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Omoigui Diffusion Technique of Intercostal Nerve Block

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Abstract

This paper describes the relevant anatomy and rationale behind our Diffusion Technique for intercostal nerve block. Using the Diffusion Technique developed by Omoigui, the left middle and index fingers are placed to stabilize the superior and inferior borders of the rib, at a site proximal to the area of pain. A 3 cm, 25 gauge, short-beveled needle is inserted directly onto the midpoint of the rib and 1-3 ml of local anesthetic solution is injected over the rib. There is no attempt to walk off the lower border of the rib and there is no advancement of the needle into the subcostal groove. There is minimal to no risk of any accidental pleural puncture as compared with the Bonica technique. The Omoigui diffusion technique utilizes the spread and diffusion characteristics of the injected local anesthetic to produce blockade of the cutaneous branches and intercostal nerves. This diffusion technique has showed similar therapeutic results as the standard approach. We include a series of cases that responded successfully to this simple diffusion technique for intercostal nerve block.

Keywords: Intercostal nerve block; Diffusion; Cutaneous branch; Rib; Injection

Introduction

Intercostal nerve block is a useful procedure for relieving and defining potential source(s) of pain in the chest and abdominal wall. Intercostal neural blockade at the posterior axillary line relieves pain of somatic origin but does not relieve pain arising in the thoracic or abdominal viscera, which are supplied by nociceptive fibers that follow sympathetic pathways located near the vertebral column. Intercostal nerve blocks can offer relief of severe posttraumatic, postoperative, or post infectious pain in the thoracic or abdominal wall. Other indications include severe pain involving rib fractures or dislocation of the costochondral joint, pain associated with herpes zoster or Intercostal nerve entrapment in the abdominis rectus sheath, and postoperative pain from thoracotomy, sternotomy, and after renal surgery through flank incisions. Caution should be used when performing bilateral Intercostal blocks, since ventilation may be impaired.

Anatomy

The Intercostal nerves are the ventral rami of Thoracic Nerves T1 through T11; however, the twelfth ventral ramus is called the subcostal nerve because it lies below the 12th rib. It travels between the transversesabdominus and internal oblique muscles of the abdomen. The Intercostal nerve provides preganglionic sympathetic fibers to the sympathetic chain via the white rami communicantes and receives postganglionic neurons from the sympathetic chain through the gray rami communicantes (Figure 1). These gray rami join the spinal nerves near their exit from the intervertebral foramina. A short distance beyond the intervertebral foramina, the nerve root divides into the posterior and anterior primary divisions. The posterior primary division carries sensory and motor fibers to posterior cutaneous and muscular tissues, which are paravertebral. The primary anterior division that becomes the intercostal nerve gives rise to the lateral cutaneous branch just anterior to the midaxillary line, which sends subcutaneous fibers anteriorly and posteriorly (Figure 2). The intercostal nerve continues to the anterior trunk where it terminates as the anterior cutaneous branch. The collateral branch runs forward inferiorly to the main nerve on the upper border of the rib below. The main nerve and its collateral branch give off numerous muscular branches.

