# INTRODUCTION

The growth of laparoscopic surgical procedures is due to the use of smaller incisions that reduce surgical stress and postoperative pain as well as reduce overall morbidity, thus resulting in rapid recovery, earlier ambulation, shorter hospital stay, better maintenance of homeostasis and rapid return to daily living activities. These benefits area achieved without compromising surgical outcomes ***(Joshi and Cunningham, 2013).***

The pneumoperitoneum and the patient positions required for laparoscopy induce pathophysiologic changes that complicate anesthetic management. An understanding of the pathophysiologic consequences of increased intra-abdominal pressure (IAP) is important for the anesthesiologist who must ideally prevent or, when prevention is not possible, adequately respond to these changes and who must evaluate and prepare the patient preopera-tively in light of these disturbances ***(Sarbari et al., 2013).***

Compared to open surgical procedures, pain after laparoscopic procedures is considered to be less intense and of shorter duration. Nevertheless, adequate pain control is critical to hasten postoperative recovery and ambulation. The origin of pain after most laparoscopic procedures is predominantly visceral rather than parietal (i.e., from incision site). In addition, shoulder pain secondary to diaphragmatic irritation is also common and can limit the patient's ability to return to normal activities ***(Sarbari et al., 2013).***

The factors that could influence postoperative pain include duration of procedure, degree of IAP, and the volume of residual subdiaphragmatic gas after surgery. Optimal pain therapy for patients undergoing laparoscopic surgeries includes the use of multimodal analgesia techniques ***(Gourishankar et al., 2014).***

Dexmedetomidine significantly reduces hemodynamic changes and anesthetic requirements as it has sedative, analgesic, and anxiolytic properties. It does not interact with the GABA mimetic system so does not depress respiratory drive and centrally mediated reduction in sympathetic tone offers cardio-protective effect. Adjunctive Low dose dexmedetomidine infusion effectively attenuates haemodynamic stress response during laparoscopic surgery with reduction in post-operative analgesic requirements ***(Gourishankar et al., 2014).***

The transversus abdominis plane (TAP) blocks have been implemented successfully for pain control after laparoscopic surgery. The TAP block is a relatively new regional anesthetic technique that targets the sensory nerve supply of the anterior-lateral abdominal wall. First described by Rafi et al in 2001, the block is performed by injecting local anesthetic into the plane between the internal oblique and the transversus abdominis muscles using the triangle of Petit as a landmark. This plane is infiltrated with local anesthetics to target the T7–T12 intercostal nerves, the ilioinguinal, iliohypo-gastric, and the lateral cutaneous branches of the dorsal rami of L1–L3 ***(Michael et al., 2013).***

Recently, there has been a surge of interest in the use of IV lidocaine in abdominal surgery due to its analgesic, antihyperalgesic, and anti-inflammatory effects. Intravenous lidocaine improves postoperative analgesia, fatigue, and bowel function after laparoscopic colectomy. These benefits are associated with a significant reduction in hospital stay ***(Tikuisis et al., 2014).***

# Aim of the Work

The objective of this work is to state recent modalities of perioperative pain control for laparoscopic surgeries.

# PAIN PATHWAYS

## Nociception versus Pain:

Nociception includes all forms of information processing triggered by noxious stimuli (i.e., stimuli that are damaging to normal tissues). In awake animals or human subjects, nociception may lead to withdrawal or vegetative responses and/or to the sensation of pain. Pain as defined by the International Association for the Study of Pain (IASP) is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage." Although pain is always a subjective sensation, nociception can be measured in terms of objective parameters ***(Sandkühler, 2013).***

The term *nociception* is derived from *noci* (Latin for harm or injury) and is used to describe neural responses to traumatic or noxious stimuli. All nociception produces pain, but not all pain results from nociception. Many patients experience pain in the absence of noxious stimuli. It is therefore clinically useful to divide pain into one of two categories: (1) **acute pain**, which is primarily due to nociception, and (2) **chronic pain**, which may be due to nociception, but in which psychological and behavioral factors often play a major role ***(Rosenquist and Vrooman, 2013).***

## Acute Pain

Acute pain is caused by noxious stimulation due to injury, a disease process, or the abnormal function of muscle or viscera. It is usually nociceptive. Nociceptive pain serves to detect, localize, and limit tissue damage. This type of pain is typically associated with a neuroendocrine stress response that is proportional to the pain intensity. It's most common forms include post-traumatic, postoperative, and obstetric pain as well as pain associated with acute medical illnesses, such as myocardial infarction, pancreatitis, and renal calculi. Most forms of acute pain are self-limited or resolve with treatment in a few days or weeks. When pain fails to resolve because of either abnormal healing or inadequate treatment, it becomes chronic. Two types of acute (nociceptive) pain: somatic and visceral are differentiated based on origin and features. Nociceptive pain results from tissue damage causing continuous nociceptor stimulation ***(Rosenquist and Vrooman, 2013).***

