Poststernotomy Pain: A Clinical Review

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POORLY CONTROLLED PAIN is associated with sympathetic nervous system activation and an increased hormonal stress response. This response may contribute to multiple adverse postoperative events, including myocardial ischemia, cardiac arrhythmias, hypercoagulability, pulmonary complications, and increased rates of delirium and wound infection. In a systematic review of trials that examined postoperative pain and patient outcomes, better pain control was associated with lower rates of cardiovascular complications, pneumonia, and postoperative hypercoagulability.[1]

According to the American Heart Association, between 1996 and 2006, the total number of cardiovascular operations and procedures performed in the United States increased 33% annually from 5,444,000 to 7,235,000.[2] In 2006, an estimated 448,000 coronary artery bypass graft (CABG) operations were performed. Most cardiac surgery is performed through a median sternotomy. Because of the large number of cardiac operations performed annually and the link between optimal postoperative pain management and improved clinical outcome, anesthesiologists must champion the current best practice. Therefore, an evidence-based review of the epidemiology, pathophysiology, and prevention and treatment of both acute and chronic poststernotomy pain is presented.

METHODOLOGY FOR THE LITERATURE REVIEW

To identify relevant articles for the review, the web site http://www.pubmed.gov was used to query the following phrases: sternotomy pain, acute sternotomy pain, chronic sternotomy pain, thoracic epidural and sternotomy pain, thoracic epidural and cardiac surgery, spinal anesthesia and sternotomy pain, spinal anesthesia and cardiac surgery, regional anesthesia and sternotomy, regional anesthesia and cardiac surgery, local anesthesia and cardiac surgery, and pain and cardiac surgery. The authors also identified studies of interest from the reference lists in studies that were reviewed. All articles identified were obtained in full text. Both authors agreed on the relevant studies to include in the review.

EPIDEMIOLOGY OF ACUTE STERNOTOMY PAIN

The assessment and quantification of acute pain can be highly variable and dependent on the interval of assessment as well as the instrument used for quantification. A number of scales are used in clinical practice to quantify pain. These include the facial expressions scale, the visual analog scale (VAS), numeric rating scales, and verbal rating scales, among others. Certain scales are better suited than others for particular patient populations. For example, the facial expressions scale can be used in patients who are unable to communicate verbally (eg, tracheostomy or ventilated patients). Pain comparisons among the multiple scales are fraught with difficulty because the scales have various magnitudes or units of measurement.

A number of studies have suggested that cardiac surgery patients have significant pain after surgery in both the intensive care unit and after their transfer to the floor.[3-5] Recent prospective studies have described the incidence, severity, and risk factors for acute sternotomy pain. In a prospective cohort study of 213 CABG surgery patients, subjects were assessed 4 days after surgery using the VAS.[6] In this study, patients experienced more postoperative pain than they anticipated. Forty-nine percent had severe[6] pain at rest, 78% had severe pain during coughing, and 62% had severe pain during movement.

In another prospective study of 705 cardiac surgery patients, pain related to activity was assessed daily on postoperative days 1 through 6 using the VAS.[7] Patients experienced their most severe pain while coughing, followed by moving, turning in bed, getting out of bed, and, finally, during deep breathing. Although pain scores were highest during the immediate postoperative period, patients still reported a mean pain score of 4.33 while coughing and a mean pain score of 3.09 with deep breathing on the sixth postoperative day.

In a third prospective study of 200 consecutive patients who had cardiac surgery through a median sternotomy, pain was assessed using VAS on postoperative days 1, 2, 3, and 7.[8] In this study, the highest pain scores were recorded on days 1 and 2 (mean of 3.7 and 3.9, respectively) with a significant decrease on day 3 (mean of 3.2) and day 7 (mean of 2.6). It also was noted that the location of the most intense pain changed over time to shoulder pain on postoperative day 7.

An Australian study of 102 patients in the intensive care unit after cardiac surgery specifically studied patients' perceptions about postoperative pain and their overall satisfaction.[9] In this