Each intercostal nerve enters the intercostal space between the parietal pleura and the posterior intercostal membrane. It then runs forward, inferior to the intercostal vessels in the costal groove of the corresponding rib, between transversusthoracis and internal intercostal muscle. The first six nerves are distributed within their intercostal spaces. The seventh to ninth intercostal nerves leave the anterior ends of their intercostal spaces by passing deep to the costal cartilages, to enter the anterior abdominal wall. In the case of the tenth and eleventh nerves, since the corresponding ribs are floating, these nerves pass directly into the abdominal wall. The lower intercostal nerves (7th to 11th nerves) supply the skin of the abdomen. Also, these nerves also
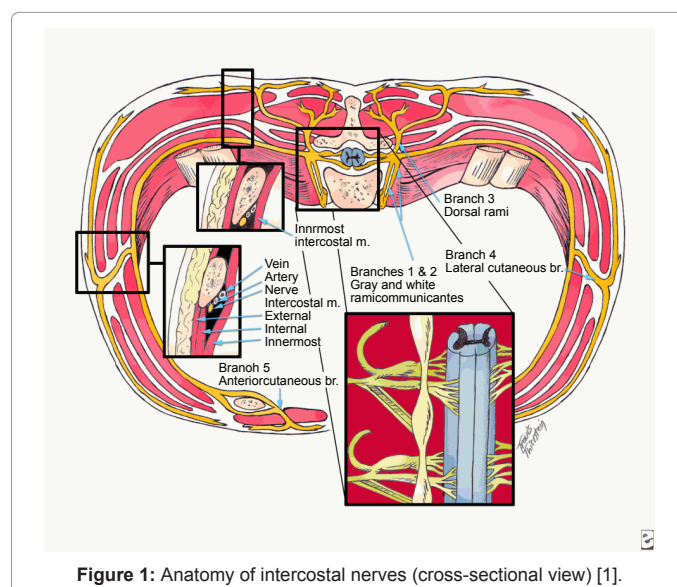

Figure 1: Anatomy of intercostal nerves (cross-sectional view) [1].

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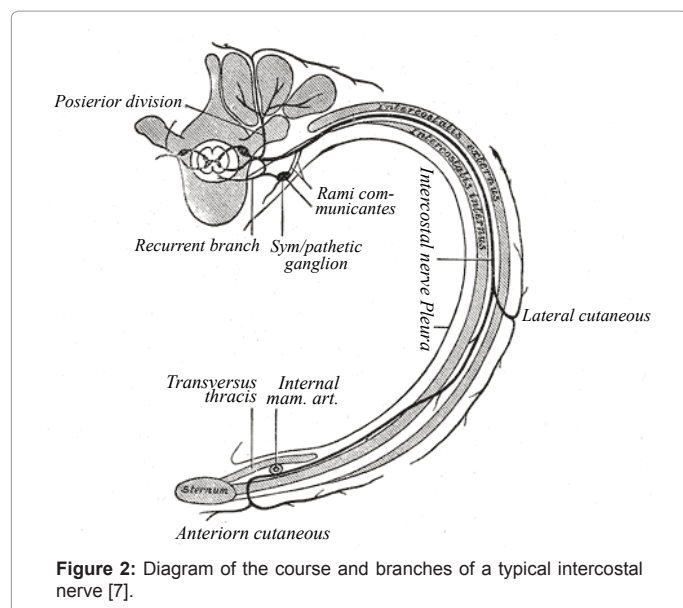
Figure 2: Diagram of the course and branches of a typical intercostal nerve [7].

supply the muscles of the abdomen leading to the tickle response. The anterior division of the first thoracic nerve divides into a large superior part and a small inferior part. The superior part joins the brachial plexus. The inferior part becomes the first intercostal nerve. The first intercostal nerve runs along the first intercostal space, and ends on the front of the chest as the first anterior cutaneous branch of the thorax. It usually gives off no lateral cutaneous branch. The second intercostal nerve may also contribute a small branch to the brachial plexus. The lateral cutaneous branch of the second intercostal nerve is called the intercostobrachial nerve because it supplies the floor of the axilla and then communicates with the medial brachial cutaneous nerve to supply the medial side of the upper limb as far as the elbow.