## Somatic Pain

Somatic pain results from activation of nociceptors in cutaneous and deep tissues, such as skin, muscle and subcutaneous soft tissue. Typically, it is well localized and described as aching, throbbing or gnawing. Somatic pain is usually sensitive to opioids ***(Aitkenhead, 2013).***

## Visceral Pain

Visceral pain arises from internal organs. It is characteristically vague in distribution and quality and is often described as deep, dull or dragging. It may be associated with nausea, vomiting and alterations in blood pressure and heart rate.stimuli such as crushing or burning, which are painful in somatic structures, often evoke no pain in organs. Mechanisms of visceral pain include abnormal distension or contraction of smooth muscle, stretching of the capsule of solid organs, hypoxaemia or necrosis and irritation by algesic substances. Visceral pain is often referred to cutaneous sites distant from the visceral lesion. One example of this is shoulder pain resulting from diaphragmatic irritation ***(Aitkenhead, 2013).***

Accordingly, visceral pain differs from somatic in several important ways. Visceral pain has the following properties:

- It is diffuse in character and poorly localized.
- It is typically referred rather than being felt at the source.
- It is produced by stimuli different from those adequate for activation of somatic nociceptors. Adequate stimuli for production of visceral pain include distention of hollow organs, traction on the mesentery, ischemia, and chemicals typically associated with inflammatory processes.

- It is associated with emotional and autonomic responses typically greater than those associated with somatic pain ***(Aitkenhead, 2013).***

## Pain pathways:

The dorsal horn of the spinal cord is the major receiving zone for primary afferent axons that transmit information from sensory receptors in the skin, viscera, joints, and muscles of the trunk and limbs to the central nervous system. Nociceptive primary afferent axons (i.e., those that respond to tissue damaging stimuli) terminate almost exclusively in the dorsal horn, which is therefore the site of the first synapse in ascending pathways conveying the sensory information that underlies conscious perception of pain. In addition, it contains neuronal circuits involved in generating local reflexes. In the Gate Control Theory of pain, ***Melzack and Wall (1965)*** proposed that inhibitory interneurons in the superficial part of the dorsal horn play a crucial role in controlling incoming sensory information before it is transmitted to the brain. This theory aroused a great deal of interest in organization of the dorsal horn. However, despite intensive study since then, our knowledge of the neuronal circuitry of the region remains limited ***(Todd and Richard, 2013).***

The dorsal horn contains four neuronal components: (1) central terminals of primary afferent axons, which arborize in different areas, depending on their diameter and the type of sensory stimulus that they respond to; (2) interneurons, with

axons that remain in the spinal cord, either terminating locally or extending into other spinal segments; (3) projection neurons, with axons that pass rostrally in white matter to reach various parts of the brain; and (4) descending axons that pass caudally from several brain regions and play an important role in modulating the transmission of nociceptive information ***(Todd and Richard, 2013).***

## Laminae of Rexed

The spinal grey matter has been divided into 10 laminae on the basis of cyto-architectonic studies. Laminae I–VI make up the dorsal horn, VII–IX make up the ventral horn and lamina X is a cluster of cells around the central canal. Lamina I is termed the marginal layer, lamina II is the substantia gelatinosa (and is divided into IIo (outer) and IIi (inner). The laminae run the entire length of the cord fusing with the medullary dorsal horn ***(Ellis and Lawson, 2014).***

Laminae I and II, which are referred to as the superficial dorsal horn, constitute the main target for nociceptive primary afferents However, the deeper laminae (III–VI) also have an important role in pain: some nociceptive primary afferents terminate in this region, and many neurons in these laminae (including some projection cells) are activated by noxious stimulation. Lamina I, also known as the marginal layer, forms a thin sheet covering the dorsal aspect of the dorsal horn and contains both projection neurons and interneurons. Lamina II is also known as the substantia gelatinosa because the lack of

myelinated fibers gives it a translucent appearance. Virtually all the neurons in this lamina are interneurons, and they are densely packed in its outer part. Lamina III also contains a high density of neurons. Most are interneurons and are generally somewhat larger than those of lamina II, but scattered large projection neurons are also present. The border between laminae II and III can be identified more easily by the absence of myelinated axons in lamina IIi and their presence in lamina III. This can be seen with myelin stains or dark-field microscopy of unstained sections. Laminae IV–VI are more heterogeneous, with neurons of various size, some of which are projection cells. The borders between these laminae are difficult to determine with certainty ***(Todd and Richard, 2013).***

