anxiety activates the sympathetic nervous system, increasing arousal, muscle tension, and the release of catecholamines, which collectively lower the pain threshold and amplify the sensory experience [23]. A distinction is commonly made between trait anxiety - a stable personality characteristic reflecting a predisposition to heightened emotional reactivity - and state anxiety, a temporary emotional response to situational stressors [24]. Women with high trait anxiety often report significantly lower pain tolerance, even before labor begins, while increased state anxiety during labor further intensifies pain perception [25]. Evidence also suggests a bidirectional relationship between anxiety and labor pain: heightened anxiety amplifies nociceptive processing, and increased pain levels, in turn, exacerbate anxiety [26]. This interaction explains why psychological interventions aimed at reducing antenatal anxiety - such as cognitive-behavioral techniques or relaxation training - can lead to measurable reductions in reported labor pain [27].

A woman's expectations of childbirth significantly influence her pain experience. Negative expectations and fear of labor are associated with increased pain perception and greater analgesia requirements [28]. Conversely, women who anticipate a manageable experience and feel well-prepared for labor report lower pain intensity and higher satisfaction [29]. Prenatal education programs, including structured childbirth preparation classes, have been shown to improve maternal confidence, decrease anxiety, and enhance coping strategies during labor [30]. One randomized controlled trial demonstrated that women who received targeted antenatal education and psychological support required less pharmacological analgesia and reported lower pain scores than those receiving routine care [19]. In addition, social support - from partners, family, or healthcare professionals - plays a protective role. Continuous support from trained personnel, such as midwives or doulas, is associated with reduced need for medical pain interventions, shorter labor durations, and improved maternal satisfaction [31]. Supportive birth environments also mitigate fear and facilitate emotional regulation, indirectly reducing perceived pain.

Severe or poorly managed labor pain is not only a physical challenge but also a risk factor for adverse psychological outcomes [32]. Research demonstrates that intense labor pain correlates with increased rates of postpartum depression (PPD), post-traumatic stress disorder (PTSD), and negative birth-related memories [33]. In particular, women who experience a mismatch between their expected and actual childbirth experience are at heightened risk for emotional distress [34]. Approximately 20 % of women with traumatic birth experiences later develop significant PTSD symptoms, which can negatively affect maternal-infant bonding, breastfeeding, and long-term psychological well-being [35]. Moreover, recent meta-analyses suggest that early psychological interventions during pregnancy - focusing on stress reduction, cognitive reframing, and relaxation techniques - can reduce the risk of both PPD and birth-related PTSD [36]. These findings underscore the importance of integrating psychological screening and targeted mental health support into antenatal and perinatal care to optimize both physical and emotional outcomes for mothers.

Genetic factors in labor pain perception

Individual differences in the perception of labor pain are not solely explained by physiological or psychological factors; accumulating evidence highlights a

significant role of genetic variability in modulating pain sensitivity and analgesic response [37]. Genetic factors influence multiple aspects of pain perception, including nociceptive processing, neurotransmitter regulation, and endogenous pain modulation pathways. Among the most extensively studied genes in the context of labor pain are those involved in the serotonergic and opioidergic systems, particularly the serotonin transporter gene (SLC6A4) and the μ-opioid receptor gene (OPRM1).

The serotonin transporter (SERT), encoded by the SLC6A4 gene, plays a central role in regulating serotonin (5 - HT) reuptake from the synaptic cleft, thereby modulating serotonergic signaling and influencing both the sensory and affective dimensions of pain [38]. Two functional polymorphisms of this gene have been most extensively studied. The first is the 5 - HTTLPR polymorphism, located in the promoter region of the SLC6A4 gene, which consists of a short (S) and a long (L) allele. The S allele is associated with reduced transcriptional efficiency, resulting in lower SERT expression and elevated synaptic serotonin levels [39]. Functionally, carriers of the S allele exhibit greater amygdala reactivity to emotionally salient stimuli, a mechanism that has been linked to heightened pain sensitivity and increased emotional distress during labor [40]. The second is the STin2 VNTR polymorphism, located in intron 2 of the same gene, which consists of a variable number of tandem repeats affecting SERT transcriptional activity. Specific allelic variants, such as STin2.10, have been associated with enhanced serotonergic activity and altered modulation of pain perception [41].

The μ-opioid receptor, encoded by the OPRM1 gene, mediates the analgesic effects of endogenous and exogenous opioids, including those administered during labor [42]. The A118G single nucleotide polymorphism (SNP) in OPRM1 has been widely studied for its influence on pain sensitivity and opioid response. Carriers of the G allele have been shown to exhibit reduced receptor binding affinity and lower analgesic response to opioids [43, 44]. However, findings regarding its influence on labor pain remain inconsistent, which may reflect differences in study inclusion criteria, types of opioids used, routes of administration (epidural, intrathecal, intravenous), and outcome measures employed to assess pain.