Standard techniques of intercostal nerve block

The Posterior Intercostal Block, as described by Bonica is carried out easily at the angle of the rib, where it is the most superficial and easiest to palpate [1]. The patient is placed in the lateral position with the target side up if performing a unilateral block or in prone position if performing bilateral blocks. A 3 cm, 25 gauge, short beveled needle is inserted through a skin wheal at the lower edge of the posterior angle of the rib. The second finger of the left hand is placed over the intercostal space and the skin is pushed gently cephalad so that the lower edge of the rib above can be palpated simultaneously. This technique protects the intercostal space, thus reducing the risk of passing the needle into the lung. The needle is advanced until the lower part of the lateral aspect of the rib is reached. After reaching the rib, the needle is grasped with the thumb and index finger of the left hand about 3-5 mm above the skin surface. The skin is moved caudally with theleft index finger to allow the needle to slip just below the lower border of the rib and then the needle is advanced until the left thumb and finger grasping the needle become flush with the skin. Aspiration is attempted; if negative, 3-4 ml of local anesthetic solution is injected. The purpose of this technique is to inject local anesthetic solution as close as possible to the intercostal nerve as it travels in the subcostal groove.

In the Anterolateral Intercostal nerve Block described by Bonica the block is performed at the anterior axillary line proximal to the takeoff of the anterior cutaneous branch of the thoracic intercostal nerves and is useful for alleviating the pain of sternotomy, fracture of the sternum, and dislocation of costocartilage articulations [1].

The Lateral Intercostal Block technique, described by Bonica is performed 3-4 cm posterior to the midaxillary line where the lateral cutaneous nerve pierces the intercostal muscles and divides into anterior and posterior branches. A block at this site is preferable for somatic pain caused by disorders of the chest and abdominal wall [1].

Diffusion technique for intercostal nerve block

With the Diffusion Technique by Omoigui, the left middle and index fingers are placed to stabilize the superior and inferior borders of the rib, respectively at a site proximal to the area of pain. A 3 cm, 25 gauge, short-beveled needle is inserted directly onto the midpoint of the rib and 1-2 ml of local anesthetic solution is injected over the rib. There is no attempt to walk off the lower border of the rib and there is no advancement of the needle into the subcostal groove. There is minimal to no risk of any accidental pleural puncture as compared with the Bonica technique. This diffusion technique utilizes the spread and diffusion characteristics of the injected local anesthetic to produce blockade of the peripheral branches and intercostal nerve blockade. This diffusion technique has showed similar therapeutic results as the standard approach.

Case Report: 1

Mr. P.L presented with history of chest pain for two days that he described to be sharp and moderate in nature. He stated that he was carrying a heavy box of household utensils when he dropped it and the edge of the box struck him in the chest. The pain was severe and rated at a pain score of 9/10. Chest examination revealed tenderness at the right 4th rib at mid clavicular line. A working diagnosis of right chest wall contusion with possible fracture of the rib. Mr. P.L. was given Dilaudid 2 mg IM injection and sent for X-ray of the ribs. The patient was placed on MS Contin 30 mg PO q 12 hours. The patient returned to the clinic two weeks later with persisting complaint of anterior chest pain and failure of the MS Contin to relieve his pain. Mr. P. L stated that his pain level has been a 9-10/10. The pain woke him up at night and was more severe when the weather is cold.

Examination revealed tenderness to palpation of the right 4th and 5th ribs at mid clavicular line. X-ray showed an undisplaced fracture of the 4th rib. We then performed our diffusion technique for intercostal nerve block.

The patient was placed in the left lateral position. Sterile Prep and Drape was done in the usual fashion. A 25G needle was inserted to the midpoint of the right 4th to 6th ribs at the anterior axillary line. 2 ml of Lidocaine 1% was injected over each rib.

The patient experienced immediate relief of his chest pain within 3-5 minutes. A few hours later, the intercostal block wore off, but the pain score never exceeded 4/10. The rib pain was completely resolved by the time of his subsequent visit to the clinic two weeks later.

Case Report: 2

Mr. J. D. presented in the clinic with established osteoporosis and a history of right rib cage pain for seven days. He reported that his pain radiated to his upper mid-back and was associated with occasional tingling. The pain score was at 6/10. He described his pain as intermittent with the pain score ranging between 0/10 to 8/10, aching in nature, and stabbing when he sat up on a hard chair. He reported his pain gets worse with activity, especially when he vacuums his house

and when he sits for a long period of time. Palpation of right rib cage revealed moderate tenderness of ribs 9 to 12. X-rays of his bilateral ribs cages showed no evidence of fracture or any other abnormality of the costal cage.