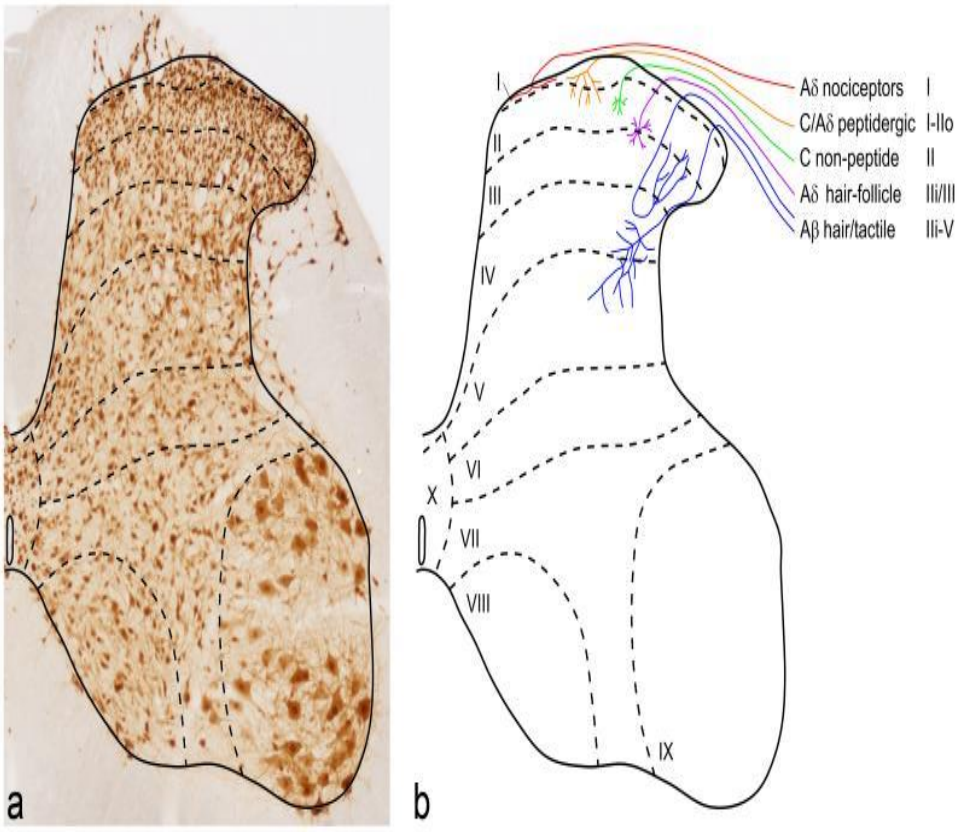


**Figure (1):** Rexed's laminae ***(Todd and Richard, 2013).***

## Primary afferent fibers

Primary sensory neurons provide constant feedback on the external environment, as well as the ongoing state of the body. The somata of those that innervate the limbs and trunk are located in sensory ganglia associated with spinal nerves (dorsal root ganglia). Their axons bifurcate within the ganglion and give rise to a peripheral branch that innervates various tissues and a central branch that travels through a dorsal root to enter the spinal cord, where it forms synapses with second order neurons ***(Todd and Richard, 2013).***

The peripheral targets of these fibers provide a convenient means for classification. Fibers innervating skin are described as cutaneous sensory neurons. Likewise, those innervating abdominal or pelvic viscera are termed visceral afferents. Within these populations, fibers can respond to various sensory modalities, including mechanical, thermal, and chemical stimuli ***(Baumgärtner, 2010).***

Modality-specific groups are further divided according to the intensity of their adequate peripheral stimuli. Those that respond to gentle mechanical force or innocuous thermal stimuli are low-threshold mechanoreceptors or innocuous cooling or warming afferents. Fibers responding only to stimulus intensities considered tissue threatening or potentially tissue damaging are termed nociceptors. As a group, primary sensory neurons exhibit a rich diversity in morphological and functional properties, including somatic membrane properties, laminar location of central projections, neurochemical content, and response properties of the central networks that they activate. The most common means of classifying primary sensory neurons is based on the conduction velocity of their peripheral axons, which is directly related to axon diameter and whether the axon is myelinated ***(Todd, 2010).***