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1053-0770/2506-0045$36.00/0

doi:10.1053/j.jvca.2011.08.001

Key words: sternotomy, pain, cardiac surgery

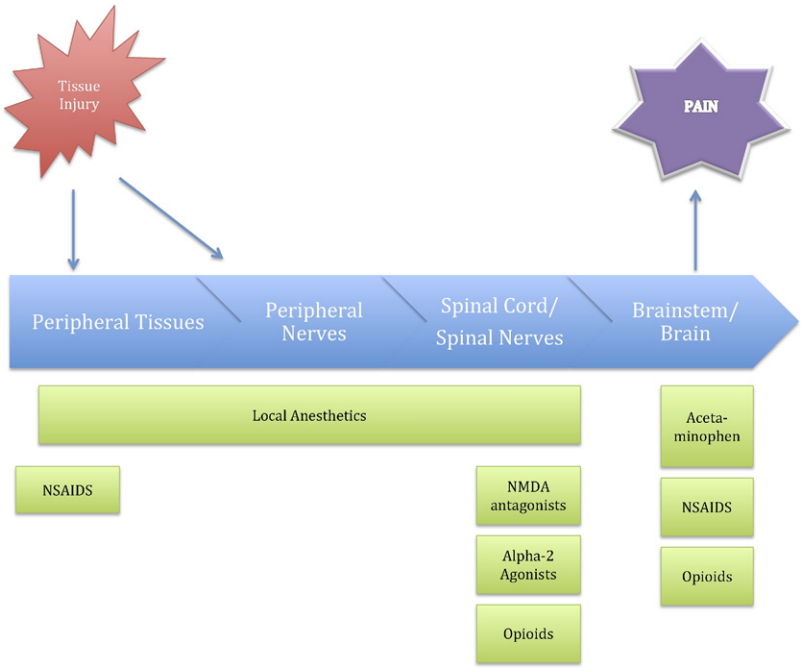

Fig 1. Simplified pain pathway depicting site(s) of action of common analgesic medications. (Color version of figure is available online.)

study, most patients were satisfied with their pain control. This study showed that females had worse pain after sternotomy, patients who had internal mammary artery harvesting had more intense pain, and elderly patients were denied analgesia more often than young patients.

In summary, it appears that many patients experience significantly greater pain than expected after sternotomy. Typically, acute pain is worst on the first postoperative day at the site of surgical incision. Usually, the worst pain is experienced during movement or coughing. Significant pain often continues for up to a week after surgery, and the location of pain may shift during this time period away from the site of surgical incision and to the shoulders.

PATHOPHYSIOLOGY OF ACUTE STERNOTOMY PAIN

The mechanisms of postsurgery pain are complex, but generally speaking, in addition to nociceptive input from direct tissue trauma, an inflammatory response leads to the sensitization of peripheral and central pathways resulting in the experience of pain. Most sternotomy pain occurs because of tissue injury in the skin, subcutaneous tissues, bone, and cartilage. Intercostal nerves arising from thoracic nerve roots innervate the sternum, ribs, and surrounding subcutaneous tissue. The principal thoracic nerves supplying the sternum are T2 to T6. The parietal pleura also is innervated densely with pain fibers that can be activated by either mechanical or chemical stimuli.[10] In contrast, the visceral pleura does not have significant sensory innervation. The pericardium is innervated with pain fibers that arise from the vagus nerve, phrenic nerve, and sympathetic trunks.[11]

When tissue injury occurs from surgery, numerous inflammatory mediators are released, including ions (eg, sodium, potassium, and calcium) bradykinin, substance P, histamine, 5-hydroxytryptamine, adenosine triphosphate, nitric oxide, prostanoids, and leukotrienes.[12,13] Some of these molecules directly activate nociceptors, whereas others work through indirect mechanisms. These inflammatory molecules also play an important role in the sensitization of both peripheral and central neurons to subsequent stimuli. Primary afferent fibers (A-delta and C) conduct impulses from peripheral nociceptors to the dorsal horn of the spinal cord. From here, sensory information is relayed primarily via the spinothalamic tract to the supraspinal structures, including the brainstem, thalamus, and cortex, where the ultimate experience of pain takes place (Fig 1).

It is believed that acute tissue injury occurs after sternotomy not only at the site of surgical incision but also at more distant sites because of prolonged sternal retraction, which may lead to rib fracture, costochondritis, rib joint dislocation, or nerve injury.[14] The presence of chest tubes and mediastinal tubes, which irritate the parietal pleura and pericardium, are also a significant source of pain for patients. Finally, pericarditis can occur after pericardiotomy, leading to significant pain.

In summary, acute sternotomy pain is mechanistically complex and occurs secondary to tissue injury and inflammation not only at the site of surgical incision but also at distant sites that are injured during prolonged sternal retraction and from the presence of chest and mediastinal tubes.

PREVENTION AND TREATMENT OF ACUTE STERNOTOMY PAIN

As mentioned previously, optimal pain management mitigates the stress response to surgery and may improve clinical outcomes for patients although this has been difficult to definitively prove. Poorly controlled pain after surgery has been