The patient was placed in the semi-lateral position. Sterile Prep and Drape was done in the usual fashion. A 25G needle was inserted to the right ribs 8 to12 at the posterior angle of the rib. 1 ml of Lidocaine 2% with 5 mg Ketorolac was injected over each rib. A total of 4 ml Lidocaine 2% and 20 mg Ketorolac was injected. The needle was withdrawn. A sterile band-aid strip was applied over the sites of injection. The procedure was well tolerated. The patient experienced immediate relief of his chest pain within 3-5 minutes. The patient was observed for 30 minutes and then discharged with specific instructions. The patient came back 8days later with the pain score of 0/10 on the right rib cage. He did not experience any numbness or tingling for the last seven days after he received the Intercostal Nerve Block in the last clinic visit.

Case Report: 3

Mr. O.I. presented in the clinic with a history of right chest pain for one day with the pain level of 10/10. He provided a history of a fall off a horse. Patient described his pain as severe, sharp and stabbing, which got worse with activity and woke him up at night. Patient stated that his pain was aggravated with deep respiration and relieved when he raised his arm up. He denied headache and fever. Palpation of the chest revealed tenderness in the right upper chest. Normal breath sound was heard bilaterally. Trachea was not displaced. Chest X-ray showed minimal displacement of the right fourth posterolateral rib fracture. There was no pneumothorax, cardiomegaly or pulmonary venous congestion.

Mr. O.I. was given Demerol 50 mg SQ and Toradol 60 mg IM. Patient did not get any relief from the right chest pain. We then performed our diffusion intercostal nerve block.

The patient was placed in the semi-lateral position. Sterile Prep and Drape was done in the usual fashion. A 25G needle was inserted to the right ribs 3 to 5 at the anterior axillary line. 2 ml of Lidocaine 1% was injected over each rib. The needle was withdrawn. A sterile band-aid strip was applied over the sites of injection. Pain went from 10/10 down to 0/10 within 2-3 minutes. Patient experienced immediate relief from chest pain.

The procedure was well tolerated. The patient was observed for 30 minutes and then discharged with specific instructions. The patient came back a few days later with pain score of 4/10 but he was able to control his pain with oral pain medications. Mr. O.I. did not need any further procedure.

Rationale Supporting the Diffusion Technique

According to one anatomic study of intercostal nerve block technique, iothalamatemeglumine 60% (Conray) was injected bilaterallyinto the intercostal grooves of the ninth or tenth ribs in 30 surgicalpatients. Roentgenograms showed extensive spread of the contrast centrally and peripherallyfrom the site of injection within 30 seconds, with almost completeabsorption within 10 minutes 30 seconds [1]. These findings help to explain how the injected anesthetic is spread during an intercostal nerve block regardless of the site of injection. In another study of twenty patients undergoing thoracotomy, twelve patients received intercostal nerve injection with 10 ml of 0.5% bupivacaine with methylene blue, and eight patients received 5 ml