From the distribution of these peripheral conduction velocities, primary sensory neurons are routinely divided into different groups: Aα/β, Aδ, and C. The Aα/β group consists of large myelinated axons with the fastest peripheral conduction

velocity, the Aδ group contains smaller fibers that are thinly myelinated and conduct at an intermediate velocity, and the C group consists of the smallest, unmyelinated, and most slowly conducting fibers. Within each group there is a wide range of functional types of primary afferents, as defined by sensory modality ***(Benzon et al., 2013).***

Most sensory neurons with fibers conducting in the Aα/β range respond to innocuous mechanical stimuli, do not encode noxious stimulus intensities, and are classified as low-threshold mechanoreceptors. Some of these fibers, however, respond to relatively innocuous mechanical stimuli but also encode stimulus intensities in the noxious range and in some cases respond to noxious heating of the skin. This trend reverses with decreasing conduction velocity, with a majority of Aδ fibers and most C fibers being classified as nociceptors ***(Benzon et al., 2013).***

The central terminals of primary afferent fibres terminate in the dorsal horn of the spinal cord, which is organized into different laminae, extending from the superficial to the deep dorsal horn. Most nociceptive Aδ and C fibres terminate superficially in laminae I–II, with a smaller number reaching deeper laminae, whereas Aβ-fibres predominantly innervate laminae III–VI ***(D'Mello and Dickenson, 2008).***

Visceral afferents terminate primarily in lamina V and, to a lesser extent, in lamina I. These two laminae represent points of central convergence between somatic and visceral inputs.

Lamina V responds to both noxious and nonnoxious sensory input and receives both visceral and somatic pain afferents. The phenomenon of convergence between visceral and somatic sensory input is manifested clinically as referred pain ***(Rosenquist and Vrooman, 2013).***

**Table (1):** Primary afferent fibers and their functions ***(Benzon et al., 2013).***

| Modality | Receptor | Fiber Type | Conduction Velocity and Diameter | Rate of Adaptation | Function |
|---|---|---|---|---|---|
| Proprioceptive | Golgi and Ruffini endings, muscle spindle afferents | Aα | 70–120 m/s 15–20 μm | Slow and rapid | Muscle tension, length, and velocity |
| Mechanosensitive | Meissner, Ruffini, Pacinian corpuscles, and Merkel disc | Aβ | 40–70 m/s 5–15 μm | Rapid (slow—Merkel) | Touch, flutter, motion, pressure, vibration |
| Thermoreceptive | Free nerve endings | Aδ | 10–35 m/s 1–5 μm | Slow | Innocuous cold |
| | Free nerve endings | C | 0.5–1 m/s <1 μm | Slow | Innocuous warmth |
| Nociceptive | Free nerve endings | Aδ | 10–35 m/s 1–5 μm | Slow | Sharp pain |
| | Free nerve endings | C | 0.5–1 m/s <1 μm | Slow | Burning pain |

## Spinal projections of primary sensory neurons

The axons of most second-order neurons cross the midline close to their dermatomal level of origin (at the anterior commissure) to the contralateral side of the spinal cord before they form the spinothalamic tract and send their fibers to the thalamus,

the reticular formation, the nucleus raphe magnus, and the periaqueductal gray. The spinothalamic tract, which is classically considered the major pain pathway, lies anterolaterally in the white matter of the spinal cord. This ascending tract can be divided into a lateral and a medial tract. The lateral spinothalamic (neospinothalamic) tract projects mainly to the ventral posterolateral nucleus of the thalamus and carries discriminative aspects of pain, such as location, intensity, and duration. The medial spinothalamic (paleospinothalamic) tract projects to the medial thalamus and is responsible for mediating the autonomic and unpleasant emotional perceptions of pain. Some spinothalamic fibers also project to the periaqueductal gray and thus may be an important link between the ascending and descending pathways. Collateral fibers also project to the reticular activating system and the hypothalamus; these are likely responsible for the arousal response to pain ***(Bourne et al., 2014).***

## Supraspinal structures

Third-order neurons are located in the thalamus and send fibers to somatosensory areas I and II in the postcentral gyrus of the parietal cortex and the superior wall of the sylvian fissure, respectively. Perception and discrete localization of pain take place in these cortical areas. Although most neurons from the lateral thalamic nuclei project to the primary somatosensory cortex, neurons from the intralaminar and medial nuclei project to the anterior cingulate gyrus and are likely involved in mediating the suffering and emotional components of pain ***(Bourne et al., 2014).***