Several additional genes have been implicated in the modulation of labor pain perception, although the available evidence remains limited. The COMT (catechol – O - methyltransferase) gene, which regulates catecholamine degradation and prefrontal dopaminergic activity, has been studied primarily through the Val158Met polymorphism. The Met allele has been associated with enhanced pain sensitivity in experimental models and chronic pain syndromes; however, findings specific to labor pain remain inconclusive [45]. Variants of the KCNS1 gene, which encodes a subunit of voltage-gated potassium channels, have been linked to altered neuronal excitability and an increased susceptibility to chronic pain states, including neuropathic conditions [46]. Similarly, certain haplotypes of the GCH1 (GTP cyclohydrolase 1) gene have been associated with reduced pain sensitivity, likely due to increased production of tetrahydrobiopterin (BH4), a cofactor involved in endogenous analgesic mechanisms [47]. While these findings are promising, most studies investigating candidate genes are limited by small sample sizes and require replication in larger, well-controlled cohorts to establish robust associations.

One of the key insights from recent research is that genetic predispositions alone rarely determine pain perception. Instead, the interaction between genetic variants and psychological or environmental factors plays a decisive role [48]. For instance, women carrying the S allele of 5 - HTTLPR and reporting high antenatal anxiety exhibit the highest levels of perceived labor pain, whereas carriers of the same genotype with low anxiety do not differ significantly from other genotypes. This emphasizes the necessity of adopting a biopsychosocial model in understanding labor pain, integrating genetic, psychological, and contextual influences.

Discussion

Labor pain is a complex and highly individual experience that cannot be fully explained by physiological mechanisms alone. Growing evidence suggests that the perception of pain during childbirth arises from a dynamic interplay of biological, psychological, and social factors [49]. While nociceptive mechanisms account for the transmission of painful stimuli, individual differences in pain intensity and emotional responses are strongly influenced by genetic predispositions, psychological states, and contextual influences. Integrating these dimensions into a biopsychosocial framework provides a more comprehensive understanding of labor pain and offers opportunities for developing more personalized approaches to obstetric care.

Genetic variability plays an important role in shaping how women perceive and regulate pain during childbirth, particularly through its interaction with emotional processes. The serotonin transporter gene (SLC6A4) has been extensively studied due to its role in serotonergic signaling, which influences both sensory and affective pain pathways [38]. The 5 - HTTLPR polymorphism, consisting of short (S) and long (L) alleles, is of particular relevance. Carriers of the S allele demonstrate reduced transcriptional efficiency and lower serotonin transporter expression, resulting in higher synaptic se-

rotonin levels [39]. Functionally, S-allele carriers exhibit greater amygdala reactivity to emotionally salient stimuli, which has been linked to heightened pain sensitivity and increased emotional distress during labor [40].

Psychological factors strongly influence how labor pain is experienced and processed. Among these, anxiety is one of the most consistent predictors of heightened pain [22]. Elevated anxiety during pregnancy and labor activates the sympathetic nervous system, increasing arousal, muscle tension, and catecholamine release, all of which lower the pain threshold [23]. Beyond anxiety, expectations, coping strategies, and previous birth experiences play pivotal roles. Women who anticipate labor to be overwhelming or unmanageable report higher pain intensity and are more likely to request analgesia, whereas positive expectations and effective coping strategies are associated with lower perceived pain and greater satisfaction with childbirth [28].

Social support represents another critical contextual factor. Support from partners, family members, and healthcare providers contributes to reduced stress levels, enhanced emotional security, and more effective pain management during labor [31]. Continuous support from trained personnel, such as midwives or doulas, has been linked to shorter labor durations, lower use of pharmacological interventions, and improved childbirth experiences [30]. These findings highlight that psychological and environmental influences can either exacerbate or buffer the impact of genetic predispositions on labor pain.

The biopsychosocial model conceptualizes labor pain perception as the outcome of a dynamic interaction between biological, psychological, and social factors. Biological influences encompass nociceptive mechanisms, neurochemical modulation, and genetic variability, including polymorphisms in genes such as SERT, OPRM1, and COMT. Psychological factors involve both trait and state anxiety, pain-related fear, cognitive appraisals, and coping strategies, all of which shape how pain is experienced and interpreted. Social and contextual determinants - such as prenatal education, partner and healthcare support, and broader cultural influences - further modulate these processes. Crucially, these domains do not operate in isolation but interact continuously. For instance, a woman carrying the S allele of 5 - HTTLPR who also presents with high antenatal anxiety and limited social support is more likely to perceive labor pain as intense and distressing. In contrast, strong emotional support, positive expectations, and structured preparation for childbirth can buffer genetic vulnerability, resulting in a less overwhelming pain experience [48]. This integrative framework underscores that labor pain is not merely a biological phenomenon, but rather a multifaceted, context-dependent experience shaped by the interplay of genes, emotions, and environment.

Applying a biopsychosocial perspective in obstetric care has important clinical implications. Early identification of women at higher risk for intense labor pain - for example, those carrying genetic variants associated with heightened emotional reactivity combined with high antenatal anxiety - could inform personalized care plans [50]. Psychological interventions, such as cognitive-behavioral therapy (CBT), relaxation training, and mindfulness-based techniques, have demonstrated efficacy in reducing labor-related anxiety and pain perception [27]. In addition, understanding individual differences in genetic responses to opioids, such as OPRM1 polymorphisms, may support tailored analgesic strategies, optimizing efficacy and minimizing unnecessary interventions. Integrating psychological screening and, in the future, genetic profiling into antenatal care could help guide both pharmacological and non-pharmacological pain management, ultimately improving maternal satisfaction and postpartum mental health outcomes.

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Conflict of interest

None to declare.

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