of 0.5% bupivacaine with methylene blue. The area of spread of the methylene blue was measured after the pleural cavity was incised. The 10 ml group had a mean area of spread of 51.1 cm^2 as opposed to 17.6 cm^2 for the 5 ml group. In the 10 ml group, eight patients had bupivacaine-methylene blue spread to two intercostal spaces, three patients to three intercostal spaces, and one patient to four intercostal spaces. In the 5 ml-group, seven patients had bupivacaine methylene blue spread confined to one intercostal space and one patient to two intercostal spaces [2]. This demonstrates that there is extensive spread of local anesthetic after intercostal nerve block injection. Such extensive spread of local anesthetic puts in question the rationale for additional risk in advancing a needle right next to the intercostal nerve. Axonal transport plays a critical role in supplying materials for a variety of neuronal functions such as synaptic transmission, and cell survival. Materials may be transported within a nerve in anterograde and retrograde axonal directions. Neuronal tracer dye applied to the exposed distal endings of nerves has been demonstrated to travel by retrograde axoplasmic flow into the proximal cell bodies of the nerves [3]. Proximal neuronal blockade will occur after application of local anesthetic to terminal nerve endings. In addition, interruption of nociceptive afferent impulses from peripheral nerve endings at the site of injury will also inhibit the release of neuropeptides and the propagation of the inflammatory response by the proximal nerves [4].

Discussion

In order to understand why this Diffusion technique for Intercostal Nerve Block has shown similar therapeutic results to those of the standard approach, we need to look at the anatomical relationship of intercostal nerves, muscles and structures which they supply. An intercostal nerve courses along the inferior edge of eachof the 1st through 11th ribs. A subcostal nerve is locatedbeneath the 12th rib. These nerves innervate the musclesthat join the ribs and provide sensory input from the overlyingskin of the chest. (The first three intercostal nerves alsomediate sensation from the upper extremities and axilla.) The intercostal nerves also refer sensation from the adjacent lower parietalpericardium, the parietal pleura, and the peripheral segmentof the intra-thoracic diaphragm [5]. The subcostal nerves locatedunder the 12th ribs along with the intercostal nerves from T6 to T11 innervate the muscles of the upper abdominal region andthe overlying skin. The Intercostal Nerves give rise to Lateral Cutaneous Branches about midway between the vertebrae and sternum. The Lateral Cutaneous Branches then divide into anterior and posterior branches as they pierce the Intercostalesexterni and Serratus Anterior Muscles. The anterior branches runs forward to the side and the forepart of the chest while the posterior branches run backward, and supply the skin over the scapula and Latissimus Dorsi Muscles. In our diffusion technique of Intercostal Nerve Block, we inject local anesthetic solution directly over the ribs. The anesthetic solution diffuses within the subcutaneous tissue, muscles, intercostal membranes and intercostal space. The anesthetic solution then blocks peripheral nociceptors and peripheral nerve endings including both medial and lateral branches of the Anterior Cutaneous Branches, which are the terminal endings of each intercostal nerve. The anesthetic solution may also be transported by retrograde axoplasmic flow from the peripheral branches into the intercostal nerve. The anesthetic solution also interrupts nociceptive afferent impulses from peripheral nerve endings at the site of injury and inhibits the release of neuropeptides by the proximal nerves and the propagation of the inflammatory response from the site of injury [6]. Our diffusion technique utilizes the spread and diffusion characteristics of the injected local anesthetic fluid solution. We believe that injection

procedures are both an art and a science. Unless a procedure entails radio-frequency destruction of a nerve, physicians should take advantage of the diffusion characteristics of local anesthetic solutions prior to incurring any additional risk in trying to place a needle next to a nerve. We have performed this diffusion intercostal block on several patients with success each time and without any complication. We have used volumes of up to 3 ml per rib and have observed cutaneous anesthesia to a Wartenberg Pinwheel, in the dermatomes of the intercostal nerve proximal to the site of rib injection. Sensory block is more pronounced and may extend to intercostal spaces below the injected rib when higher volumes of local anesthetic are injected (3 ml per rib). It is important to recognize that intercostal blocks are associated with the highest systemic absorption of local anesthetic and not to exceed the toxic dose of the local anesthetic.

Conclusion

The Omoigui Diffusion technique for intercostal nerve block is simple and easy to perform in an operating room, emergency room or clinic, and associated with less risk and complication.However, we have described three cases and there has been no comparison to other techniques in terms of patient outcomes. Future research is needed before any evidence-based conclusions can be made.

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